

**Climate Change and Variability as Determinants of Vegetation Cover Dynamics
and Livelihood Responses of the Forested Communities of Southwest Nigeria**

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Faculty of Environmental Design and Management
Lead City University, Ibadan, Nigeria**

**In Partial Fulfillment of the Requirement for the Award of Doctor of Philosophy
Degree (Ph.D.) Degree in Environmental Management**

Certification

This is to certify that this Thesis was carried out by Mr. Ayeni Olatunji David, Matriculation number LCU/PG/000256 of the Department of Environmental Management, Faculty of Environmental Design and Management, Lead City University, Ibadan, Nigeria and that this work has not been previously submitted.

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Dedication

This thesis is dedicated to Almighty God. The Alpha and Omega, the beginning and the ending, the father of our Lord Jesus Christ.

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It therefore goes without saying that all the contributors to this project are exonerated from any liability concerning every information released for the success of the thesis.

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Abstract

The Study investigates Climate Change and variability impacts on vegetation cover dynamics and livelihoods of the forested communities in Southwest Nigeria. This study based on spatial and temporal dimension of climate change and responses of communities whose livelihood linked to government forest reserves within 2 kilometers in Akure, Ologe, Gambari and Okoiro forest reserves. 275 structured questionnaire and key interview administered to 24 selected villages; Climatic data was obtained from Nigeria Meteorological Agency (NiMet), (1991-2020); and Landsat data obtained from remote sensing through United State Geological Survey (USGS), (1990-2020). Analysis methods adopted were: Standardize Anomaly, Time series analysis, Normalized Vegetation Index (NDVI) using trend analysis and remote sensing/thermal bands of images regression analysis and Pearson's Chi-square analysis. Observed rainfall and temperature were revealed to be higher than the standardized normal and irregular pattern was detected in the time series. Temperature values were predicted to be highest in every February, while rainfall peak period in September in all the study area except Ologe forest reserve (June). Also, annual rainfall and average annual temperature are predicted to increase. The result also revealed loss of vegetation cover to other land uses in Akure (8km²), Gambari (36.9km²), and Okoiro (0.936km²), except Ologe that gained 39.1km² due to afforestation program by Nigeria Conservation Foundation (NCF). Satellite temperature increased between 1.9⁰C and 4.7⁰C in the forest reserves. It is concluded that there was negative relationship between vegetation cover and land surface temperature that has significant impact on the livelihoods. Finally, the respondents' perception of climate revealed rainfall variability and temperature increased that differ from 30 years ago (p value < 0.05). This study recommends bottom-up approach

action plans through integration of observed climate, spatial data and local perception to enhance agro-forestry supports in communities.

Keywords: Land use, Climate change, Vegetation cover, Livelihoods, Southwest Nigeria.

Word Count: 298

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Chapter One

Introduction

1.1 Background to the Study

Climate is commonly defined as the synthesis of weather averaged over a long period. It is the statistically appreciable variations of weather parameters that stay for a long period, which could be decades or longer. Climate change can as well be defined as the occurrence which happened as a result of natural variability or effect of human activities. This is the frequency and magnitude shift of sporadic weather events as well as the slow continuous rise in global mean surface temperature¹. The purpose of the use of climate data differs but the standard averaging period is 30 years¹. The magnitudes of the day-to-day or year-to-year variations in environmental phenomenon are also studied apart from statistical averages¹. Also, the climate is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period ranging from months to thousands or millions of years¹. The deviation of climate parameters from standardize normal leads to greatest environmental, social, and economic threats facing our world today². Apart from wind speed and direction, humidity and solar radiation, the most meteorological variables used in climatic trend studies are precipitation and temperature.^{3, 4} The long-term trend has been detected all over the world with regards to the temporal distribution of rainfall^{5, 6}. It is very obvious beyond doubt that the climate system is warming with the evidence observed in increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level⁷. The reason why rainfall and temperature are used in investigating meteorological variables in climatic trend

studies is mainly due to the serious impacts that their spatial and temporal changes can have on several environmental and socioeconomic aspects⁸.

Generally, scientists have agreed that the global climate is changing⁹. Variations in amount, intensity, frequency, and type of climatic parameters have been observed in climate changes. Precipitation generally demonstrates large national variability and El Nino and changes in atmospheric circulation patterns such as North Atlantic Oscillation have substantial influence. Regionally, such changes are expected to be different from the global average since responses to external forcing in regional rainfall trends depend on atmospheric circulations, interactions of the atmosphere and ocean, and geographic factors such as altitude⁹.

It was established that we are in a geological epoch, Holocene, which is the period that began at the end of last ice age. But due to the influence of human activity on earth's ecosystems which reached extreme stage has made it to be the central driver of environmental change. Because of this scenario, scientists have argued that we should think of ourselves as living in a new epoch called the Anthropocene. This epoch attracted debate within the scientist's world, when this actually started. Could it be mid-twentieth century? The industrial Revolution? Or could it be earlier than that- say when the agriculture became major feature in human life? Within the scientists, the last one was agreed on. In view of this, the vegetation of the planet began changing dramatically between 4,600 and 2,900 years ago. The likely cause was primarily human activity which include agriculture, deforestation and the use of fire to clear landscapes^{10,11}.

Since the industrial revolution (1750), human activities have more increased markedly the global atmospheric concentrations of greenhouse gases, than thousand years ago

because of technology advancement¹². A lot of studies have shown that temperature is rising and rainfall frequency and intensity are fluctuating ^{13,14}.

The total amount of monthly or annual rainfall is as important as the yearly distribution when evaluating its impact on the climate system such as atmosphere, biosphere, hydrosphere, and lithosphere. The primary producer of any ecosystem is vegetation which is the total plant (trees, shrubs, climbers, grasses etc.) cover forming parts of the biological system¹⁵. Natural vegetations are vitally necessary component on earth and they dictate all forms of life¹⁶. Vegetation has been a source of food, soil fertility, oxygen, and support in the survival of all living beings such as spiritual fulfillment that contributes to improving quality of lives^{17,18}.

The role of local and regional carbon storage, hydrology, and global climate dynamics is also performed by natural vegetation ¹⁹. The result of increases in greenhouse gases has been the increase in global average temperature and change in precipitation patterns over the past 100 years. The impact is on numerous site factors and biochemical processes of the vegetative communities such as permafrost thawing, water availability, fire regime, biotic interaction, and invasion. Distribution ranges of many species and communities have been altered as well as the boundaries of biomes due to climate change ^{20,21}.

Natural and anthropogenic factors act as the determinant for the distribution changes caused by climate change. Such changes are in form of the magnitude of climatic change, landscape fragmentation, dispersal capabilities of individual species, seed availability, and interaction with land use^{22,23}. The unpleasant impact of climate change such as an increase in temperature, rainfall fluctuation, sand storms, desertification, low agricultural yield, drying up of water bodies, and sea-level rise are

real in the desert-prone eleven front-line states of Nigeria. The front-line state has extended to Southwest Nigeria due to severe and uncontrollable anthropogenic activities that attracted extreme climatic parameters feedback on human and the environment²⁴. Facts have been established that the impacts of rising temperature and rainfall fluctuation on farming are being felt across major agroecological zones in Nigeria²⁵.

The major threats confronting the livelihoods of the inhabitants of the frontlines state of Nigeria are environmental degradation and attendant desertification. These lead to increasing population pressures, intensive agricultural land use, overgrazing, bush burning, and extraction of fuelwood and other biotic resources. Cattle grazing has also been found to be detrimental to the human race, climate change, and forest management. This involves the pastoralists who are often nomadic or transhumant and who are solely dependent on the natural grassland for cattle, moving about in search of pasture for grazing. Factors that determine their movement are: the quantity and quality of the natural pasture depend on soil type; the duration of the rainy season; the amount of rainfall received and; grazing pressure exerted by cattle grazing the grassland²⁶. The effect of these have spill over to Southwest Nigeria which is considered more favorable than the recognized front-line state environmentally²⁷.

The study of livelihood as a concept has its root traceable to disciplinary lines such as economics and development studies. The multiple definitions and conceptualizations of the concept have largely reflected these lines²⁸. Livelihoods can be thought of as the way people fend for themselves. Livelihoods contribute to human well-being, which includes tangibles as assets and goods for consumption²⁹. International Development Studies (IDS) gave the following definition of livelihood “A livelihood

comprises capabilities, assets (both material and social resources) and activities required for a means of living.

A livelihood is sustainable when it can cope with and recover from shocks and stresses, and maintain or enhance its capabilities and assets, both now and in the future, while not undermining the natural resource base³⁰.

According to the livelihoods framework described by the UK Department for International Development (DFID); five types of capital support livelihoods³⁰:

1. Natural capital (such as lands, water, forests, and fisheries);
2. Human capital (such as knowledge and skills);
3. Financial capital (such as income opportunities);
4. Physical capital (such as infrastructures), and,
5. Social capital (such as social networks).

Globally, the trends of the climate change are manifesting through, flora and fauna, melting glaciers, and decreasing mountain snow caps. For example, the mosquito belt has considerably expanded to higher elevations due to the temperature increase, frequency, and droughts. The scenario is that the interaction between climate change and national socio-economic policies will drastically reduce crop yields in the foreseeable future in most African countries considerably under a warmer climate, while the shift in forest ecosystems is predicted to shift their ranges and lose some of their bio-diversity with consequential impoverishment in the natural heritage of the countries and a decline in tourism. In most African Countries, the impacts of climate change, whether biophysical, social or economic, are therefore a source of great concern³¹. Climate change impact and the vulnerability of the forested communities

differ regionally and globally. The vulnerability in each region is superimposed on climate change effects such as poor agricultural practices, poverty, low farming outputs, poor ecosystems management practices, and lack of innovation. The result of this is food insecurity with its chain effect on the livelihood of the poor societies³².

The major drive of this research is to provide a detailed analysis of the implication of the multiple impacts of climate change and variability on Southwest Nigeria communities and providing way of livelihood sustainability in terms of coping with and recovering from shocks and stresses from weather vagaries. It also focuses on maintaining or enhancing community capabilities and assets both now and in the future while not undermining the natural resources base.

1.2 Statement of the Problem

From the aggregate of the past events of the earth, climate (global, regional, and local) has never been static. The non-static natures are in various magnitudes ranging from variability through fluctuation, trends, and abrupt to gradual changes. It is crystal clear that the world has entered and emerged from a series of ice-ages. It is believed that variability in terms of fluctuation or trends is an inherent attribute of climate or weather³⁰. The world climate has been changing and will continue to change³².

Frequentative changes in climate parameters in Southwest Nigeria have impact on the livelihoods of forested populations and lead to food insecurity, decline in per capital farm income, land and soil degradation aggravated by biodiversity loss, survival and economic development threat³³. Indeed, projected future climate change is almost certain to affect negatively vegetation and agriculture resource base in the study area³⁴. Also, it has become a subject of concern globally that rural poverty and environmental degradation are two intertwined challenges developing countries are facing³⁴.

Improving rural household livelihoods, and at the same time realizing ecological conservation in rural areas has called for research.³⁵ Human use of natural resources has made ecosystem services to be highly vulnerable and subsequent land use change³⁶. Also, the management of natural resources governance in southwest Nigeria encourages unhealthy competition in forest exploitation that drives deforestation and forest degradation³⁷.

Previous studies have shown that there are evidences of climate change in Southwest, Nigeria and it has greatly impacted the ecosystem, livelihoods, settlement, health and water resource. It has been observed that the climate parameters such as rainfall and temperature are changing in the Nigeria Savanna and that ecosystem-based livelihoods are already impacted^{38,39}. However, the present study is combining three ecological zones (Mangrove, Rainforest and Guinea Savanna) in Southwest Nigeria. Also, examination was carried out on climate trend and its impacts on water resources in the Oke-Ogun area of Oyo State. Two meteorological data periods from two stations were used together with social perception⁴⁰. The present study combined climate data from four meteorological stations and earth observation data (satellite imageries).

Another study investigated the feedbacks of land use land cover and climate on Ogun, Owena and Asa Basins using Satellite imagery analysis. The study reported that there was commensurate increase in the runoff coefficient of the three basins (Ogun, Owena and Asa) with decrease in forest between 1981 and 2000⁴¹.

In addition, previous studies also anchored on either the vegetation cover dynamics in tropical Africa especially in Nigeria using change detection capability of some remotely sensed images to account for the rate of deforestation and land-use changes in their study areas^{42,43,44,45,46}. Some on rainfall trend,^{47,48,49}. Some on vegetation

dynamics and livelihood^{50,51}. Some on climate change and livelihood^{52,53,54}. Some on maintenance/governance of forest ecosystems³⁵. Some on Land use and forest biodiversity⁵⁵. Some on climate and vegetation⁵⁶. Some on Livelihood diversification in southwest Nigeria ^{57,58,59}. Finally, a research on Determinant of forest land use decisions among rural farmers in Southwest Nigeria⁶⁰. In all these researches, due consideration was not given to changes in rainfall and temperature patterns, which is the trending issue affecting all facet of lives, their impact on vegetation cover dynamics, and forest communities' livelihoods in different ecological zones in southwest Nigeria.

What is not clear is the nature of this change, fluctuations, variations, and trends in specific regions like Southwestern Nigeria. Southwest Nigeria represents a specific case where strong topographic effects, exposure to oceanic influence, and strong heterogeneity of vegetation types contribute to uncertainty on the fate of the ecosystem under changing climate conditions. This region's main occupation is farming, mainly rain-fed agriculture. Any change, variation, or fluctuation of climate, whether slowly or rapidly has been seriously affecting the occupation of the inhabitants of this region. Therefore, a thorough knowledge of the behavior of climate, present, and future, will contribute significantly to the wellbeing of the people. The ultimate magnitude of climate change and the severity of its impacts depend strongly on the actions that human societies take to respond to these risks ^{61,62}. In Southwest Nigeria, low levels of education and poorly developed communication and marketing infrastructures further complete the task of developing location-specific responses that effectively address the vulnerability of communities in remote areas to claim climate-related disaster impacts⁶³.

The present study attempts to examine thirty-year analysis of recent changes in rainfall and temperature patterns, and their effect on vegetation cover and forest communities' livelihood, and the adaptation and mitigation methods employed with their implications in southwestern Nigeria.

1.3 Research Questions

- i. What are the observed and perceived trends in annual and monthly variations of rainfall and temperature as climate parameter in the study area?
- ii. What are the patterns of vegetation cover dynamics observed and perceived in the selected communities in the study area?
- iii. What are the prevailing livelihoods practiced in selected communities in Southwest Nigeria?
- iv. What are the adaptation and mitigation strategies that are already in use in the forest communities to ameliorate the impact of climate change in the study area and how such strategies can be modified for the effectiveness and sustainability of forests?

1.4 Aim and Objectives of the Study

The aim of the study is to investigate the impact of climate change, vegetation cover dynamics on livelihood activities of the forested communities of Southwestern Nigeria'.

The specific objectives are to:

1. Examine the observed trends of rainfall and temperature in Southwestern Nigeria in the past 31 years (1990-2020) using meteorological data and earth observation data.
2. Determine the trends and of Land Surface Temperature and vegetation cover changes between 1990 and 2020 through Landsat Imageries.

3. Investigate the impact of climate change and observed vegetation cover dynamics pattern on the livelihood of the selected communities of the study area over three decades, using respondents' perceptions.
4. Evaluate the relationship between demographic characteristics of the residents of forested communities and the adaptation strategies employed in the forest communities for the improvement of livelihood and effective sustainability of forestry resources.

1.5 Hypotheses

Based on the research objectives, the following hypotheses were tested.

1. There is no trend in the rainfall and temperature in the study locations.
2. There is no significant change in the pattern of vegetation cover in the selected communities of the study area.
3. There is no significant impacts of climate change and vegetation cover dynamics on livelihoods existing in the study area.
4. There is no significant relationship in demographic characteristics and adaptation strategies practiced in the study locations.

1.6 Significance of the Study

Climate is an important factor responsible for the development of vegetation and the life wire of sustainability of human existence in Southwest Nigeria. The nature of rainfall- the sequence of rainfall events, duration of rainfall, rainfall amount, rainfall variability, rainfall intensity is very essential in determining threat to vegetation and livelihoods⁶⁴. Annual and seasonal rainfall and temperature patterns also determines the type of animals and plants that survive in Southwest Nigeria⁶⁵. Temperature determines whether precipitation falls as rain or dew. How much water is stored in the soil or how much water runs off depends on the nature and properties of the soil

(water balance) through temperature. This temperature, as well as the topographic setting determines the duration of time when soil is moist enough for plant growth⁶⁶. Climate affects nearly every aspect of our lives, from our food sources to our transportation, infrastructure, from what clothes we wear, to where we go on holiday. It has a huge effect on our livelihoods, our health, and our future. It determines the socio-economic capability of any region, nation, and continents. Also, vegetation engenders the functionality of climate especially radiation budgeting which is a prerequisite of livelihood sustainability in Badagry Ondo and Ibadan. Vital for healthy coastal ecosystem (mangrove forest), protect the coastline from erosion, storm damage, and wave action, inhabited by fishermen and women. It is a dependable source of fuelwood for domestic and small-scale food processing as well as income generation for the study locations. Forest resources exploration and usefulness are basic knowledge to any afforestation and conservation policies. In this wise, sustainable environmental resources should be tailored towards forestation, conservation planning program, and awareness of the livelihood of the rural communities in Southwest Nigeria, on which their lives sustenance hinges. As such, crucial formation and design of public policies on forest resources will be easy. From another perspective, thorough research of this kind will go to a large extent in enhancing inter-disciplinary, cross-cultural research endeavors among scholars of disaster management, resources management, and forest resources studies, because there is no singular discipline that can solve the ever-changing and multifarious problems plaguing, forest community livelihood, and forest resources. Also due to the high degree of uncertainty of anthropogenic activities with variability in climatic variables, the study of this phenomenon is necessary to alert diversification in the livelihoods of the forested communities.

This research will clarify the type of incentives and support required by Non-Governmental Organizations (NGOs), governments, and other vested groups to enable them to partner with forested communities on natural resources and ecosystem management.

This study is significant in benefiting and drawing the attention of the government and its agencies, Policymakers, planners, investors, and vulnerable communities that need information about future climate so that they can prepare for expected climatic pattern. Similar research can be extended to every known human society in every part of the world on the same geographical locations and can be justifiably be replicated to solve other problems by applying similar decisions.

1.7 Scope of the Study

The purpose of this study is to proffer solution to the problems confronting forested communities and to bring sanity to land degradation and forest loss. The work covered parts of Southwestern Nigeria. The study examined the environmental developments over the past thirty-one (31) years (1990-2020), from the data obtained from Nigeria Meteorological Agency (NiMet), Landsat imageries and field survey. The zone lies squarely in the mangrove, rain forest, high forest, and guinea savannah region of Southwest Nigeria. This is the region where remarkable changes in patterns of rainfall (distribution), sea-level rise, violent storms, crop failures, reduced yields, flash floods, and desertification including incidences of drought are noticed⁶⁷. Further, this study explored the trends in historical rainfall and temperature data; vegetation cover dynamics; and the demographic status and economic activities in the study location. Further, forest and livelihoods in southwest Nigeria, the vulnerability of the forest and dependent livelihoods, the impact of climate change on vegetation cover dynamics, impacts of climate variability and change on southwest Nigeria

environment and adaptation, adaptive capacity, and adaptation strategies were examined. The theories considered were Regional Circulation Theory (GCT), Climax Theory (CT) and Livelihood Theory (LT) in the study. Overall, prediction of climatic parameters and mitigation strategies that will improve livelihoods and forest resources were recommended.

1.8 Limitations of the Study

The present study was conducted only in villages around the four forest reserves in three states of southwest Nigeria (Ondo, Lagos and Oyo). The limitations encountered in the cause of this study were:

- Problem of acquiring climate data for 31- year period for different locations.
- Problem of generating Landsat imageries that covered same years with climatic variables, and
- Problem of cooperation from the respondents in the forest's communities.
- The research questionnaire conducted (semi-structure and less formal interviews) does not convey the same meaning to the respondents may be due to their level of understanding of climate systems
- Problem of insecurity such as kidnapping in the study locations
- Challenges of conducting a place-based and participatory research in the face of pandemic-related disruption.

1.9 Operational Definition of Terms

1.9.1 Climate Change is a long-term continuous change (increase or decrease) in average weather conditions such as average temperature, or the range of weather such as more frequent and severe extreme storms.

1.9.2 Vegetation Cover Dynamics is the interannual vegetation variability, that responds to biogeographically factors that are primarily measured in interannual variability in rainfall and temperature regime.

1.9.3 Forested Communities are the residents in the forest reserves who play a significant role in forest protection, forest management, and land-use decision making, in facilitating support for the government.

1.9.4 Livelihoods can be thought of as the way people make a living in the existence of natural and human factors.

1.9.5 Adaptive Capacity: the degree to which adjustments in practices, processes, or structures can moderate or offset the potential for damage or take advantage of opportunities created by a given change in climate.

1.9.6 Sustainability: the ability to cope with and recover from immediate changes, stresses, and shocks (that do not necessarily threaten long-term secular change), while maintaining core properties⁶⁷.

1.9.7 Vulnerability: the magnitude to which a natural or social system is susceptible to sustaining damage from climate change. Vulnerability had been defined as the extent to which a system is susceptible to harm, as a result of exposure to stress, or is unable to cope with adverse effects of climate change, including climate variability and extremes. Vulnerability is believed to be a function of the character (demography), magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity. The vulnerability of a given system, natural or human, depends on the impacts it is exposed to and its resilience to accommodate these impacts⁶⁸.

1.9.8 Severe Weather: climatic trends that would not register as a disaster in the international community and entail an extensive range of less dramatic impacts than disasters ⁶⁹.

1.10 Study Area

The selected study areas were part of Southwestern Nigeria forest reserves. The forest reserves were made up of Mangroves, Rainforest and derived savanna (Appendix I). The forests comprise of evergreen plants, trees and shrubs that are of various height whereas the derived savanna is characterized by grassland with scattered trees. These forest reserves were purposively selected because of its large expanse rich in tree species diversity that attract wide range of economic activities associated with forest resources exploitation.

Southwest region is bounded in the north and the east by the river Niger; in the west by the Republic of Benin and in the south by the Atlantic Ocean. It lies between longitude 2°311' and 6°001' East and Latitude 6°211' and 8°371'N⁷⁰. The region is made up of six independent States; namely, Lagos, Oyo, Ogun, Ondo, Osun, and Ekiti States. It has a total land area of 77,818km² and a current population of 27,721,832⁷¹ in the year 2006 and 2020 projection of 43,389,620 at the rate of 3.2%⁷². In 2018, the state with the highest population was Lagos State (12,264,884), followed by Oyo State (7,608,579), Ogun State (5,072,892), Osun (4,682,265), Ondo State (4,458,468) and Ekiti State (3,244,242) with overall total of 37,331,330. It has a density of about 423 ppkm² ⁷³. The average temperature is about 27°C. Rainfall is bimodal with a mean annual range between 1300mm and 2500mm. The dry season is associated with Northeast trade wind emanating from the Sahara Desert while the wet season is associated with Southwest monsoon wind from the Atlantic Ocean. Like the rest of West Africa, mesoscale climate processes predominate and account for over 75% of

total rainfall received⁷⁴. These States are occupied mainly by Yoruba and Egun people who have customary rights to land resources and are primarily sedentary arable crop growers and small business entrepreneurs. The Forest Reserves (Akure, Ologe, Gambari and Okoiro) is presented in Figure 1.1.

Akure (Akure Forest Reserve), lies in tropical rainforest, with Coordinates between longitude 5°06"E to 5°38"E and between latitude 7°07"N to 7°37"N Climate Normal (CN): average annual rainfall of 1546mm and average annual temperature of 25.9°C. Humidity is 77%.

Badagry (Ologe Forest Reserve), lies in mangrove swamp forest, latitude is 6° 35'48" N and longitude 3°20'35" E., average annual rainfall of 1595mm, annual average temperature of 26.8°C and humidity of 80%.

Ibadan (Gambari Forest Reserve), lies in tropical rainforest, Latitude 7° 02' 49" and 7° 43' 21" N longitude 3° 31' 58" and 4° 08' 20" E, average annual rainfall of 1311mm, average annual temperature of 26.5°C and humidity of 74.6%

Ogbomosho (Okoiro forest Reserve), lies in Guinea Savannah, Coordinate of latitude 8°10'1" N and longitude 4°10'1" E, average annual rainfall of 1217mm, and average annual temperature of 26.1°C.

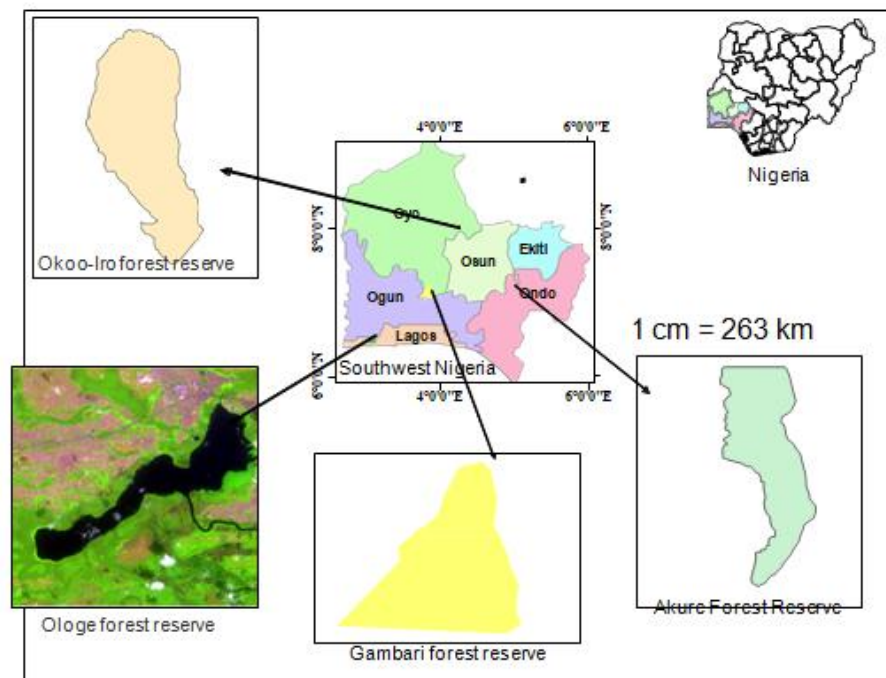


Figure 1.1: Selected Forest Reserves in the Study Area

Source:⁷⁵.

1.11 Climate and Vegetation of the Study Area

1.11.1. Climate Types Found in Southwest Nigeria

There is evidence that Southwest Nigeria is already experiencing environmental challenges attributed to Climate Change (CC) and its impacts. The tropical monsoon climate, assigned by the Köppen climate classification as "Am" is located in the southern part of the country. Monsoon from the South Atlantic Ocean influence climate which is a source of Maritime Tropical (MT) air mass in southwest Nigeria. This is a warm moist sea to the land's seasonal wind. Its warmth and high humidity give it a strong tendency to ascend and produce copious rainfall, which is a result of the condensation of water vapor in the rapidly rising air⁷⁶. Due to its location, the tropical monsoon climate has a very small temperature range. There are constant temperature ranges almost throughout the year, for example, a city like Lagos in the southwest part of Nigeria records a maximum of 28.5°C for its hottest month while its

lowest temperature is 25 °C in its coldest month. The temperature range of Lagos City is not more than 3.5°C⁷¹. There is the domination of seasonal migration of the Intertropical Convergence Zone which results in annual rainfall variability in southwest Nigeria. This induces a strong periodic cycle of precipitation⁷⁷. The southern part of southwest Nigeria experiences heavy and abundant rainfall. The region is located within the tropical region; hence, the storm is usually convectional. The annual rainfall received in this region is very high, usually above the 2,000 mm rainfall totals for tropical rainforest climates worldwide. The passage of the Inter-Tropical Convergence Zone (ITCZ) is associated with two rainy seasons⁷⁸. There is variation in rainfall on the annual scale over Southwest Nigeria, in terms of magnitude as well as time with short rain displaying stronger variability than long rains. Interannual variability is generally attributed to annual-to-decadal oscillations known as Sea Surface Temperature (SST) that influence the large-scale continental climate. The standard climate in the Southern region of Nigeria experiences a double rainfall maximum characterized by two high rainfall peaks, that is, June and September, with a short dry season and a longer dry season falling between and after each peak. The first rainy season begins around March and lasts to the end of July with a peak in June, this rainy season is followed by a short dry break in August known as the August break which is a short dry season lasting for two to three weeks in August. This break is altered by the short rainy season starting around early September and lasting to mid-October with a peak period at the end of September. The ending of the short rainy season in October is followed by the long dry season. This period starts in late October and lasts until early March with peak dry conditions between early December and late February⁷⁹.

1.11.2. Vegetation Zones of Southwest Nigeria

The ecological zones in Southwest Nigeria are based on National Forest Reference Emission Level (FREL) classification, as shown in figure 1.2, and are defined as follows: Mangrove Swamp and Coastal Vegetation, Freshwater Swamp Forest, Lowland Rain Forest and Derived Savanna. The ecosystems are strongly determined by the distinct regional topography, their tropical latitude, and proximity to South Atlantic Ocean⁸¹. Also, the vegetation zones and vegetation density as shown in figure 1.3. (Freshwater swamp/mangroves, Rainforest and derived savanna) follows the precipitation trend and other environmental factors in southwest Nigeria.

Ecological Zone of Southwest Nigeria

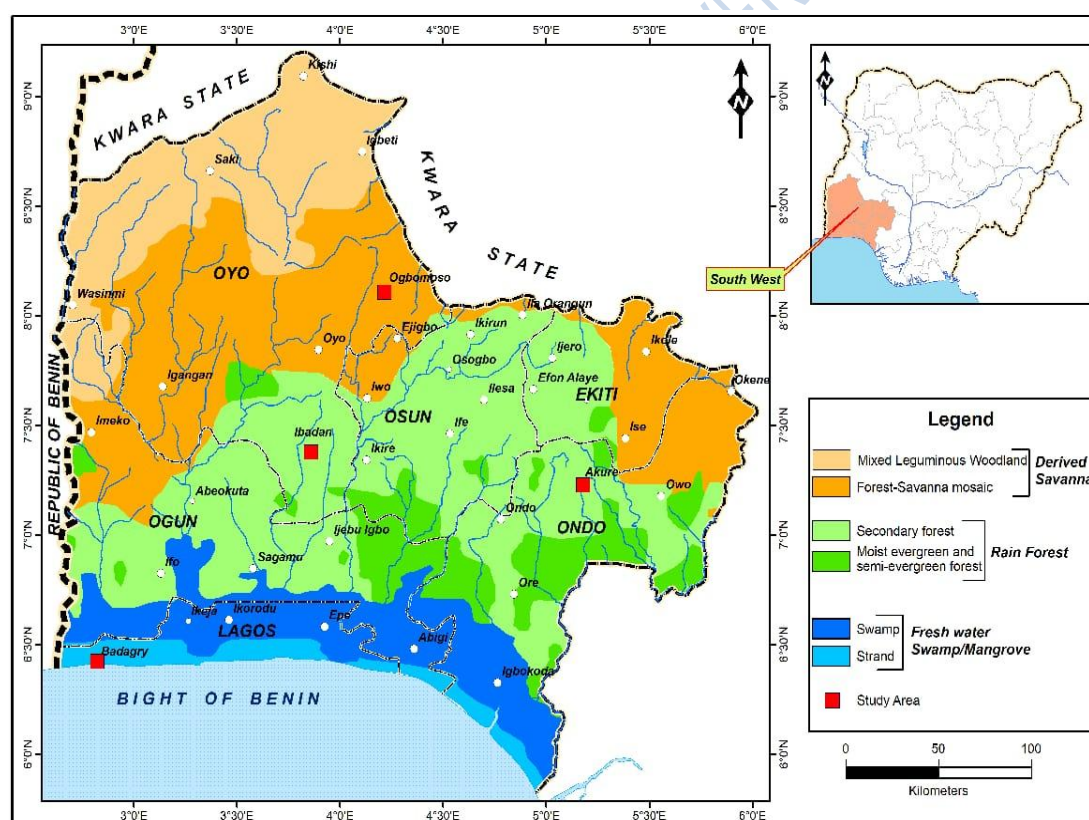


Figure 1.2 Vegetational Zones of the Study Area

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Chapter Two

Literature Review

2.1 Climate and Climate Change

Climate, a paradigm of a complex system, comprises the atmosphere, the hydrosphere, the cryosphere, the lithosphere, the biosphere, and the interactions among these compartments¹. Climate is commonly defined as the weather averaged over a long period. The standard averaging period is 30 years, other periods can as well be used depending on the purpose. Climate also includes statistics other than the average, such as the magnitudes of the day-to-day or year-to-year variations². The climate in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period ranging from months to thousands or millions of years².

There is a term "climatological normal". The World Meteorological Organization (WMO) describes climatological normal as a line used by the Climatologists to relate current climate trends to that of the past (Normal) so as to predict for the future. Scientists traditionally define it as an average over a recent 30- year period. Climate normal is used for two principal purposes; they serve as a standard against which recent or current observations can be judged, including providing a basis for many anomaly-based climate datasets such as global mean temperatures, regional mean temperature, etc. It is also an assured measure of climate prediction. As such, they are also widely used, implicitly or explicitly, as a prediction of the conditions most likely to be experienced in a given location³. A technical commission for climatology was set up by International Meteorological Organization (IMO) in 1929. At its 1934 Wiesbaden meeting, the technical commission designated the thirty years from 1901 to 1930 as the reference time frame for climatologically standard normal, in 1982 the

WMO agreed to update climate normal, and these were subsequently completed based on climate data from 1st January 1961 to 31st December 1990 and 1981 to 2010. The current climatologically standard normal period is 1991 – 2020. Any deflection from climatological normal is referred to as climate change with the resultant effect as global warming³.

2.1.1 Temperature Changes

There is no gainsaying in the fact that the earth is warming. Detailed observations of surface temperature assembled and analyzed by several different research groups showed that the planet's average surface temperature was 1.4°F (0.8°C) warmer during the first decade of the 21st century than during the first decade of the 20th century, with the most pronounced warming over the past three decades^{4,5}. The evidence of this increase in temperature is corroborated by a variety of independent observations that indicated warming in other parts of the earth system, including the cryosphere (the frozen portions of the earth's surface), the lower atmosphere, and the oceans⁶.

Natural climate variability leads to year-to-year and decade-to-decade increase in temperature and fluctuations of other climate variables, as well as substantial regional and continental differences, despite this, it cannot explain or offset the long-term warming trend⁷. The relationship of Global warming in terms of a broad spectrum of changes and some climatic parameters such as increases in the frequency of intense rainfall, decreases in Northern Hemisphere snow cover and Arctic Sea ice, warmer and more frequent hot days and nights, rising sea levels, and widespread ocean acidification are significant and inseparable⁷. Global temperatures in 2018 were 0.83°C warmer than the 1951 to 1980 mean. Globally, 2018's temperatures rank behind those of 2016, 2017, and 2015. These five years are, collectively, the warmest

years in the modern record⁸. The earth experienced its third consecutive hottest year in 2016, since record-keeping began⁸. It was concluded that global temperature continued to rise rapidly in the past decades, despite large year-to-year fluctuations associated with the El Niño-La Niña cycle (warm and cool) of tropical ocean temperature^{9,10}. Manifestation of this can be seen in the atmospheric CO₂ concentrations of the past which can be calculated very precisely from tiny bubbles enclosed in ice cores. Glacial cycles present in the CO₂ concentrations always signifies glacial cycles. The partial pressure of CO₂ lies within the range of 180 and 280 ppm in the past 400,000 years ago. The world's largest producer of CO₂ is United States with the emission of CO₂ to be 2000 in absolute¹¹.

2.1.2 Human-Induced Climate Change

Human-induced climate change and its impacts will continue for many decades, and in some cases for many centuries. There is the resultant risks effect of human activities caused individually, collectively, and in combination for a wide range of human and environmental systems, including freshwater resources, the coastal environment, ecosystems, agriculture, fisheries, human health, and national security, among others¹².

The global land surface has been warming since the Industrial revolution. Global warming increases the water holding capacity of the atmosphere, and this call forth variability in hydrological cycle accordingly¹³. In the tropical and subtropical parts of the continent, the reliance on precipitation as the water source for agricultural production is very prominent. Precipitation characteristics such as amount, frequency, intensity, are of great concern and essential to agricultural development^{14,15}. Excess (flood) or shortage (drought) precipitation is hazardous or even wreaking to crops^{16,17}.

The earth's atmosphere stands as a natural greenhouse effect that sustains the earth's surface warmer than it would have been otherwise. Life exists as an integral part of the earth's system and all living things influence the composition of greenhouse gases in the atmosphere by "inhaling" oxygen and "exhaling" carbon dioxide, thereby maintaining atmospheric chemical balance. Quite numbers of human activities, which include majorly the burning of fossil fuels, industrial activities, cattle grazing and the cutting down of forest for agricultural purposes and urbanization, are contributing substantially to the concentrations of greenhouse gases in the atmosphere, thereby disturbing this atmospheric chemical balance¹⁸.

There is broad agreement in the scientific community that this warming has been largely driven by increases in atmospheric greenhouse gases (GHGs), particularly carbon dioxide (CO₂), Methane (CH₄), and nitrous oxide (N₂O). Emissions of GHGs are often measured in the equivalent units of carbon dioxide emission, or CO_{2eq}, by indexing 100 – year global warming potentials of each gas to that of CO₂ ("CO_{2e},). In other words, other greenhouse gases are converted to carbon dioxide equivalent to justify their role on the green house " It is clear that the roles of humanity as changing the climate continues to mount, and its consequences are increasingly difficult to be unnoticed. Atmospheric carbon dioxide concentrations now top 408 parts per million (ppm), a threshold the planet hasn't seen in millions of years. Greenhouse gas emissions reached a record in 2018^{19,20}.

A significant amount of greenhouse gases has been added into the atmosphere, largely by burning fossil fuels to generate electricity, heat and cool buildings, and power vehicles, as well as by clearing forests at the beginning of the Industrial Revolution in the 1700s²¹. When these gases are emitted into the atmosphere, many remain there for long periods, ranging from a decade to thousands of years. Past activities of natural

and human emissions affect our atmosphere in the present day; current and future of such emissions will continue to increase the levels of these gases in our atmosphere for the predictable future²². “Greenhouse gases” got their name because they trap heat (energy) like a greenhouse in the lower part of the atmosphere. They are like blanket spread abroad the atmosphere. As more of these gases continue to be added to the atmosphere, more heat is being trapped. This extra heat leads to higher air temperatures near the earth’s surface as counter radiation, alters weather patterns, and raises the temperature of the oceans ²³. The greenhouse gases block the atmospheric window through which the infrared rays can pass.

The climate varies on multiple timescales, but now humans are the main agents of change and are likely to remain so for the next few centuries. It is generally understood that human-induced climate change causes global warming, but it has been very difficult to attribute the cause to climatic hazards such as heavy rainfalls, droughts, and storms, which are very devastating to society and the environment. Although the climate change effects are modest, perhaps five to fifteen percent of normal (World Meteorological Organizational Standard) for these events (rainfall, drought, and storm), if this modest is exceeded, in terms of normal requirements, it will turn to anomalies and damage increases non-linearly²⁴. In other words, it can still be bearable if the observed climate data exceeded 5-15% above normal, more than this range will turn to extreme, causing damages to humans and the environment.

2.1.3 Global Warming Caused by Anthropogenic Activities

Anthropogenic activities have been observed to be responsible to have approximately 1.0°C of global warming above pre-industrial levels, with a likely range of 0.8°C to 1.2°C. It is most likely that Global warming will attain 1.5°C between 2030 and 2052 if it continues to increase at the current rate. It has been projected by Regional

Circulation Model (RCM) that the mean annual temperature will increase by 1.4°C by 2030, 2.8°C by 2060, and 4.7°C by 2090²⁵.

As noticed, since pre-industrial times from long-term warming trend, observed Global mean Surface Temperature (GMT) for the decade 2006–2015 was 0.87°C (likely between 0.75°C and 0.99°C) higher than the average over the 1850–1900 period²⁶.

Estimated anthropogenic global warming is similar to the level of the observed warming to within $\pm 20\%$. Computed anthropogenic global warming is currently increasing at 0.2°C (likely between 0.1°C and 0.3°C) per decade as a result of past and ongoing emissions. Warming greater than the global annual average is being experienced in many land regions and seasons, including two to three times higher in the Arctic²⁶.

Warming is generally higher over land than over the ocean. Trends in intensity and frequency of some climate and weather extremes have been discovered over time past during which about 0.5°C of global warming occurred. This assessment is based on several parameters of evidence, including attribution studies for changes in extremes since 1950. Warming from anthropogenic emissions from the pre-industrial period to the present will reverberate for centuries to millennia and will continue to cause further long-term changes in the climate system, such as sea-level rise, with associated impacts, but these emissions alone are unlikely to cause global warming of 1.5°C²⁷. The situation can be worsened, if no step is taken, there is going to be persistent rise in temperature to the extent that it will be too hard to cope with. This problem will press hard on countries that so much rely on climate-sensitive resources for their sustenance of livelihood and overall development.

2.1.4 Impacts of Global Warming on Natural and Human Systems

Impacts on natural and human systems from global warming have already been observed. Many terrestrial and ocean ecosystems, alongside the services they provide have already changed due to global warming ²⁸. There have been differential impacts among different regions and different demographic groups or individual. Among all the sectors of the country, region, and communities, agriculture is the most vulnerable to climate change²⁹.

There is still some disagreement on the contribution of anthropogenic GHG emissions to temperature increases. Impacts of climate change on ecosystems, hydrological and terrestrial biological systems are gaining ground, especially in the last three decades²⁷. However, the last report of the intergovernmental panel on climate change has on the most recent, research in this area, credited most of the observed increase in global average temperature since the mid-twentieth century to anthropogenic causes with a probability of more than 90%³⁰.

2.1.5 Impact of Rainfall Variability on Livelihoods

Altered frequencies and intensities of extreme rainfall are found to have effect in soil erosion/landslides, land flooding, transportation systems, and infrastructures. Changes in rainfall variability also affect agriculture, forestry and ecosystems, hydrology and water resources, human health, tourism, and energy supplies. Variability in drought patterns affect water availability, livelihoods, energy generation and demand, and population migration^{31,32}.

Present land and/or water management practices at many places on earth seemingly very unlikely to be enough to reduce the negative impacts of climate change. Emphasis on integration of current climate variability into land and water-related management is likely to help adaptation to future climate change easier. Rainfall has much larger spatial and temporal variability than temperature, as such, it is more

difficult to identify the impact it has on changes in many systems. Erosion by water has been considered as the most serious soil degradation problem in humid tropical (Southwest Nigeria) and subtropical ³³. The spatial and temporal distribution of rainfall over the world's land surfaces is one of the most important single variables in the distinct system studied in meteorology, climatology, hydrology, land surface biology and ecology, agronomy, and many other scientific disciplines. Owing to the extreme transience and spatial inhomogeneity of rain events, which is highly determined by wind systems, relative to other climate variables, rainfall is also one of the most difficult variables to accurately monitor on the scales required by those studying land surface processes³⁴.

Rainfall total and intensity is a function of the degree of flood expected. The accumulated rainfall that can cause a flood disaster usually lasts for more than one day, and the rainfall intensity might be very strong. However, there are several criteria to define the occurrence of flood disaster caused by Heavy Rainfall Process (HRP): these are: heavy rainfall must last for some time; there should be a certain level of rainfall intensity in the process; accumulation of HRP should meet the following criteria: HRP starting with daily precipitation $\geq 0.1\text{mm}$ and ending with daily precipitation $< 0.1\text{mm}$; during HRP at least one day, there should be heavy rain (daily precipitation $\geq 25\text{mm}$)³³.

Climate change is predicted to impact the variability and seasonality of temperature and humidity, thereby involving the hydrologic cycle. Eleven of the last twelve years between (1995 and 2006) rank among the 12 warmest years in the global instrumental record of surface temperature since 1850³⁵. Improvements and extensions of numerous datasets and more sophisticated data analyses across the globe has enabled the realization of the importance of past and present climate change. Changes in

global extreme rainfall and temperatures have been well known over the last 50 years, the rate of which is almost double that over the last 100 years³⁶.

Havocs worsened by climate change have claimed hundreds of lives, destroyed thousands of homes, and cost billions of naira.³⁷ The severity and uncertainty related to projected impacts of climate change have compelled the global community to include 'Climate Action' as one of the 17 Sustainable Development Goals (SDGs) declared by the United Nations (no poverty; zero hunger; good health and well-being; quality education; gender equality; clean water and sanitation; affordable and clean energy; decent work and economic growth; industry, innovation and infrastructure; reduced inequality; sustainable Cities and Communities; responsible consumption and production; etc.). Climate change is disrupting national economies, affecting lives, costing people, communities and countries³⁸.

Terrestrial ecosystems are sensitive to fluctuations in climatic conditions, which are primarily measured as interannual variability in precipitation and temperature regimes³⁹. As there is inter-annual variability in climate parameters, so there is commensurate interannual variability in vegetation. Climate-driven interannual vegetation changes affect ecosystem services such as carbon sequestration in soil and biomass, water cycle regulation, and rain-fed crop production^{39,40,41}. In sub-Saharan Africa (SSA), climate change projections manifest a warming trend with changes in precipitation patterns ⁴².

Human activities also contribute to vegetation reduction. The major contributor to deforestation in the world is agriculture which accounts for 73%. while other major drivers including timber extraction and logging, fuelwood collection and charcoal production, uncontrolled fire, and livestock grazing account for the balance^{43,44}. African countries are highly rated as continental deforestation (about 2.8% compared

to the global average of 0.13%) and local small-scale activities including fuelwood collection and charcoal constitute the major forest degradation drivers⁴⁴.

Nigeria has the world's highest deforestation rate of about 5%. Nigeria is one of those few countries that recorded “a net loss in both forest and agriculture area” from 2010 to 2015⁴⁵.

At continental, regional and ocean basin scales, numerous long-term changes including widespread changes in rainfall amounts, wind patterns, and aspects of extreme weather such as droughts, heavy rainfall (flood), heat waves and the intensity of tropical cyclones have also been observed. Annual river runoff and water availability are a function of changes in rainfall. Areas in which runoff is reducing are likely to face a reduction in the value of the services provided by water resources⁴⁶. That is, increased rainfall variability and seasonal runoff shifts may also have negative impacts on water supply, water quality and flood risks due to climate change. Although rainfall has increased in many areas of the globe, the areas undergoing drought have also increased. Drought duration and intensity has also increased. More severe droughts have been observed over wider areas since the 1970s, particularly in the tropics and subtropics, and much of Africa ⁴⁷.

Southwest Nigeria is one of the most vulnerable regions to the effect of climate change and variability, due to its low technical-knowhow, owing to its high exposure and low adaptive capacity⁴⁸. This is aggravated by multiple stress factors that are non-climatic, such as high acute poverty levels, population pressures and overpopulation. Changing climate patterns cause biodiversity loss, as forest plants species become extinct, leading to further ecological destabilization and an alteration of community livelihoods in the affected areas⁴⁹. It is been widely projected that as global warming persists, climatic conditions will become more unpredictable and deplorable.. The

uncertainty surrounding climate change is complicated with the unpredictable surrounding the appropriateness and the likelihood of any success to acclimation of any region or community⁵⁰.

Higher temperature occurrence and decreased land rainfall contribute to changes in drought. The frequency of heavy rainfall events has also increased over most land areas and particularly since about 1950, even in those regions where there has been reduction in total rainfall amount, which is consistent with warming and observed increase in atmospheric water vapor. Increases have also been reported for rarer rainfall events (1 in 50-year return period), augmenting flood risk, the very heavy rainfall event ⁵¹.

Empirical studies have demonstrated greening and browning responses of ecosystem photosynthetic activity due to increased interannual climate variability based on sub-continental scale. Interannual vegetation response is spatially heterogeneous due to variations in mesoscale climate, mean annual precipitation and topographic factors^{52,53,54}. Knowledge of these interactions is key to making spatial projections of the impacts of climate change on natural and managed ecosystems, delineating vulnerable areas, and implementing adaptation and mitigation measures⁵⁵. To date, regional assessments of ecosystem response to climate variability faced unresolved challenges in terms of data consistency, time series analysis techniques, and statistical modeling approaches⁵⁶. It has been estimated that the composition of one-third of the world's forests could be altered due to climate change⁵⁷.

Many studies have also predicted a regional shift of species and forests and cause changes in biomes due to change in climate variables^{58,59,60}. Moreover, tropical forests are more vulnerable to climate change and therefore threaten their structure, function and services⁶¹.

2.1.7 Importance of Rainfall in Southwest Nigeria

Rainfall is very crucial for the economic development of Southwest Nigeria and larger percentage of the people are involved in rain fed agriculture (crop and plantation). As a state whose economy is heavily dependent on productive rain fed agriculture, rainfall trends are often cited as one of the causes of socio-economic problems such as food insecurity. The changing climatic conditions have been attributable to rainfall studies and have also shown that the climate is changing based on the changing pattern of rainfall⁶².

Crops and animals derive their water resource largely from rainfall. It is considered as the main determinant of the type of crops that can be grown in the area and also the period of cultivation of such crops and the farming system that can be practiced ⁶³.

Southwest Nigeria is a region that is well positioned within the tropic where the effect of sunlight is much felt throughout the year, unlike precipitation that is being determined by southwest monsoon wind from the Atlantic Ocean.

Southwest Nigeria climate has consistently been fluctuating, as it revealed by accelerating temperature; variable rainfall; rise in sea level and flooding; drought and desertification; land degradation; more frequent extreme weather events; affected fresh water resources and declining biodiversity⁶⁴.

The durations and intensities of rainfall have increased, producing large runoffs and flooding in many places.⁶⁵ Rainfall variation is projected to continue to increase. Precipitation in southern areas is expected to rise and rising sea levels are expected to exacerbate flooding and submersion of coastal lands⁶⁶. Temperature has soar up significantly since 1980s, report had it that 2021 was the warmest year on earth since 1850, and as such 2015, 2018 and 2021 are essentially tied as the fifth, sixth and seventh warmest years respectively⁶⁷. Climate projections for the coming decades

revealed a significant increase in temperature over all the ecological zones in Nigeria⁶⁸. In southwest, the great pressure on forest is on increasing population and greater demand for forest resources apart from climate change ⁶⁹. Over the years, people have lived within and around the forests. In Nigeria, in general and southwest in particular, human settlements, especially, rural households strongly depend on forest and forestland for survival. In Southwest Nigeria, there is unhealthy competition in forest exploitation and drives deforestation and forest degradation⁷⁰. Based on these uncertainties of human interventions on vegetation with uncontrollable demands for improved livelihood that arose as a result of population increase coupled with changing climate and variability that the research on the "Climate Change, Vegetation Cover and livelihoods activities of the forest Communities of South west Nigeria" is necessitated. This is in response to SDG of the United Nation "Climate Action and No Poverty"⁷¹. Studying this will enable the forested communities to strategize ways of adapting to dynamic environment now and in future.

This study will benefit government and non-governmental organization in the following areas:

a. Agriculture and Food Production: The study will help the farmers to plan their planting seasons so as to know what crops to plant and at what particular months of the year to forestall the flooding and drought events. It affords farmers a good knowledge of the weather system and plan ahead for the drier months which usually occur between November and January.

b. Food Security: It will forestall food insecurity and prevent crop failure which can arise as a result of drought and flash flood. Climate has always been the determinant of agricultural process⁷². Rise in temperature and carbon dioxide (CO₂) can increase some crop yields in some places that have not received their required optimum heat

crop level. But to realize these benefits, nutrient levels, soil moisture, water availability, and other conditions must also be met. Changes in the frequency and severity of droughts and floods could pose challenges for farmers and ranchers and threaten food safety. Meanwhile, warmer water temperatures are likely to cause the habitat horizons of many fish and shellfish species to shift, which could disrupt ecosystems. Overall, climate change could make it more difficult to grow crops and raise animals in the same ways and same places as we have done in the past. The effects of climate change also need to be considered along with other evolving factors that affect agricultural production, such as changes in farming practices and technology⁷³.

2.2 Conceptual Review

2.2.1 Concept of Climate Change

A statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer)⁷⁴. Climate change is a long-term continuous change (increase or decrease) in **average** weather conditions such as average temperature or the **range** of weather, that is, more frequent and severe extreme storms. Both can also happen simultaneously in long-term means at least many decades. Climate change is slow and gradual, and unlike year-to-year variability, is very difficult to perceive without scientific records. Scientists detect climate change looking for long-term continuous changes (trends) in climatological averages and normal and the variation around these averages⁷⁵. Milankovitch cycles hypothesis describe the cumulative effect of change that movement of earth on its climate over thousands of years⁷⁶.

Three main factors affect the amount of incident of solar radiation on the earth's surface. These are: the eccentricity of the earth's orbit around the sun; the precession

of the earth's rotation axis; and the tilting of the earth's rotation axis. These are the astronomical factors that have significant effect on earth's climatic patterns. This depends on the position of places to the sun which will determine the kind of climate prevailing with time⁷⁷.

These act as the fundamental formation of a long-term climate change on the earth, that represent the periods of ice age and warm period (glacial and interglacial periods). The planet spends less time near the sun because of the elliptical shape of the earth's orbit around the sun in one year especially during the winter season, this result in the earth getting abnormal little solar radiation which causes planet to cool in general.

Milankovitch (the shape of Earth's orbit, known as eccentricity), can't explain all climate change that's occurred over 2.5million years. Milankovitch cycles describe the collective effects of changes in the earth's movements on its climate over thousands of years. There is no record for the current periods of rapid warming earth has experienced since the pre-industrial period (1850-1900). It has been argued by scientists that human activities are responsible for major climate change, specifically, the direct input of carbon dioxide into the atmosphere from burning of fossil fuels⁷⁸.

Milankovitch cycles cannot be blamed in that it covers hundreds of thousands of years while the earth current warming has taken place over time of scales of decades to centuries. Milankovitch only consider just one factor that may contribute to climate change both past and present whereas atmospheric carbon dioxide played a major responsibility in driving the degree of temperature fluctuations over the last several million years.

2.2.2 Climate Variability

Climate varies over long time such as seasons and years instead of day-to-day like weather. Some summers are colder than others depending on the position to the sun.

Some years have more overall precipitation depending on the wind system and intercontinental convergence zone positioning. Even though people have fair perceptive of climate variability, it is not as noticeable as weather variability because it happens over seasons and years. Evidence includes statements like: “the last few winters have seemed so short,” or “there seem to be more heavy downpours in recent years.”⁷⁹.

Scientists think of climate variability as the way climate fluctuates yearly above or below a long-term average value, that is climate normal. You can think of it as a story with two parts: average and range.⁸⁰ These parts complement each other; understanding the range gives context to the average and Climate trend is the term used when the change is discernable whether upward or downward in the values of the climatic element concerned. When these variations become periodical or cyclical it becomes a climatic cycle. When variations occur in such a manner that a new state or average conditions in the climatic elements exist, then a climate change has taken place⁸¹.

Climatic variations or fluctuations are rather the general nomenclature for shifts in the values of these climatic elements. While variations or fluctuations occur in a short-term period such as diurnal, monthly, annually, trends in climatic cycle or change are detected only over longer periods of time⁸².

Minor fluctuations or variations in climate does not normally have great impact but a noise which can be easily adapted to by humans. However, when the departure of climatic phenomena is so significant and so prolong to the extent of culminating a new state of climate, then there will be problem of adjustment, thereby the environment, man and his activities become vulnerable⁸³.

The speedy rate in variations or change in climate also stress the vulnerability of man, his socio-economic activities and the ecosystems in general to change. Averages and ranges of climate parameters are used to make important societal decisions; for example, climatology normal of precipitation and historical records of storm events are used to calculate probabilities of future rain events. This information is useful to Engineers by using the data to design community storm water drainage systems. These data also serve as a baseline against which to compare current weather and climate data. Without a baseline there is no way to understand how current observations fit into the bigger picture. Climate Normal are three-decade averages including temperature and precipitation. This product is produced once every 10 years⁸⁴.

2.2.3 Climate Change Adaptation

Adaptation is the process through which societies avail themselves better able to cope with an uncertain future. Societies always find ways of reducing the negative effect brought by climate change by making the appropriate adjustments and changes. There are many options and opportunities to adaptation⁸⁵. These ranges from technological options such as increased sea defenses or flood-proof houses on silts, to behavior change at the individual level, such as reducing water use in times of drought and using insecticide-sprayed mosquito nets. Other forms of adjustments include, taking to early warning systems for extreme events, better water management, and improved risk management, various insurance options and biodiversity conservation. An adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, which moderates harm or exploits beneficial opportunities⁸⁶.

The effect of climate change in different communities /region /countries/ continents are always unsimilar, long-term are not easily predictable, due to latitudinal

positioning. This is because adapting to these three traits is difficult because they require making context-specific and forward-looking decisions in terms of a different climate impacts and vulnerabilities when the future is uncertain. Planners must put at the back of their mind that climate change adds an additional source of unknowns for decision makers to manage, hence, they must accept “uncertainty as inherent to the climate change problem⁸⁷.

Adaptation Coalition Framework, has goals that need to be pursued because of the uncertainty nature of climate change. There should be an integration of four perspectives: Firstly, it has to be locally driven and across sectors with the input of non-local knowledge and resources, because, climate change impacts are highly diverse and context-specific which is very essential for planning, secondly, these impacts often represent long-term changes, so institutions must adapt with an eye towards the same time scale, thirdly, climate change impacts are difficult to predict by nature and a framework must be developed with the appropriate flexibility to evolve, and, fourthly, adaptation must go beyond being reactive to climate impacts to focusing on precautionary measures and concentrating on the underlying drivers of vulnerability^{88,89}.

2.2.4 Concept of Climate and Ecosystem Sensitivity

The concept of **climate sensitivity** technically only applies to equilibrium climate states. This refers to the total warming at the end when there is full adjustment of climate systems- oceans, cryosphere, and biosphere, to the imposed forcing. In reality, there is dynamism in the strength of climate forcing and feedbacks. They are continuously varying, and it takes the climate system, especially the oceans, a long time to warm up in response to a positive climate forcing⁹⁰. In addition, climate feedbacks are not always included in many estimates of climate sensitivity that is

associated with processes that operate on decadal to centennial time scales, such as the disappearance of glaciers, changes in vegetation distribution, or changes to the carbon cycle on land and in the oceans; several recent studies that consider some of these processes have suggested that earth's climate sensitivity may be substantially higher than the aforementioned "best estimate"⁹¹. Nevertheless, estimates of climate sensitivity are a useful basis for justifying and evaluating the causes of observed climate change and estimating how much the earth will ultimately warm in response to past, present, and future human activities. Forests of different climatic zones, different types, different regions and different succession stages react to climate change divergently due to their dissimilar sensitivities and resilience to disturbance^{92,93,94}.

Ecosystem sensitivity to climate variability varies across southwest Nigeria and identifying the determinant factors of this sensitivity is very crucial to assessing region-wide vulnerability to climate change and variability. **Sensitivity** is the degree to which a system will respond to a given change in climate, including only harmful effects⁹⁵.

2.2.5 Climate Change and Vegetation Cover

Changes in the world climate can be responsible to changes in terrestrial ecosystems, which are primarily measured as interannual variability in precipitation and temperature regimes^{96,97}. Shifting environmental factors are major reasons for vegetation change over time, and these include climatic factors such as wind, temperature, rainfall etc. and hydrologic regime of the soil, the effect of substrate erosion etc. Ecosystem services such as carbon sequestration in soil and biomass are affected by climate-driven interannual vegetation changes, water cycle regulation and rain-fed crop production^{98,99,100,101}. Studies have shown that, increased interannual

climate variability has resulted into greening and browning responses of ecosystem photosynthetic activities^{102, 103..}

Viewed on a regional and local scale, interannual vegetation response are of different effect which are characteristically spatial heterogeneous due to variations in mesoscale climate, mean annual precipitation and topographic factors ^{104,105,106.} Taking cognizance of these interactions is a guide to making spatial projections of the impacts of climate change on natural and managed ecosystems, delineating vulnerable areas, and implementing adaptation and mitigation measures^{107.} The present arrangement of natural resource governance in Southwest Nigeria encourages unhealthy competition in forest exploitation and drives deforestation and forest degradation^{108.}

2.2.6 Concept of Deforestation

The process whereby vegetation is being cut down without any simultaneous replanting for economic or social reasons is called deforestation. Direct, human-induced conversion of forested land to bare land or non-forest land-uses including agricultural land, pasture/rangelands, perennial plants plantation, settlement, road construction and urban lands, resulting in open breakup of the cover and/or reduction in crown cover from what we can call forest^{109.} The implication of deforestation is disadvantageous on the environment in terms of wildlife denial of habitation, increased desertification, biodiversity, among many other reasons. It is the accelerating removal or thinning of forests by humans. Deforestation is one of the biggest problems in global land use. Area of forest cleared for human use, which include removal of the trees for wood products and for crop lands and grazing lands are the basis for estimating deforestation. In the practice of clear-cutting, all the trees

are removed from the land, which completely destroys the forest. There are also partial logging and accidental fires that thin out the trees enough to change the forest structure dramatically¹¹⁰. As a result of technology development and expansion in human beings, more food, materials, and shelter are being manufactured at a great rate, mostly gotten from forestry. An estimated 18 million acres of trees are clear-cut each year for new development and wood products satisfaction; that is just under half of all the trees on the planet since the industrial revolution began. With trees noted for large production of oxygen, clearly that it is disadvantageous for humans- and especially not good enough for the animals that call the forest home¹¹¹.

Deforestation has been a major threat to human survival and also render homeless millions of different tree species that lives in the forest which is a big conservation issue to the universe. Such human activities need to stop for sustainability¹¹². Recently, there was high competition on the purchase of large mass of land by the land merchants to resell to interested individuals for shelter and not for any other purpose. The land was deforested without the intention to replant. This practice is fostering the poverty level of the rural communities and denials of other benefits that could have been accrued from the forest aside the cause of environmental hazards with its chains of negative feedbacks.

Nigeria is one of those few countries that recorded “a net loss in both forest and agriculture area” from 2010 to 2015¹¹³. Thus, Nigeria's high deforestation rate, apart from conversion of forest to agriculture, may not be unconnected to the prevailing natural resource governance regime that is substantially skewed in favor of managing natural resources as common pool resources with little exclusivity¹¹³.

2.2.7 Climate Change and Livelihoods.

Livelihoods can be thought of as the way people make a living. A person's livelihood refers to their means of meeting up basic necessities of life including food, water, medicine, shelter and clothing. It presents the inter-relationship of the main factors that affects people's livelihoods¹¹⁴. Livelihoods contribute to human well-being, which includes tangibles as assets and goods for consumption. A livelihood comprises capabilities, assets (both material and social resources) and activities required for a means of living. Sustainability of livelihood is determined by when it can cope with and recover from shocks and stresses, and maintain or enhance its capabilities and assets, both now and in the future, while not undermining the natural resource base ¹⁰⁹. Livelihoods are affected by climate change, in the sense that environmental problem such as variability in the onset and cessation of rainfall, amount of rainfall, ground water depletion, increase in concentration of greenhouse gases, depletion of pollinators habitat, soil degradation, which all have negative consequences on sustainable livelihood, are induced by climate change. The adverse effects of these tell hard on forest communities because of their vulnerability due to low income earning as they depend solely on the ecosystem for their income, food, nutritional security, and livelihoods. Hence, rainforest agroecosystems are experiencing a decline in agricultural production outputs.¹¹⁵. This has opened the rural communities to little or no resources to adapt or mitigate its effect. Forest resources are being depleted due to deforestation, illegal grazing, urbanization, poverty and poor management. Consistence change in climate parameters affect the livelihood of forested communities and poses challenges to survival, food security, and economic development.¹¹⁶. Rise in temperature, increase in rainfall causing flood, drought, strong wind, and landslides have been a threat to both natural and human society

which have led to internal displacement of persons, destruction of lives and properties and livelihoods disease, food insecurity, violence as a result of struggle over limited resources and increase suffering and penury. The effect of these climate extremes is not equally distributed among and within the groups of people in the same communities which may be due to their differential demographic's characteristics such as, age, geographical location, gender, health status etc¹¹⁷.

The study of livelihood as a concept has its root traceable to disciplinary lines such as economics and development studies. The multiple definitions and conceptualizations of the concept have largely reflected these lines. Livelihoods can be thought of as the way people make a living. A livelihood comprises the capabilities, assets (stores, resources, claims and access) and activities required for a means of living: a livelihood is sustainable which can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation; and which contributes net benefits to other livelihoods at the local and global levels and in the long and short term."¹¹⁸.

A person's livelihood refers to their means of securing basic necessities of life including food, water, medicine, shelter and clothing. It presents the main factors that affects people's livelihoods, and typical relationship between these. Livelihoods contribute to human well-being, which includes tangibles as assets and goods for consumption. ¹¹⁹.

There is the concept of livelihood diversification which is defined as the process by which families construct a diverse portfolio and social support capabilities in order to survive and to improve their standard of living. The livelihoods of forest fringe communities in Southwest Nigeria depend, largely, on the renewable natural

resources that they can find in the forests and any activities that impacts on the integrity of the forest which disrupt the livelihood of the dependent communities.

Forest fragmentation and deforestation remains a central problem in the high forest zone of southwest Nigeria due, primarily, to both legal and illegal timber exploitation and arable crop farming. The consequence has been a dramatic change in climate and evolution of strategies to sustain rural livelihoods. In most African countries deforestation rates have increased over the past four decades, with significant effects on rainfall, temperature, water resources, wildfire frequency, agriculture and livelihoods¹²⁰.

2.2.8 Review of livelihood Approaches:

The review covers the approaches of DFID, Oxfam, CARE and UNDP. According to the livelihoods framework described by the UK Department for International Development (DFID); five types of capital support livelihoods: 1. Natural capital (such as lands, water, forests and fisheries); 2. Human capital (such as knowledge and skills); 3. Financial capital (such as income and opportunities); 4. Physical capital (such as infrastructures), and 5. Social capital (such as social networks).

The approaches to livelihoods depend on the emphasis and the scope of operations. All these approaches follow the definition of Chamber and Conway of livelihood.

2.2.8.1 CARE's Livelihood Approach

This approach major concern is on helping the poorest and most vulnerable. Those that easily feel the impact of climate change and variability. The emphasis is on three major phenomena: (1) The possession of human capabilities for instance, education, skills, health, psychological orientation (2) access to tangible and intangible assets and (3) the existence of economic activities. CARE belief that if such category can be accessible to these vital phenomena, it will make remarkable difference in rural

communities' livelihoods and their security will be well guaranteed. The scope of CARE's livelihoods approach encompasses both rural and urban contexts. The summary activities of CARE are in co-existence of promotion, protection and provision. Also, in order to achieve these, rural communities should be well equipped with Personal empowerment, social empowerment and service delivery. In view of this, for easy operation, CARE proffer phases that include the following steps. (1) Identify potential geographical areas using secondary data detecting where poverty is concentrated, (2) Identify vulnerable groups and the livelihood constraint that they face, (3) Gather analytical data noting the trends overtime and drivers to be monitored, and (4) Selecting the communities for programmed intervention as a good legacy to other communities to maximize multiplier effects ¹²¹.

a Livelihood Promotion: This focuses on saving and credit, crop diversification and marketing, reproductive health, institutional development, personal empowerment and community involvement service delivery activities. These are longer-term development.

b Livelihood Protection: this is security based. This includes, programs that focus on early warning systems, cash and food for work, seeds and tools, health education and flood protection.

c. Livelihood Provisioning: This involves provision of food, water, shelter and other essentials, that will take care of unforeseen contingencies.

2.2.8.2 DFID's Sustainable Livelihoods Approach

This approach aims to eliminate poverty in poorer Countries. This is achieved through sustainable livelihoods. The initiative came from the rural side of the organization with efforts to extend to urban livelihoods. Also, the process extending discussion of Sustainable Livelihoods (SL) ideas and how they fit with other existing procedures

such as Country programming systems. In line with CARE, DFID adopts a version of the concept that. "A livelihood comprises the capabilities, assets, and activities required for a means of living. Quality of livelihood to be sustainable is when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not affecting the natural resource base;¹²².

DFID modified livelihood definition by identifying many ways of applying livelihood approach. Six underlying principles to all approaches were proposed by DFID:

1. People-Centered- that is, working with the people in consonant with their characteristics (cultural, customs and costume) and their current livelihood strategies, social environment and ability to adapt.
2. Responsiveness and participatory- Poor people must be involved in livelihood priorities. Outsiders need processes that enable them to listen and respond to the poor.
3. Multi-level- Outsiders must recognize various level of poverty both at micro and macro. Micro level activity informs the development of policy and effective enabling environment, and macro level is about the structures and processes which support people to build upon their own strength.
4. Conducted in Partnership- Involvement should be both public and private sector.
5. Sustainable- In terms of economics, institutional, social and environmental. All these must be balanced to archive maximum level of Sustainable Livelihoods (SL).
6. Dynamic- Sustainability must be in line with livelihood changes.

DFID emphasized the importance of livelihoods of capital assets and classified it into 5 categories: natural, social, physical, human and financial. Also stresses on the impact of the development activities on the people. The activities that can contribute to poverty elimination according to higher organization level of DFID are: Enabling

action, inclusive action and focused action. What is missing out in DFID SL approach is the gender concerns that is under-emphasized in the SL Framework.¹²³

2.2.8.3 Oxfam Great Britain's (GB) Sustainable Livelihoods Approach.

This approach adopted a sustainable livelihoods approach in the early 1990s. The aim of this agency is to come up with a broad framework that could accommodate issues of environmental change together with concerns about globalizing markets, deteriorating economic rights, gender and wider social inequality, and the need to strengthen less privileged people's participation in the development process. Oxfam uses the SL approach in planning and assessment of projects and wider programs and incorporates it as part of its overall strategic aim. Oxfam SL approach is one solution fits all. The Agency considers SL language to be compatible with the idea and languages throughout its structure. Like other agencies, Oxfam also stresses that sustainability needs to be looked at from the angles of economic (the functioning of markets, credit supply); social (networks, gender equity); institutional (capacity building, access to services and technology, political freedom) ecological (quality and availability of environmental resources). The overall outcome expectations of Oxfam are that: 1. people living in poverty will achieve food and income security, and 2. people living in poverty will have access to secure paid employment, labor rights, and improved working conditions. Also, other corporate aims and change objectives articulate rights to social services, 'the right to life and security', and various forms of social equity. Oxfam has made success in the former area the approach has helped articulate the need to help deprived people gain better access to and more control over productive resources, strengthen their position in markets, and ensure that these improvements are structural rather than temporary. In the latter area, the approach has

been used to formulate inclusive and participatory projects and to assess their impact on livelihoods, the environment and social relations.¹²⁴

2.2.8.4 UNDP's human Development Approach

There are three basic principles, an analytical framework and objective, which help explain the popularity of Sustainable Livelihood Approach (SLA). These are that the notion intervention has to be evidenced-based rather than instigated in top-down fashion without taking cognizance of the happening in the community; there should be analytical framework that will explain what is and what can be done. That is, the available capitals, their vulnerability and the involvement of institution. This provides a yardstick for an analysis and; finally, an overall development objective. This in terms of improvement of livelihood sustainability. Either, by making capital less vulnerable or by enhancing the available capitals to add their contributions the sustainability or improving the instructional context. These fundamental principles are echoes by United Nation Development Program human development approach which itself gain credence from other works¹²⁵

In this human development was the major concern in enhancing capability.

Human development is a process of enlarging people's choices.

In principle, these choices can be infinite and change over time. But at all levels of development, the three essential ones are for people to lead a long and healthy life, to acquire knowledge and to have access to resources needed for a decent standard of living. If these essential choices are not available, many other opportunities remain inaccessible¹²⁵

Remarkable success will be achieved by enlarging the capital base such as education.

The development should meet the needs of present generation without affecting the

sustainability of future generations. However, the concept of sustainable development is wider than the protection of natural resources and the physical environment. It is when humans are protected that other capitals protections are guaranteed¹²⁶

The concept is not compromising tree by considering people alone. SLA does not seek to facilitate human development at the detriment of the environment. DFID faulted the UNDP-HDR in that people believe in short-term survival of natural capital such as soil, water, and genetic diversity, rather than the sustainable management of these resources because of their poverty status. DFID believes in sustainability. Therefore, any step towards sustainability needs to involve the rural people and they must be made to be aware of their livelihoods activities as to whether they are contributing positively or negatively to the environment. The focus should be on long-term measure rather than short-term. Sustainability has to be holistic. The notion of UNDP centers on the basic needs such as water, food, shelter, clothing etc. of people as a measure of poverty and alleviation¹²⁷.

2.2.9 Forested Communities

Renewable natural resources such as forest support human well-being on the earth. Sustainable forest ecosystem is a bedrock for promoting food security by “supporting the four dimensions of food security -food availability, access to food, food utilization and stability over time”¹²⁸. It also provides the ecosystem services that enhance the continued production of fresh water for agricultural and domestic needs (reducing runoff)¹²¹. Providing the enabling environment for the local communities to participate in natural resource management is critical to sustainable management of natural resources such as the forest ecosystems¹²⁹. As such, forested community serves as agent of maintenance of the forest, security against illegal activities and insurance for sustainability of forest resources. In forested community there should be

synergy between the stake holders and the Government to forestall conflict. The natural resources governance arrangement and initiatives at the local levels are critical to reducing resource conflicts and encourage community participation in resource management and sustainable use of natural resources. Poor natural resource governance, “drives conflicts and create the tragedy of the commons with concomitant composite environmental, social and human security challenges”¹³⁰.

It has been established that community forest management is an interesting mitigation option to reduce carbon emissions. Community forest management is at the core of the REDD+ implementation¹³¹.

2.3 Theoretical Review

2.3.1 Vegetation Theories

Climate and environmental change are expected to alter plant species distributions; plant community composition and diversity; vegetation structure (e.g., biomass, leaf area); and ecosystem processing of carbon, nutrients, and water. These vegetation responses to climate change and environmental factors will be the result of many lower-level vegetation responses, including changes in net plant carbon uptake, plant water use, plant growth and biomass allocation, competitive interactions, and responses to disturbances¹³²

Vegetation theories entail majorly on vegetation classification which serves to facilitate the recording of information, providing intelligent discussion of vegetation, to enable people to communicate vegetation easily without bias and to help in understanding the phenomenon itself¹³³. Climax theory is the major criterion for a vegetation classification. Climax constitute the major unit of vegetation, yardstick available for comparison and natural classification of plants communities also a basis for decision making and evaluating the effects of resource management¹³⁴. Climax

concept has been agreed upon to be use for land management agencies and worldwide classification systems. Shifting environmental factors are responsible for vegetation change over time and these can include climatic factors as well as hydrologic regime of the soil, the effects of substrates erosion et c. Some notable vegetation theories include the climax theory and the potential natural vegetation theory^{135,136}. These theories deal majorly with the mature phase of succession. In general terms, succession begins with the pioneer stages, followed by the intermediate state and the climax or mature stage. The mature stage is very critical because it depicts a condition when vegetation condition is at a balance with environmental conditions and can only be altered when there is a disturbance episode. This disturbance could come in the form of human activities (deforestation, urbanization etc.) or natural factors (climate induced forest fires, earthquake, volcanic/tectonic activities etc.). The potential natural vegetation (PNV) concept was faulted for the reason that vegetation cannot correspond exactly to what was there before human disturbance began, except there can be records of changes in topography, soil and climate that have taken place across large areas of the world in the period since human impact began; in addition, many taxa have become extinct or have migrated. As such, PNV is more of theoretical concept than a true prediction of future^{137,138}. Succession phenomena, besides being intrinsically complex at a functional level are also diverse and can be classified into two types based several criteria: ¹³⁹

a. **Exogenous-** change in vegetation driven by environmental conditions, for example climate change, changes in salinity or soil humidity.

b. **Endogenous-** this is change occurring within the plant or vegetation species at a site. Expansion of new species and disappearance of others due to the intrinsic evolution of the community's biota. This is the case when shade-tolerant plants

become established after the tree canopy develops, or when litter steadily accumulates to a closed organic layer on top of the soil¹³⁹.

2.3.1 Nexus Between Climate Change, Vegetation Cover, Livelihoods and Forested Communities

Human prosperity depends tightly to vegetation resources as more than 80% of the rapidly population leans on traditional livelihoods strategies such as subsistence agriculture. People and forest relationship and their associated biological diversity are very deep and has a long history, reflecting the genesis of human species in forest and savannas¹⁴⁰.

Three major headings form the impact of climate change: ecological, social, and economic. The ecological impacts of climate change include shifts of vegetation biomes and related effects on biodiversity; change in forest density and agricultural production; expansion of arid land; decline in water quantity and quality; and stresses from pests, diseases, and wildfire¹⁴¹.

An outstanding social impact may include changes in employment, equity, risk distribution, and human health, and relocations of populations.

Economic impacts include increased risk and unpredictability of forest or agricultural production, alteration in productivity for crops and forest products, reduction in supply of ecosystem goods and services, increased cost of utilities and services, and altered energy needs. These lead to populations being vulnerable to climate change through impacts on the necessities and comforts of life such as water, energy, housing, transportation, food, natural ecosystems, and health systems which the myriad species of fauna and flora of the forest have provided. The nature and magnitude of climate change impacts remain uncertain, particularly those related to rural communities: the complex nature of farm decision making, in which there are many non-climatic issues

to manage; the likely diversity of responses within and between regions; the difficulties that might arise if climate changes are nonlinear or increase climate extremes; time lags in responses of communities; and; the possible interactions among different adaptation options which can be inhibited by economic, institutional, and cultural barriers¹⁴². In light of these uncertainties, there is a need to increase our understanding of how ecosystems, social and economic systems, human health, and infrastructure will be affected by climate change in the context of other stresses such as flood and drought¹⁴³.

Expression of vegetation theory and conceptual models, as well as the development of vegetation analyses, is comprehensively explained by Fuzzy Systems Vegetation Theory. It is applicable to vegetation/environmental relations and the effects of environmental dynamics on vegetation composition.¹⁴⁴ One of the key issues in global change of terrestrial ecosystem recognized is vegetation dynamics and responses to the climate change¹⁴⁵. Among them, precipitation and temperature strongly influence the vegetative conditions¹⁴⁶. In particular, monsoon precipitation and temperature are well known to determine vegetation distribution. Because vegetation requires humidity, rain, and favorable temperatures, regional weather can be characterized by these parameters. Heat stress occur to plants when temperature exceed 30°C, and this can slow down plant growth and lead to the threat of nutrient deficiency, and sustainability of crops and trees requires a certain quantity of 69 percent nitrogen and a certain level of water for their growth which can be between 400mm and 800mm¹⁴⁷. Precipitation reduces towards hinterland from the coast as such, changes in vegetation and land use / land cover are closely correlated with changes in seasonal precipitation and land temperature, which in turn have effect on regional climate.

Vegetation also influences the regional climate by controlling the albedo (reflection), and thus moderate the land-atmosphere interaction. Vegetation, an important component of global ecosystem, modulates the ecosystem through water retention, atmosphere circulation and terrestrial soil stability, and helps to maintain a balance of ecosystem greatly. Climate variability affects local ecosystem strongly, produces notable local ecosystem changes ¹⁴⁸.

The potentiality of forests in slowing down the current trend of global warming by sequestering CO₂ from the atmosphere is very eminent. It is estimated that in the last few decades. The world's forests have absorbed as much as 30% (2 Pg. C year⁻¹) of annual global anthropogenic carbon dioxide (CO₂) emissions has been recorded, which is the same amount as absorbed by oceans¹⁴⁹. As such, scientific management of forest resources is one of the priority sectors not only for achieving Sustainable Development Goals (SDGs) through ecosystem services, but also as contributing measures of adaptation and mitigation to climate change.

It has been estimated that the composition of one-third of the world's forests could be altered due to climate change. Research Scientist have predicted regional shift of species and forests, and cause changes in biomes due to change in climate variable^{150,151}. The impacts of this shift vary in degree, magnitude, probability, frequency and duration, across different regions of the continent, while modifications in the structure and functioning of the ecosystems are expected to be produced by these impacts. Since the natural range of most types of ecosystems is primarily determined by climate, it is highly ascertained that combination of temperature and rainfall patterns, are primarily determined by natural range of most types of ecosystems, a change in these climate variables therefore implies a change in the structure and functioning of the forest ecosystems. Moreover, tropical forests are

more vulnerable to climate change and therefore threaten their structure, function and services¹⁵².

The importance of forest to man's survival cannot be overemphasized due to the various environmental, social and economic benefits it provides. Forest renders habitation for various species of trees, animals and fishes. Vegetation plays an important source of energy, livestock fodder, construction materials, food stuff and medicine. More importantly, forest aids in the global cycling of water, oxygen, carbon and nitrogen; lend stability to hydrological system; regular supply of fresh water; prevent flood, soil erosion and situations of river bed downstream.

Forests play a critical role in maintaining the climate, freshwater systems, soil and biodiversity, all of which are critical to food security and other key aspect of human well-being. The potential impacts of climate change on food security may be best understood in light of changes in Africa's livelihoods landscape¹⁵³.

The line of diversification out of agricultural-based activities, 'de-agrarianizing' had been recognized in the livelihoods of rural people in many parts of sub-Saharan Africa. Unexpected shift from previously expected food production as a primary source of people's food security contests the assumption that people's food security in Africa derives primarily from their own agricultural production. Livelihoods are 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 the forest-based income generating activities¹⁵⁴.

2.4 Conceptual Framework and Model Specification

2.4.1 Conceptual Framework

2.4.2 Vulnerability and Adaptation/Mitigation to Climate Change

Figure 2.1 shows Adaptation strategies to climate change as inevitable because of the limited available Knowledge, poverty technology impoverishment and population increase in the face of limited resources and low level of technology.

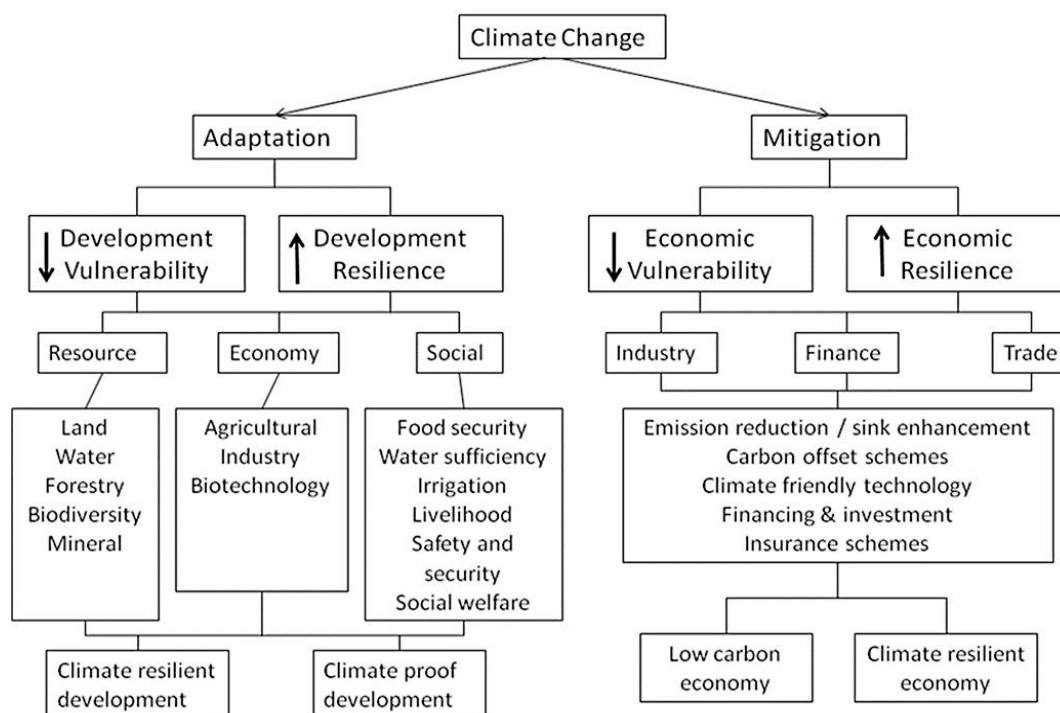


Figure 2.1 Vulnerability and Adaptation to Climate
Source: ¹⁵⁵

As a global issue, the effects of climate change will happen everywhere around the world. Therefore, adaptation measures should be considered alongside mitigation measures; to ensure that the welfare of the society is under control. Adaptation is not a unilateral responsibility but shared responsibility between government, non-governmental organization, community and business entities; that have a stake and role in responding to the climate change impact. This is illustrated in the figure 2.1 which shows the vulnerability (tendency to be affected) and the resilience (tendency to resist an adverse effect) of climate change effects on different sectors of life such as on Land, water, biodiversity, minerals, economy and social life. An effective adaptation measure will result in positive outcome such as food security, industrial

and agricultural revolution etc. thus resulting in a climate resilience economy. The same can be said about effective mitigation that begin from economic vulnerability with the effect on industry that require amelioration measure which comes as a result of using climate friendly technology (solar panel, wind energy, tree planting, Hydrogen power energy etc.), these strategies will bring about emission reduction/sink enhancement, financing and investment, insurance scheme, carbon reduction, cleaner air quality and less emissions. These result to low carbon economy and climate resilient economy¹⁹⁵.

The livelihood concept is a way of looking at the complexity of people's livelihoods especially the livelihoods of the poor, whether they be urban or rural. This always showcase the various livelihood characteristic such as strategies and objective pursued, and associated opportunities and constraints.

The five capitals of sustainable livelihood are: Natural capital: natural resource stocks (soil, water, air, genetic resources, fisheries, biodiversity etc.) and environmental services (hydrological cycle, pollution sinks etc.); Human capital: skills, knowledge, labor (includes good health and physical capability); Economic or financial capital: capital base (cash, credit/debt, savings, and other economic assets); Social capital: social resources (networks, social claims, social relations, affiliations, associations); Physical capital: Infrastructure (buildings, roads), production equipment and technologies. The capital is divided into direct and indirect capital. Direct capital includes, building, machinery, cash, land and so on, while the indirect capital (less obvious immediately) encompasses, socio network, knowledge and good health. All are important but vary from one household to another, as observed from the field, in terms of balance combination¹⁹⁶. This results into different adaptation and mitigation measures in different household and different villages.

On identification of these assets and assessed in relation to what they have been used for or their potentiality, the next thing to do is to explore the vulnerability context in which they exist in terms of the trends, shocks and stresses. Exploring this is to release information as to what is happening now and in future¹⁹⁷.

2.4.3 Concept of Forested Community

Community forestry is defined as “any situation which intimately involves local people inhabiting within and around the forest in a forestry activity. This entails a chain of situation that ranges from woodlots (uncultivated land without tree) in areas which are lacking wood and other forest products for local needs, through the planting of trees alongside crops at the farm level to provide cash crops and the processing of forest products at the household, artisan or small industry level to generate income for the forested communities, to the activities of forest dwelling communities”¹⁹⁸.

Community forestry refers to ecological sustainability through forest management and local community benefits as central goals, with some degree of responsibility and authority for forest management formally vested in the community. It primarily entails involving the local communities in conservation of the forests around them, training them on tree plantation and management, integrating tree planting with food crop cultivation (agroforestry), employment of some of the local people as staff of the protected area, community development projects as well as involving the people in the formulation of conservation policies.

Currently, the practice of Community-Based Natural Resources Management (CBNRM) is very limited in Nigeria¹⁹⁹.

Community forestry—is a system where there is an agreement between communities and governmental agencies to work together to collectively develop a plan for managing natural resources, and each share responsibilities associated with the plan. The idea of a community-driven forest management and planning process is not new (bottom-up approach). The concept of community forestry was discussed 80 years ago, and noted some requirements for community forests in North America: To establish a community forest, cheap land is very necessary, large areas of forests close to towns or cities, and markets that are nearby. The emphasis of these types of plans is thus on meeting the needs (economic, social, and environmental) of the community that lives in the area within or surrounding the forest²⁰⁰.

From time immemorial, human settlements have been associated with tropical forests, and to date, in Nigeria. Human settlements are found within or beside forest regions, mostly the rural dwellers, whose lives and existence depend tightly on the forests and their resources. For instance, in Omo Biosphere Reserve, Southwest Nigeria, there are about 20 enclaves inside the reserve, mainly located on the periphery, and four timber camps and one small town. There are an estimated 20,000 inhabitants living inside the reserve and during the dry season there is a temporary influx of Hausa people from the north, Igbo people from the east and non-Nigerians. Also, Gambari forest reserve, whose communities are alongside and inside the forest. Most of the inhabitants of Nigeria are farmers and timber workers, indicating that their livelihood depends on the forests residing within or beside forest ecosystems, depending on these ecosystems for survival. Their exploitation of forest useless the efforts of forest conservation, leading to constant conflicts between Government, law enforcement agencies and the communities. The best solution is a synergy system of participatory

community-based forest resources management, in which the communities are regarded as stakeholders rather than as threats²⁰¹.

2.5 Model Specification

There are two models adopted in this research which include: Regional Circulation Model and Sustainable Livelihood Conceptual Framework Model.

In climatology, there are only two types of models used: The Global circulation/climate model (GCM) that is used to run for whole globe and the Regional Circulation/Climate Model (RCM) for running for regions or any part as it may require²⁰². A climate model is a complex system of mathematical equations which represents the physical process among various components which contribute to the climate of the region (Southwest of Nigeria). To bridge observed and simulated data sets, statistical bias correction was used for implementation²⁰³. Evaluation of process-based climate models was used as a guide line about models in climate changes assessment and studies related to the impact assessment of climate change in the study areas. For model selection and ensemble projection Bayesian model averaging is used while 95% prediction interval was used to detect the climate variability. Meta-analysis was used for scenario analysis²⁰⁴. In other to evaluate the climate model, Nigeria Meteorological Agency (NiMet) observational data and historical simulated data of the same variables and for the same period was used.

The statistical approach here explored the relationships between climatic data series which are not perfectly similar, such as monthly rainfall, minimum and maximum temperature. This approach allows for the comparisons of data series of different time periods and lengths. The standardized anomalies of seasonal values of temperature and rainfall was calculated for each site by using their means and standard deviations calculated for the reference period 1981–2010 (climatological normal period). For

evaluation purpose, data for the baseline time period, which is 1990-2020 was used for both observed and simulated data. The RCM was used for the impact assessment studies of climate change on vegetation and livelihoods of the forested communities in Southwest Nigeria. Hence, information at higher resolution of 30km by 30km was adopted²⁰⁵.

Autoregressive integrated Moving Average was employed for the data series (ARIMA). ARIMA is a model that can be fitted to time series data to predict future points in the series. MA(q) stands for moving average model, the q is the number of lagged forecast error terms in the prediction equation. SARIMA is seasonal ARIMA and it is used with time series with seasonality

The AR stands for autoregressive and refers to using lagged values of our target variable to make our prediction. For example, we might use today's, yesterday's, and the day before yesterday's sales numbers to forecast tomorrow's sales. That would be an AR (3) model as it uses 3 lagged values to make its prediction.

The I stand for integrated. It means that instead of taking the raw target values, we are differencing them. For example, our sales prediction model would try to forecast tomorrow's change in sales (i.e., tomorrow's sales minus today's sales) rather than just tomorrow's sales. The reason we need this is that many time series exhibit a trend, making the raw values non-stationary. Taking the difference makes our Y variable more stationary.

The MA stands for moving average. A moving average model takes the lagged prediction errors as inputs. It's not a directly observable parameter unlike the others (and it's not fixed as it changes along with the models in other parameters). At a high level, feeding the model's errors back to itself serves to push it somewhat towards the correct value (the actual Y values).

SARIMA models are ARIMA models with a seasonal component. As Per the formula SARIMA(p,d,q)x(P,D,Q,s), the parameters for these types of models are as follows:

p and seasonal P: indicate number of autoregressive terms (lags of the stationaries' series)

d and seasonal D: indicate differencing that must be done to stationaries' series

q and seasonal Q: indicate number of moving average terms (lags of the forecast errors)

s: indicates seasonal length in the data

$$\begin{array}{ccccccc} (1 - \phi_1 B) & (1 - \Phi_1 B^4) & (1 - B) & (1 - B^4) & y_t = & (1 + \theta_1 B) & (1 + \Theta_1 B^4) e_t \\ \uparrow & \uparrow & \uparrow & \uparrow & & \uparrow & \uparrow \\ \text{(Non-seasonal)} & \text{(Non-seasonal)} & & & & \text{(Non-seasonal)} & \\ \text{AR(1)} & \text{difference} & & & & \text{MA(1)} & \\ & \uparrow & & \uparrow & & & \\ \text{(Seasonal)} & & \text{(Seasonal)} & & & \text{(Seasonal)} & \\ \text{AR(1)} & & \text{difference} & & & \text{MA(1)} & \end{array}$$

Where:

$$\text{AR (1)} = Y_t = \alpha_1 Y_{t-1} + e_t \quad \text{Equation 2.1}$$

$$\text{Non-Seasonal AR (1)} \Rightarrow Y_t(1 - \alpha_1 B) = e_t.$$

Two approaches were taken to determine the ideal SARIMA parameters: Auto Correlation Function (ACF) and Partial Auto Correlation Function (PACF) plots, and a grid search. The ACF and PACF plots were used as a starting point to narrow down to a few potential parameters, and then a grid search was used to identify the best parameters.

For ease of interpretation SARIMA (1,0,1) s x (0,1,1)12:

p = 1 and P = 0 (significant positive spikes in ACF and PACF plots)

d = 0 and D = 1 (first difference and seasonal difference)

q and Q both equal 1 (significant negative spikes, PACF decay is more gradual)

s equal to 12 (monthly seasonal component)

Using these parameters, the model was fit to the data, and then a new set of ACF and PACF plots of the model's residuals was evaluated.

With a starting point of $(1,0,1) \times (0,1,1)_{12}$, a grid search was set up to test a number of different parameter combinations. It's worth looking at models where $p = 0, 1$, or 2 and $q = 1$ or 2. A metric that can be used to compare the relative quality of each model is AIC (Akaike information criterion), which is an estimator of out-of-sample prediction error; a lower AIC score indicates a more predictive model.

In the second model adopted for this study, Department for International Development's Sustainable Livelihoods (DFID's) Framework was modeled for sustainable forested communities in Southwest Nigeria. The assets (natural, physical, human, social and financial capitals), the activities and access to these (mediated by institution and social relations) that together determine the living gained by the households was considered in the research.

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Chapter Three

Research Methodology

This chapter presents the method adopted in the current study for the purpose of collecting relevant data necessary for achieving the research objectives. The chapter is arranged in the following sub-headings: research design, sampling techniques survey, Data capturing and research instrument. The research activities cut across social science, environmental science, climate science, remote sensing, Geographical Information System (GIS), agriculture and Forestry. The research activities include: social surveys (livelihood activities), reviewing of existing data such as rainfall and land surface temperature; satellite temperature, Vegetation cover surveys and mapping, through remote sensing; and; the problems confronting these phenomena were examined in the objectives

3.1 Research Design

A descriptive research design with social survey method was applied in the study. The researcher used both the primary and the secondary data for the purpose of the study.

A close-ended questionnaire and a mix of both formal and informal interviews with leading thinker in the local communities was designed to collect social survey data.

Secondary data were collected from available books, publications, research studies, articles, website, satellite images World Meteorological Organization (WMO) and Nigeria Meteorological Agency (NiMet). Four forest reserves in three states in Southwestern Nigeria were selected to collect primary data and the researcher visited each village that surround the forest reserve to source for information. The information provided a representation of a broader understanding of societal drivers that were considered relevant and credible regarding their perception and livelihoods. After collecting all necessary data, it was subjected to analysis and tabulated in a

descriptive manner. This tabulated information was used to measure the respondent's perception on climate change, vegetation dynamics and livelihoods. To measure this perception level, a four points scale has been used which is denoted by 1=Strongly Agreed (SA); 2= Agreed (A);; 3=Disagreed (D); and, 4=Strongly Disagreed (SD). Also, Yes or No style of answer was adopted on few occasions. The construction of questionnaire was based according to the standard form for the formulation of appropriate question. The following guidelines was given special consideration in the construction of the questionnaire: To be certain that each question is relevant to the topic; To ask the questions that the respondents can and willing to answer; To express each question as simple as possible; To state questions in specific concrete term; To obtain criticism of all the prepared items by a colleague or friend and; To state the items in the language that respondent use in everyday conversation.

Monthly values of cumulated rainfall and mean temperature of some stations characterizing the different climatic conditions of the region for the period of 31 years (1990-2020) was considered ^{1,2,3} (Tables 3.1 and 3.2). The Meteorological Stations are: Ondo, Ikeja, Ibadan and Kwara. Due to unavailable meteorological station in some selected study area, the nearest station that were within the range of climatological effect were used such as Ikeja meteorological station (Badagry) and Eyenkorin Meteorological Station in Kwara (Ogbomosho). The Vegetation Dynamics was investigated through Land Satellite Imageries

Table 3.1 Meteorological Annual Rainfall (mm) Data for the Study Location**1990-2020**

Year	Akure	Badagry	Ibadan	Ogbomosho
1990	2011.3	1368.9	1363.6	1020.1
1991	2096.6	1610.1	1396.3	1469.4
1992	1804.9	1671.8	1173.6	931.6
1993	1655.6	1188.4	1574.8	1177
1994	2134.6	1671.5	1095.1	1242
1995	2503.2	1141.3	1471.1	1409.2
1996	1827.8	1629.8	1506.2	945.3
1997	2283.6	1589.5	1360	1334.4
1998	1375.3	1749.6	1148.1	1596.5
1999	2101.2	926.5	1640.5	1539.3
2000	2069.1	1197.7	1208.4	993.3
2001	1516.6	1125.2	1133.6	697.7
2002	1928.1	1392.1	1196.4	957.1
2003	1690.2	1802.3	1304.5	1286.7
2004	1861.5	1699.2	1006.6	1327.1
2005	1914.7	1483.9	1314	1317.1
2006	1944.9	1516.9	1198.5	1303.8
2007	2026.8	1539.8	1079.3	1292.2
2008	2062.1	1553.7	1435.8	1401.4
2009	2157.7	1393.2	1504.1	1343.1
2010	1587.1	1669.5	1762.5	924.3
2011	1999.8	1748	1433.6	1086.5
2012	1991.6	1557	1537.7	1079.1
2013	1447.3	1726.7	1548.8	1271.5
2014	1544.8	2117.1	1148.1	22965
2015	2518.4	1182.6	1028.7	1701.1
2016	1588.2	1426.8	1347.7	2552.6
2017	1645	1615.6	1362.5	1483
2018	1997.6	1476.6	1389.6	2195
2019	2558.6	2096.4	1784.9	2012.2
2020	1439.5	1412.7	2130	1964.2

Source: Nigeria Meteorological Agency, 2021

Note: Ondo Meteorological data used for Akure; Ikeja Meteorological data used for Badagry; Kwara Meteorological data used for Ogbomosho.

Table 3.1 displayed the 31-year observed rainfall data for the four selected study locations.

Table 3.2: Average Meteorological Temperature (°C) of the Study Location**1990-2020**

Year	Akure	Badagry	Ibadan	Ogbomosho
1990	26.8	26.9	27.7	26.9
1991	26.4	26.8	27.8	26.6
1992	26.5	27.2	27.5	26.4
1993	26.6	27.3	27.6	26.5
1994	26.5	26.9	27.6	27.2
1995	26.8	26.8	27.7	27.2
1996	26.8	26.7	28.0	27.1
1997	26.8	27.5	27.6	27.0
1998	27.5	27.6	29.0	27.6
1999	26.7	26.9	28.0	27.1
2000	26.9	27.1	28.3	26.6
2001	26.7	27.2	28.1	27.3
2002	26.8	27.2	28.4	26.8
2003	27.1	27.1	27.9	26.7
2004	27.0	27.0	28.3	26.2
2005	27.3	27.5	28.0	26.6
2006	27.3	27.5	28.1	26.7
2007	26.6	27.4	28.1	27.0
2008	27.1	27.6	28.3	26.7
2009	27.2	27.8	27.9	27.3
2010	27.8	27.9	28.5	26.4
2011	27.4	28.0	28.2	27.2
2012	27.2	27.6	27.7	27.3
2013	27.1	27.7	28.0	27.3
2014	27.1	27.4	28.0	27.1
2015	27.4	27.7	28.2	26.8
2016	27.2	28.3	28.4	27.4
2017	27.2	28.1	27.0	27.8
2018	26.9	28.1	27.2	27.4
2019	28.1	26.9	27.8	26.9
2020	27.5	28.1	25.2	27.4

Source: Nigeria Meteorological Agency, 2021

Note: Ondo Meteorological data used for Akure; Ikeja Meteorological data used for Badagry; Kwara Meteorological data used for Ogbomosho.

Table 3.2 displayed the 31-year observed temperature for the selected study location

Particular attention was given to the problems arising from the low quality and inhomogeneities of the data.

3.2 Population of the Study Area

The population of the study area was 24000 according to 2020 projected population census (Table 3.3). A total number of 24 villages were involved, based on villages that were less than 2km around the forest. 10% of this population were interviewed which amount to 300 households on the premise of average number of people in the household to be eight (8) for rural area⁴.

Formula for Calculating Population Rate

$$P_1 = P_0 e^{f(r)(n)} \quad \text{(Equation 3.1)}$$

P_0 = Population at the initial date/person

P_1 = Expected population

r = Annual rate growth

n = Number of years between P_0 and P_1

Table 3.3: 1991 Population Census Data for the Study Area

Villages	Pop(1991) Census	Pop(2020) projected	No of Household	Sample size (10%)
Ogbomosho F.R. GR: 4.56%				
Ayegun and others	344	1291	161	16.1
Ayegun 11 and others	392	1471	184	18.4
Odan-bon and others	431	1617	202	20.2
Ilogbo Ikemu Asawo Ikolaba Iletuntun	353	1325	166	16.6
Akure F.R. (Ondo) GR: 5.86% HH				
Owena	516	2823	122	12.2
Eleshin				
Lafiaji camp	248	1357	170	17
Obada	350	1915	114	11.4
Obadore camp	232	1269	159	15.9
Ladapo camp	128	700	88	8.8
Dejo/okeoja	418	2287	286	28.6
Okecementi	329	1800	225	22.5
Odunjo	922	5044	631	63.1
Sokoto	299	1636	205	20.5
Onigambari F.R.(Ibadan) GR: 2.32% HH				
Olubi	297	582	73	7.3
Dalley	351	688	86	8.6
Onigambari	600	1175	147	14.7
Olowa	95	186	23	2.3
Busogboro	532	1042	130	13
Longe	327	641	80	8
Seriki	102	200	25	2.5
Onipe	410	804	100	10
Badagry F.R.(Ologe) Lagos GR: 5.61% HH				
Oko afo	1200	6106	763	76.3
Araromi	200	1018	127	12.7
Mushin	270	1374	172	17.2
Esepe	120	611	76	7.6
			4,476S	447.6

Source: National Population Commission

3.3 Villages in the Study Area and their Households

Table 3.4: Forest Reserve Distribution of villages and the households in the selected communities.

Forest Reserve	Communities	Sample
Akure	Akure	71
	Obadore	49
	Kolawole	3
	Ladapo	8
	Owena	9
	Saw Mill	2
Gambari	Gambari	62
	Longe	8
	Oloowa	2
	Olubi	1
	Onipe	9
	Seriki	1
	Busogboro	14
	Dalley	8
	Gambari	19
Ogbomosho	Ogbomosho	66
	Asawo	3
	Ayegun Ikolaba	4
	Odanbon	26
	Iletuntun	19
	Yemetu Ayegun	3
	Ilogbo	7
	Itemu	4
Badagry	Ologe	76
	Araromi	12
	Mushin	31
	Oko Afo	28
	Esepe	5
Total	24	275

Source: Field survey, 2021

Table 3.4 presents the villages that were considered and interviewed in the study area: In Akure, 5 villages (71 households); Ibadan, 8 villages (62 households); Ogbomosho, 7 villages; (66 households); and Badagry, 4 villages (76 households). All these villages are closer to the Forest Reserves so as to get the proper information about the environment. Villages that were more than 2km were not considered. The households that were far away were also not taken into consideration. The total number of villages are 24 with 275 questionnaires successively retrieved from the respondents out of 300 household heads (Table 3.5). The assumption is that the farther away the forest from the community, the lesser will be the disturbance⁵.

Table 3.5 Percentage of response from the questionnaires administered.

Response	Total	Percentage
Administer	300	100
Retrieved	275	91.7
Total	275	100

Source: Field Survey Results, 2021

3.4 Sample and Sampling Techniques

Purposive sampling technique was used to select the study area. Study locations were selected based on ecological zones, at least one from an ecological zone that falls within the study area. Therefore, there were total numbers of four study locations with particular high social vulnerability (risk + response) to climate change as identified through existing data bases or key informants. Measure was taken by assuring variation between sites in climate change hazards, livelihoods impact, wealth and ecology, such as altitude differences between forested communities.

After the fieldwork exercise in all the communities involved, reports were produced, documenting the information gathered. These four locations reports were used as the primary information sources for this research and the companion Toolkits. As a consequence, the process for building adaptation and drivers of vulnerability considered were:: exposure to climate parameters, rainfall, in both intensity and total amount, sensitivity to climate change, land use changes, forest changes and adaptive capacity- The presence of large sources of natural resources wealth, means that the potentials to adapt is relatively high. However, what the researcher envisaged was that the large inequalities between the haves and have-nots may act in disfavor to adaptation to have-nots in the study area.

3.4.1 Sample Size

The target population in the survey were villages around the forest reserves while the sampling frame was 2km away from the forest reserves^{6,7}. 10% of the households or respondents is required from each village. Probability or random sampling was employed to guarantee good representation of the sample. In this, systemic sampling was used, in that every 5th household head was interviewed to assure freedom from bias.

3.5 Description of the Instruments

The primary data were collected using field observations, administration of structured questionnaire and in-dept interviews (IDI). A set of questionnaires was arraigned for selected households and key informant guides was also designed for offices in charge of natural resources and focused groups. Individual, community life and human-environment interaction were part of the consideration in drawing the questionnaire which include:

- Information about the land use/landcover change- Cropland, pastureland, forestland, population and urbanization.
- Climate hazards and its impact on local livelihoods -Natural (rainfall and temperature), physical (health), social (cultural, custom and other social network) and financial (income, opportunities).
- Sources of incomes that support sustenance for the livelihood- Farming, livestock rearing, forest product, fishing, hired laborer, hunting, artisan, gathering of non-timber forest products, transportation and civil servant
- Vulnerability to climate change effect- reduction in yield, flooding, shortage of food, undefined season, pests and diseases and forest fire.
- Climate change effect on crop.
- Perception of impact of land use on vegetation cover- Farming activities, illegal grazing, fuel wood, illegal logging activities and illegal hunting.
- Forest products used by the communities- Fire wood, timber, tree roots, leaves, fruits, Rubber, Latex, Resins, Medicinal herbs and Gum.
- Perceptions on impact of climate change on vegetation
- Perception on air temperature and rainfall
- Feelings about the onset of rainfall
- Perception on climatic parameters - rainfall and yield; rainfall and forest product; relative humidity and diseases; pests' infection and climate parameters; forest product and land degradation; humidity and yield of forest product; temperature and forest product; Solar intensity and forest products; and past weather conditions and present.

- Adaptation strategies utilized – planting of different varieties, different planting dates, practicing shifting cultivation, irrigation practice, use of organic fertilizer
- Benefit of LUCC – on food production, pasture land, economic empowerment, income and livelihood diversification, land for settlement, basics services, infrastructure, farming fuel wood, medicinal plants.
- Perception on farming system - Rain-farming, Private grassland, Communal grassland, Forestland, Wetland, bare land
- Security defense against forest failure – agriculture (subsistence and market), home management and self-employment.
- Security against crop failure – rearing of animal, poultry keeping wild game

Secondary data was used such as climatic data (Rainfall, maximum temperature and minimum temperature) for Akure, Ikeja, Ibadan and Eyenkorin in Kwara, from Nigeria Meteorological Agency (NiMet) that covers 1990-2020. This study also involves examining the relationship between Land Use Land Cover (LULC) and Land Surface Temperature (LST) changes within the selected forest reserves using remote sensing satellite data. It utilized Landsat data acquired between 1990 and 2020 to assess LULC changes over time and resulting spatial temperature variation. To achieve this, the study explored the land use land cover using land cover indicator such as Normalized difference Vegetation Index (NDVI), Normalized Build Up Index (NDBI) and thermal bands of the images to assess land use /cover change pattern and the impacts of such changes on surface temperature⁸.

3.6 Validation of Research Instrument

Validation of a research instrument refers to the extent to which data collection strategies accurately measure what it is designed for. It is the degree to which it is

truthful, the extent to which the research findings are really about what they were purpose to be. In ensuring of validity of the data, questionnaire, interview, effective data collection and analysis were considered by the researcher. Those considerations helped a great deal to demonstrate validity, by putting into perspective, all matter arising from the topic under investigation.

3.7 Reliability of the Instrument

The degree with which an instrument accurately measures parameter free of error is called reliability. This is a measurement of the proportion in the variation that is due to the diversity of values that the variable adopts and that are not product of error. This is the extent to which data collection technique or techniques will result into consistent findings. In other words, other researchers will have similar observation and make a conclusion while employing the same instruments. Transparency in how sense was made from the raw data ensure reliability to guarantee reliability in this study from its design and reporting, the researcher made sure that reconnaissance survey is in place for testing of data collection and how to conduct the actual field survey. As such, the field pre-testing was based on selecting a fraction of the communities before conducting the actual field survey.

3.7.1 Pilot Survey

A pre-test of the instruments was carried out on 10% which represent 30 respondents of the sample under study using Onipe village in one of the study locations in Gambari Forest Reserve. The purpose of the pilot survey was basically to conduct a reconnaissance general and specific ecologies; test the field instruments; and establish a contact with the community, opinion leaders and other stakeholders through the State authority. The pilot survey was carried out on February 3rd, 2021. There were four forests reserves with surrounding communities considered. These are: Akure

Forest Reserve, Ologe Forest Reserve, (Badagry, Lagos), Gambari Forest reserve (Ibadan), and Okoiro Forest reserve (Ogbomosho). The pilot survey revealed that the ecology surrounding the communities across the study area were inhomogeneous due to differential climatic conditions. It was revealed that the socio-economic and demographics profile including livelihoods were almost the same. The respondents showed an understanding of all the questions through the guide of researcher.

Two types of questions were used in the questionnaire. Closed-ended questions, with multiple choices or Yes or No style of answer (dichotomous questions) in step-wise style, each answer leading to a specific set of follow up question with no open-ended questions except where it is inevitable such as "strongly agree, agree, disagree and strongly disagree". These types of questions were used in order to:

1. Make expected demand upon the respondent.
2. Easy response assured and efficient collection of data.
3. Confidentiality of information protection was assured.
4. It permitted easy, quick and accurate analysis of responses
5. The way questions were combined were very interesting to the respondents to give accurate answer

3.7.2 Interview Result from the Pilot survey

The findings about the questionnaire from the pilot survey carried out were that, some of the household heads were not around in some households but researcher discovered that somebody else who was experienced could give expected answer to the questions. Another thing was the issue of the cattle rearing which had negative effects on the success of existence of the inhabitant of the communities, sustainability of the forest resources, the crops planted by the farmers and also to the environment. All other questions were relevant and were responded to, excellently. The interesting aspect of

it was that the villagers thought researcher came to rescue them through government from the unpleasant situations arising in the communities.

3.8 Method of Data Collection for the Study

The primary data obtained for this study were obtained through structured questionnaire, In-dept Interview (IDI) and Household interviews including the household heads or any adult member of the selected households., photography, use of Global Positioning System (GPS) instrument, Focus Group Interviews (FGI) and field observations, with the key informants such as community leaders, association of wood sellers, group of farmers, chiefs, forest superintendents and head of charcoal association were interviewed in the communities involved.

The use of digital camera equipped was considered as a useful tool to take all necessary pictures for references to the events on the field. Also, it helped in serving as records for future monitoring of changes that may take place in the study area.

Field survey of respondents in different study areas was carried out to investigate the various problems confronting the forest dwellers in respect of extreme climatic occurrence and the various ways of their adaptation to such events. The adaptation employed were related to demographic structure to determine the factors which help the various adaptation methods. As such, these acted as a pointer to which method can be more appropriate that can still help the forested communities in adaptation and mitigation to climate change. The weak adaptation strategies investigated were the area to be acted upon to reduce the effect of climate change on livelihoods.

Secondary data used were climatic data that covered 1990-2020

3.8.1 Meteorological Stations and Period of Data used

Table 3.6 presents the GPS locations of the study areas, the specific periods considered and the numbers of years involved.

Table 3.6: Meteorological Stations and Period of Data used

Station	Latitude	Longitude	Period	Number of Years
Ondo (Akure)	7°.17'	5°.18'	1990-2020	31
Ikeja (Badagry)	6°.26'	3°.25'	1990-2020	31
Ibadan	7°.26'	3° 54'	1990-2020	31
Kwara (Ogbomosho)	8°.44'	4°.49'	1990-2020	31

Source:¹²

Landsat satellite imageries of the study areas for 1990, 2000, 2010, and 2020 which were obtained from the United State Geology Survey (USGS)⁹. Others were seminar papers, conferences, unpublished materials of relevance to the study, annual reports, text books, periodicals, journals, the use of Internet etc.

This study also focused on the land use change and temperature characteristics for the period of 31 years. Land cover maps were utilized to quantify land cover change in the periods under investigation¹⁰.

The Landsat satellite images was downloaded from the official website of US Geological Survey as standard products, i.e., geometrically corrected. and used in order to achieve the research objectives⁹. The study area was located in the Landsat path 191 and row 55. The pixel sizes of the images were 30m x 30m with the

exception for the thermal infra-red (IR) bands (band 6) and (10-11) respectively, which has 100-m resolution bands¹¹. All the images were obtained in the same season (rainy). The obtained Landsat data (Level 1 Terrain Corrected (L1T) product) have been pre-georeferenced to Universal Transverse Mercator (UTM) zone 31 North projection using World Geodetic System (WGS-84) datum. The other necessary corrections were performed in this study. Table 3.7 presents the specifications of Landsat Thematic Mapper (TM), Enhance Thematic Mapper plus (ETM+) and Operational Land Imager (OLI) images which are the three-medium resolution Landsat Imageries in assessing land use land cover pattern of the study area. The time interval selected were based on available data⁷.

Table 3.7: Satellite Images

Satellite Sensor	Spatial resolution	Acquisition years	Path	Row	Source	Category
Landsat 5, 7 (TM & ETM+)	30m x 30m	1990, 2000, 2010	190/191	55	GLCF	Secondary
Landsat 8 (OLI)	30m x 30m	2020	190/191	55	GLOVIS	Secondary
	Google Earth	2020				Secondary

Source: Satellite Images, 2021

3.9 Administration of Research Instrument and Method of Data Collection

The data collected were computed and analyzed using frequency, percentages, descriptive and inferential analysis covering the respondent's demographic and perception, alongside research questions was done and presented in tables, graphs, figures and plates as the case may be. Aggregation of the questionnaire for other analysis covering land use land cover etc. were processed to obtain scores for each of the respondent. The Likert rating scale method was used to analyze the collected data

from the questionnaires. The scores were 4,3,2,1 for agree, strongly agree, disagree and strongly disagree, respectively, to obtain an aggregated score for the variables. This was used to obtain correlation among the important variables as it relates to respondents' adaptation and mitigating strategies to climate change. This was also used to test the significant level between the dependent and independent variables using Statistical Package for Social Sciences (SPSS) version 20.0.

3.10 Adaptation and Mitigation Strategies

Climate is one of the most important factors in agricultural productivity, which could directly or indirectly influence productivity since the climate is linked to physiological and phenological processes. It is, therefore, essential to understanding the various strategies used by farmers to mitigate the adverse impact of climate change and the factors that influence farmers' adoption and intensity of climate change adaptation strategies among forest dwellers in South-west Nigeria. Mitigation and adaptation are the two main response to climate change. Measures to reduce increase in greenhouse emission or increase terrestrial storage of carbon (sequestration) is mitigation measure. What is very crucial is how do we repair, reduce or remove the past damage, improve the present livelihoods and prevent the future impact of climate change on livelihoods and still conserve the vegetation resources in the environment. While all responses to climate change that may be used to reduce vulnerability is referred to adaptation. Household socio-demographic characteristics and other forms of institutional factors have great influence on adoption and intensity of climate change adaptation^{13,14}. Adaptive capacity depends on sufficient education, assets, information and income. Regions with the least adaptive capacity are more vulnerable to climate change¹⁵. An understanding of geographic variation and impacts is essential to efficient deployment of adaptation

actors. Adaptation is the method of adjusting to a sudden unpleasant situation in the environment. Adaptive capacity is the ability of individuals and communities to adjust to climate change, to moderate potential changes, to take advantage of opportunities or to cope with the consequences within the resources available to them¹⁶.

3.10.1 Climate Change Response Determination

Pearson's Chi-Square test was used to test how likely it is that an observed distribution is due to chance. This is also known as "goodness of fit" statistic, because of its ability to measure how well the observed distribution of data fits with the distribution that is expected if the variables are independent. That is, the level independence of factors that affects the various adaptation methods adopted in the study area. This is a helpful statistical formula that measures the strength between variables and relationship. Chi-Square test, test the null hypothesis that the variables are independent. The test compares the observed data to a model that distributes the data according to the expectation that the variables are independent. A Chi-Square test is designed to analyze categorical data. The categorical data are of two types: 1. Nominal Variable: A nominal variable has no natural ordering to its categories. They have two or more categories. For example, Marital Status (Single, Married, Divorcee); Gender (Male, Female, Transgender), etc. 2. Ordinal Variable: A variable for which the categories can be placed in an order. For example, Customer Satisfaction (Excellent, Very Good, Good, Average, Bad), (Strongly agree, agree, Disagree, strongly disagree) and so on¹⁷

Pearson's Chi-Square Coefficient (X^2 value)

Bayes Theorems:

$$X^2 = \sum_{i=1}^n \frac{(O_i - E_i)^2}{E_i}$$

(Equation 3.2)

Where

X^2 = Chi-Square

O_i = Observed frequency

E_i = Expected frequency

Monthly rainfalls (mm) and temperature (°c) were sourced from Nigeria Meteorological Agency (NiMet), Abuja. NIMET has been the only agency responsible for the collection and compilation of reliable weather data in every part of the nation. Time series analysis of climatic variables in form of trends analysis and seasonality index were examined in the analysis. The standardized anomalies of seasonal values of rainfall and temperature were calculated for each site by using the means and standard deviations calculated for the reference period (1981-2010).

Also, NDVI, NDBI and temperature retrieval from satellite data was adopted, covering the period of the study. The statistics of the land cover dynamics was calculated as absolute increments of the whole study area on map, by subtracting percentage area among 1990 and 2000 and as a relative percentage increment or decrement from 2000 as it is applicable to another Landsat maps¹⁸. The epoch scenes chosen as shown in Table 3.3 revealed two major methods employed in this study: sub-pixel analysis and land surface temperature retrieval. The selection of the Software used in this study centers on the image processing procedures: *Idrisi taiga* 17.0 edition was used to handle the prognosis part of the images. That is, it was used for the development of land use/land cover classes and subsequently for the change

detection analysis of the study area. ArcGIS 10.5 complements the display and processing and enhance images of the data used. Also, regression analysis was employed to examine the change in temperature images and respective indices of LULC (Figure 3.1).

3.11 Decadal Analysis of Rainfall and Temperature Anomaly and Coefficient of Variation in the study locations.

In analyzing the decadal climatic parameters, 30-year (1991-2020) data were considered for comparison with the climate normal (1981-2010) to observe the disparity between the observed and the expected. This gave knowledge of the decadal trends across the study locations and enhanced the predictability instrument of the phenomenon. Arbitrary threshold values of +4 and -4 have been assigned to the mean of extremely humid and extremely dry. The positive or negative sign is related to the positive and negative precipitation anomalies.

Table 3.8 Calculation of Rainfall Anomaly Index (RAI)

	RAI Range	Classification
Rainfall Anomaly Index (RAI)	Above 4	Extremely Humid
	2 to 4	Very Humid
	0 to 2	Humid
	-2 to 0	Dry
	-4 to 2	Very Dry
	Below -4	Extremely Dry

Source:¹⁹

The rainfall anomalies of a given geographical area over a long period is considered as the major hydro-meteorological variable that result to climate change and also a

dominant factor affecting agricultural and livelihood which requires serious attention of research. The variability of rainfall (anomalies), is defined as the deviations of annual rainfall from long-run averages. This variability is a recurring phenomenon that threatens agricultural systems and disproportionately impacts the developing world²⁰. Coefficient of Variation is a measure of dispersion of data points around the mean. The characteristic feature of rainfall in Nigeria is its variability. The variability of rainfall is computed with the help of CV. The values of CV show the change from the mean value of rainfall. The CV of annual precipitation is an index of climatic risk, indicating likelihood.

Rainfall Anomaly is calculated as yearly observed rainfall subtracted from the reference period rainfall value (standardized normal) divided by the Standard Deviation (SD).

$$X - \mu / \sigma \quad (\text{Equation 3.2})$$

Where X= observed value of rainfall (Historical data)

μ = Average value reference period

σ = Standard deviation

Coefficient of Variation is denoted by:

$$SD / MEAN \times 100 \quad (\text{Equation 3.3})$$

Where SD= Standard Deviation

MEAN = Average of the decade period

3.11.1 Time Series Analysis of Climatic Variables

A Time Series (TS) is a sequence of observations ordered in time where adjacent observations are correlated. This can be used to model, simulate, and forecast behavior for a system. Time series models are frequently used in fields such as climate, economic, finance, biology and engineering. Mostly these observations were collected at equally spaced, discrete intervals. When there is only one variable upon which observations are made, we call them a single time series or more specifically a univariate time series such as monthly and annual rainfall and temperature used in this study (homogenous data).

A basic assumption in any time series analysis/modeling is that some aspect of the past pattern will continue to remain in the future. Also, under this set up, often the time series process is assumed to be based on past values of the main variable (Rainfall and Temperature) but not on explanatory variables, which may affect the variable. So, the system acts as a black box and we may only be able to know 'what' will happen rather than 'why' it happens. It is tactically assumed that information about the past is available in the form of numerical data. Ideally, at least 50 observations are necessary for performing Time series analysis/ modeling²⁰. The processes of the application of Time Series on the observed climatic data in this study

are as follow:

3.11.2 Climatic Derivations

Monthly rainfall data collected for the study areas was used to derive the Precipitation Effectiveness Indices (PEI): onset, cessation, monthly rainfall in the growing season (March, April May, June, July, August, Sept and October), fluctuation of rainfall across the months and years were examined through seasonality index⁸. While Temperature Effectiveness Temperature Indices (ETI) were derived; average temperature, optimum temperature, maximum temperature and minimum temperature.

3.11.3 Time Plot

This is the graph of observation X_t against time t . It is the first step to take in time series analysis. It depicts some characteristics of interest that are present in the series like the trend and the seasonal variation.

3.11.4 Estimation and Isolation of Component of Time Series

A time series is a collection of observation made sequential at equal interval of time. This is denoted by X_t , where X_t is the observed value at time t . (rainfall/temperature versus years). Time Series Analysis (TSA) involves the investigation of the degree and the pattern of dependent observation X_t . Time series observation can be discrete or continuous in nature.

Discrete time series data is a single point value for time series frequency (daily, weekly, monthly, quarterly, and annually). This discrete time series data was applied for this study. Continuous time series is given as interval value and continuous time series can be converted at discrete time series by measuring its constant interval.

3.11.5 Deterministic Time Series Model

In the analysis of a time series; either of the following two (2) models could be assumed.

1. The multiplicative model i.e.

$$X_t = T_t \cdot S_t \cdot C_t \cdot I_t \quad (\text{Equation 3.4})$$

2. The additive model

$$X_t = T_t + S_t + C_t + I_t \quad (\text{Equation 3.5})$$

Where:

X_t - The value of the variable at a particular time

T_t - Trend

S_t - Seasonal variation

C_t - Cyclical variation

I_t - Irregular variation

The objective of time series analysis is to isolate individual components on the original composite series such that each component can be measured and analyzed independently of the other.

3.11.6 Trend (T_t)

The trends refer to the general direction in which the time plot appears to be moving. A time series is said to contain a trend if the means changes systematically with time. Trend could be increasing or decreasing. A time series that has no trend is said to be stationary²⁰.

3.11.7 Unit Root Tests

Many climatic, economics and financial time series exhibit trending behavior or more stationarity in the mean. Leading examples are asset prices, exchange rates and the levels of macroeconomics aggregates like real Gross Domestic Products (GDP). An important econometric task is determining the most appropriate form of the trend in

the data. For example, in Automatic Regression Moving Average (ARMA) modeling, the data must be transformed to stationary form prior to analysis. If the climatic data are trending (going up or down), some forms of trend removal is required. Two common trend removal or de-trending procedures are first differencing and time trend regression. First differencing is appropriate for trend I (1) time series and time trend regression is appropriate for trend stationary I (0) time series. Unit root tests can be used to determine if trending data should be first differenced or regressed on deterministic function of time to render the data stationary.

Unit root tests are used to identify the stationarity property of a time series data. One of the applications of unit root tests is to test the random walk hypothesis of time series data. The most widely used unit root test is the Augmented Dickey Fuller test. A few time series data exhibit a structural change from their usual trend due to various reasons.

3.11.7.1 Augmented Dickey Fuller Test (ADF)

The unit root tests described above are valid if the time series Z_t is well characterized by an AR (1) with white noise errors. Many financial time series however, have a more complicated dynamic structure than is captured by a simple AR (1) model. The basic autoregressive unit root test to accommodate general ARMA (p, q) models with unknown orders and their test was augmented and this is referred to as the Augmented Dickey Fuller tests (ADF)¹⁵. Augmented Dickey Fuller test is performed to identify whether data series is stationary or not. A time series, under random walk hypothesis is expected to follow a random walk. The ADF test relies on a parametric transformation of the model that eliminates the serial correlation in the error term without affecting the asymptotic disturbances of the various T statistics, given the model below.

$$\mathbf{z}_t = \phi \mathbf{z}_{t-1} + \varepsilon_t \quad (\text{Equation 3.6})$$

Where $\mathbf{z}_t$ is the natural logarithm of unemployment at time t. This process is said to have all the available information in the past and is also called a long memory process.

In the Dickey Fuller test, we consider the AR model

$$\mathbf{z}_t = \phi \mathbf{z}_{t-1} + \varepsilon_t \quad (\text{Equation 3.7})$$

The hypothesis of interest is that of null of $\phi = 1$ implying a random walk series versus the alternate of $\phi < 1$. This issue of using this test is that, under null hypothesis the data is non stationary and the test statistics does not follow the standard t distribution anymore, but rather ADF distribution.

The Dickey Fuller critical values for this model have been obtained by Monte Carlo simulation.

The ADF test, tests the null hypothesis that a time series $\mathbf{y}_t$ is I(1) against the alternative that it is I(0), assuming that the dynamics in the data have an ARMA structure. The ADF test is based on estimating the test regression.

$$\mathbf{z}_t = \beta' \mathbf{D}_t + \phi \mathbf{z}_{t-1} + \sum_{j=1}^p \phi_j \Delta \mathbf{z}_{t-j} + \varepsilon_t \quad (\text{Equation 3.8})$$

Where

$\mathbf{D}_t$, a vector of deterministic terms (constant, trend etc.). The lagged difference terms $\Delta \mathbf{z}_{t,j}$ are used to approximate the ARMA structure of the errors, and the value of p is set so that the error ε_t is serially uncorrelated. The error term is also assumed to be homoscedastic. The specification of the deterministic terms depends on the assumed behavior of $\mathbf{z}_t$ under the alternative hypothesis of trend stationarity as described in the previous section. Under the null hypothesis, $\mathbf{z}_t$ is I (1) which implies that $\phi = 1$. The ADF t-statistic and normalized bias statistic are based on the least squares estimates of (3.3) and are given by

$$ADF_t = t_{\phi=1} = \frac{\phi-1}{SE(\phi)} \quad (\text{Equation 3.9})$$

$$ADF_{n=1} = \frac{T(\phi_{-1})}{1 - (\phi_1 + \dots + \phi_n)} \quad (\text{Equation 3.10})$$

The null and alternate hypotheses for the regression are;

$$\begin{aligned} H_0: \phi &= 1 \\ H_1: \phi &\neq 1 \end{aligned}$$

Accepting the null hypothesis implies a presence of it unit root

ADF Test procedure

- Estimates a regression using equation.
- The usual t-statistical is not valid, thus degree of freedom developed appropriate critical values.
- You can include a constant, trend or both in the test
- If you accept the null hypothesis, you conclude that the series has a unit root.
- In that case, you should first difference the series before proceeding with analysis.

3.11.7.2 Seasonal Unit Root Test

A recent paper explains how to test for seasonal unit roots in the process that also exhibit deterministic or stationary frequency zero when unit root may be present at some or all of the seasonal frequencies²⁰. In this section the test will be reviewed by deriving its mechanics and the asymptotic distribution of its test statistics in the case of monthly rather than quarterly data. The Monte Carlo simulations will be used to calculate the finite sample distributions of the test statistics for hypothesis about the unit root at seasonal and zero frequencies in the monthly data and to investigate the size and power property of the test under various data generating mechanisms.

3.11.7.3 The Hegy Procedure

Let $\mathbf{z}_t$ be the series of interest by a general auto-regression of the form

$$\boldsymbol{\varphi}(\mathbf{B})\mathbf{Z}_{T=\varepsilon_t} \quad (\text{Equation 3.11})$$

Where $\boldsymbol{\varphi}(\mathbf{B})$ a polynomial in backshift operator and ε_t is a white noise process. Let $\mathbf{y}_k$ be the root of the characteristic polynomial associated with $\boldsymbol{\varphi}(\mathbf{B})$. Assumed for the moment that deterministic term such as seasonal dummies or time trends, are known to be absent from the process for $\mathbf{z}_t$. In general, some or all of the $\mathbf{y}_k$ may be complex.

The frequency associated with the particular root is the value of $\boldsymbol{\alpha}$ in $e^{\boldsymbol{\alpha}j}$ the polar representation of the root. A root is seasonal if $\boldsymbol{\alpha} = \frac{2\pi j}{m}$, $j=1 \dots m-1$, where m is the number of observations per year. For monthly data, the seasonal unit roots are;

$$-1; \pm i; -\frac{1}{2}(1 \pm \sqrt{3}i); -\frac{1}{2}(\sqrt{3} \pm i); \frac{1}{2}(\sqrt{3} \pm i)$$

With this root corresponding to 6,3,9,8,4,2,10,7,5,1 and 11 cycles per year respectively. The frequencies of those roots are $\pi, \pm \frac{\pi}{2}, \pm \frac{2\pi}{3}, \pm \frac{\pi}{3}, \pm \frac{3\pi}{6}$ and $\pm \frac{\pi}{6}$ respectively. We wish to know whether the polynomial in the backshift operator, $\boldsymbol{\varphi}(\mathbf{B})$, has roots equal to one in absolute value at the zero or seasonal frequencies. In particular, the goal is to set the hypothesis about a particular unit without taking a stand on whether other seasonal or zero frequency unit roots may be present. The testing developed by HEGY consists essentially of linearizing the polynomial $\boldsymbol{\varphi}(\mathbf{B})$, around the zero-frequency unit root plus the $m-1$ -unit roots given the expression above.

Thus, write $\boldsymbol{\varphi}(\mathbf{B})$ as

$$\boldsymbol{\varphi}(\mathbf{B}) = \sum_{k=1}^{\infty} \Delta(\mathbf{B}) \frac{1 - \partial_{K(\mathbf{B})}}{\partial_{K(\mathbf{B})}} + \Delta(\mathbf{B}) \boldsymbol{\varphi}^K(\mathbf{B}) \quad (\text{Equation 3.12})$$

3.11.8 Identification of Seasonal and Non-Seasonal ARMA Model

Seasonal is a pattern of a time series, which repeats at regular interval every year. We then want to focus in this section how the model of such series can be identified. But first we must note the following points to aid in model specification²².

4 observations per year if quarterly.

12 observations per year if monthly

52 observations per year if weekly.

The analyst must know the frequency of the seasonal period.

A seasonal ARMA/ARIMA model is formed by including additional seasonal term in the ARIMA models we have seen so far. It is written as follows:

ARIMA (p, d, q) $(P, D, Q)_m$

(Non-seasonal) (Seasonal)

Where m =rate of unemployment per season. The seasonal parts of the model are identified by the uppercase notation, and lowercase for the non-seasonal part of the model.

The seasonal part of the model consists of terms that are very similar to non- seasonal component of the model, but involve backshift of the seasonal period.

$$(1 - B)^d \phi_p(B) (1 - B^m)^D \phi_P(B^m) Z_t = C + \theta_q(B) \theta_Q(B^m) \varepsilon_t \quad (\text{Equation 3.13})$$

Where

$(1 - B)^d$ = the regular differencing of order d .

$(1 - B^m)^D$ = the seasonal differencing of order m

Z_t = the series of interest

$\phi_{p(B^m)}$ = the seasonal auto-regressive terms.

Given as $\phi_{p(B^m)} = 1 - \phi_1 B^m - \phi_2 B^{2m} \dots - \phi_p B^{pm}$

$\phi_P(B^m)$ = the regular auto-regressive terms.

Given as $\phi P^{(B)} = 1 - \phi P^{(B)} - \phi_2 B^2 - \dots - \phi_p B^p$

C= constant term

ε_t = The errors of residuals.

$\theta_{q(B)}$ = The regular moving average terms.

Given as $\theta_{q(B)} = 1 - \theta_q B - \theta_2 B^2 - \dots - \theta_q B^q$

$\theta_{q(B^M)}$ = The seasonal moving average terms

Given as, $\theta_{Q(B^M)} = 1 - \theta_{q(B^M)} - \theta_2 B^{2m} - \dots - \theta_{QM} B^{QM}$

The ARIMA model is often expressed as ARIMA (p, d, q) × (P, D, Q)_m, where m is the seasonal period; p, d, q are the auto-regressive, differencing, moving average orders in the non-seasonal part of the model; the P, D, Q are the auto regressive, differencing and moving average orders in the seasonal part of the model.

3.11.9 The Auto-Correlation Function (ACF) and Partial Auto-Correlation Function (PACF).

ACF is a complete auto-correlation function which drives home the values of auto-correlation of any series with its lagged values. That is, the present values are related to their past values. A time series have components like trend, seasonality, cyclic and residual. ACF takes good care of all these components while finding the correlation. PACF is a partial auto-correlation function. This finds correlation of the residuals (which remains after removing the effect which are already explained by the lags) with the next lag(s). this guides our modelling with the information at hand. While modelling multi-collinearity is usually avoided, hence relevant feature is kept.

A time series is said to be Auto-Regressive (AR) when present value of the time series can be obtained using previous values of the same time series. Moving Average (MA) is a process where the present value of series is defined as a linear combination of past errors. It is assumed the errors to be distributed with the normal

distribution. The seasonal part of AR or MA model will be seen in the seasonal lags of the PACF and ACF. For example, an ARIMA (0, 0, 0) (0,0,1) 12 model will show a spike at lag 12 in the ACF but no other significant spikes.

The PACF will show exponential decay in the seasonal lags; that is, at lags 12, 24, 36, ... Similarly, an ARIMA (0,0,0) $\times$ (1,0,0)12 model will show exponential decay in the seasonal lags of the ACF, a single significant spike at lag 12 in the PACF. In considering the appropriate seasonal order for an ARIMA model, restrict attention to the seasonal lags. The modeling procedure is almost the same as for non-seasonal data, except that we need to select seasonal AR and MA terms as well as the non-seasonal components of the models.

3.11.10 The ARMA (P, Q) Model

Auto-regressive moving average (ARMA) models form a class of linear time series models which are widely applicable. By allowing the order of an ARMA to increase, one can approximate any linear time series model with desirable accuracy. In what follows, we assume that (ε_t) is sequence of independent and identically distributed random variables with mean zero and finite variance σ^2 that is (ε_t) is a white noise series.

3.11.11 Model Diagnostic

Generally, this step includes the analysis of the residuals as well as model comparison. If the model fits well, the standardized residuals should behave as an independent and identically distributed sequence with mean zero and variance one⁷. A standardized residuals plot or a Q-Q plot can help in identifying the normality⁸. The model should pass the parametric and diagnostic check.

3.11.12 Forecasting

Forecasting plays an important role in decision-making process. It is a planning tool, which help decision maker to foresee the future uncertainly based on the behavior of past and current observations. Forecasting provide basis for economic and business planning, inventory and production control and optimization of industrial process. Forecasting is the process of predicting some unknown quantities. From previous studies, most research work has found that the selected model is not necessary the model that provides best forecasting. In this sense further forecasting accuracy test such as Mean Error (ME), Root Mean Square Error (RMSE), Mean Average Error (MAE) etc. must be performed on the two obtained².

3.12 Time Series Analysis (TSA) of Vegetation Cover and Land Surface

Temperature (LST)

Land use and land cover change (LULC) are two intertwin terminologies that are put in place of another²³. Land cover refers to the biophysical characteristics of the surface of the earth such as soil structure, water, distribution of vegetation, animals, rocks, valley, topography and other physical features of the land. While land use refers to the way in which land has been put to use by humans and their habitat for socio-economic purposes²⁴. Change in global environment has been attached to LULC. The rate at which land use, such as the need for more production, urbanization, rapid population growth, changing technologies, among the many drivers of LULC in the world today are so rapid²⁵.

Increasing population, economic expansion and human activities during the last five decades have adversely affected biodiversity and the worlds ecosystem. The changes in LULC at the same time resulting to changes that impact human livelihood²⁶. The study presents investigation of the significant variations of Vegetation Cover

Dynamics (VCD) and drivers, including, Land Surface Temperature (LST) from 1990-2020 in selected part of Southwest Nigeria. It was directly calculated by remote-sensing data using Moderate Resolution Imaging Spectroradiometer-Normalized Difference Vegetation Index (MODIS-NDVI), Moderate Resolution Imaging Spectroradiometer- Normalized Vegetation Build-up Index (MODIS-NDBI)²⁷ and Temperature Retrieval from Satellite Thermal Bands. The following are the processes for retrieving the structure of LULC in the study locations:

3.12.1 Scope of the Vegetation Cover Dynamics

This study basically involved examining the relationship between land use cover and Land Surface Temperature changes within the selected forest reserves using satellite data. It utilized Landsat data acquired between 1990 and 2020 to assess LULC changes over time and resulting spatial temperature variation. To achieve this, the study explored the land use land cover using land cover indicator such as NDVI, NDBI and thermal bands of the images to assess land use /cover change pattern and the impacts of such changes on surface temperature²⁸

3.12.2 Image Pre-processing.

In raw remote sensing data, each pixel has digital number value that corresponds to a raw measure required by the sensor²⁹. To obtain quantitative information from images, Digital Number (DN) must be converted to physical quantities, radiance and brightness temperature. It is necessary to correct images for atmospheric effects, because the presence of the atmosphere can cause significant distortions in the radiometric signal. The images that were used in this study was first converted to Top of Atmosphere (TOA) radiance using the equation 3.11³⁰.

$$L\lambda = \left(\frac{L_{MAX\lambda} - L_{MIN\lambda}}{Q_{CAL\lambda}} \right) Q_{CAL} + L_{MIN} \quad \text{(Equation 3.14)}$$

where,

$L\lambda$ = Spectral radiance at the sensor's aperture [$W/(m^2 \text{ sr } \mu m)$]

QCAL = Quantized calibrated pixel value [DN]

QCALMIN = Minimum quantized calibrated pixel value corresponding to $L_{MIN}\lambda$ [DN]

QCALMAX = Maximum quantized calibrated pixel value corresponding to $L_{MAX}\lambda$ [DN]

$L_{MIN} \lambda$ = Spectral at-sensor radiance that is scaled to QCALMIN [$W/(m^2 \text{ sr } \mu m)$]

L_{MAX} , = Spectral at-sensor radiance that is scaled to Qcalmax [$W/ (m^2 \text{ sr } \mu m)$].

The above expression does not consider the atmospheric effects, therefore there is need to convert images from radiance to reflectance measures, using equation 3.12³¹.

$$\rho\lambda = \frac{(\pi * TOA_r * d^2)}{E_{SUN\lambda} * \cos\theta_{sz}} \quad \text{(Equation 3.15)}$$

Where:

$\rho\lambda$ = Planetary TOA reflectance (unitless)

π = mathematical constant approximately equal to 3.14159 (unitless)

$L\lambda$ = spectral radiance at the sensors aperture [$w/(m^2 \text{ sr } \mu m)$]

d^2 = the earth-Sun distance (Astronomical unit)

E_{SUN} = mean exoatmospheric solar irradiance [$w/(m^2 \text{ sr } \mu m)$].

θ_{SZ} = the solar zenith angle (degree). The cosine of this angle is equal to the sine of the sun elevation θ_{SE} .

That is, $\theta_{SZ} = \cos (90 - \theta_{SE})$.

The grid referencing system of individual bands of each of the images used were transformed to one reference system (WGS_1984_UTM_Zone_31N). The re-projection is important to make accurate analysis of the datasets and comparability possible. The software projection module undertakes projection transformations using ellipsoidal formulas and datum transformations using, for example, Molodensky transform process³².

3.12.2.1 Image Classification

Land use/cover patterns and surface temperature for the years 1990, 2000, 2010, and 2020 was mapped using the pre-processed LANDSAT data (Table 3.9). To classify the images, a modified version scheme of land use/cover classification was adopted¹⁶ and the categories include Table 3.9.

Table 3.9: A modified version of the Anderson scheme of land use/cover classification.

1. Built-up Land	Residential, Commercial and Services, Transportation, Communications, and Utilities, Industrial and Commercial areas.
2. Vegetation	Cropland, Orchards, Vineyards, Nurseries, and Confined Feeding Operations Plantation and mixed forest.
3. Open Water	Streams, Lakes, and Reservoirs.

Source:³¹

The overall objective of image classification is to automatically categorize all pixels in an image into land cover classes or themes. Normally, multispectral data was used to perform the classification, and the spectral pattern present within the data for each pixel was used as numerical basis for categorization. That is, different feature types manifest different combination of DNs (Digital Numbers) based on their inherent spectral reflectance and emittance properties³³

Over the years, scientists have devised many classification strategies. From these alternatives the analyst must select the classifier that will best accomplish a specific task. At present it is not possible to state that a given classifier is “best” for all

situations because characteristics of each image and the circumstances for each study vary so greatly ²⁷. Therefore, this study intends to utilize Maximum Likelihood Classification Algorithm and spectral values based on Vegetation indices and band ratios, as integral part of the classification processes. The following vegetation indices was derived using simple mathematical operations to also segregate land use land cover types for sub-pixel analysis of the relationship between the land cover types and surface temperature. The results of these operations make classification of the study area in pixels into different land cover types relatively easy.

3.12.3 LULC Classification Schema

On the completion of the imageries, the digital classification was performed on the Landsat Scenes using the maximum likelihood supervised algorithm within *Idrisi taiga 17.0* image processing software. This classified imagery provides guide to area of forest, built-up, open water, woodland and bare land. Table 3.10 shows the land use/landcover (LULC) classification schema used²⁹. Application of image processing software further threw more light to more classification.

Table 3.10 Land Use Land Cover (LULC) Classification Schema

Code	LULC Class
1	Forest land
2	Built up
3	Open water
4	Woodland
5	Bare land

Source:²⁹

3.12.4 Temperature Retrieval from Satellite Thermal Bands for the Study Period:

Surface Temperature (ST) retrieval was carried out through three phases:

a. Conversion from Digital Number to Radiance

All the image bands are quantized as 8bit data except Landsat 8 which is 16 bits, thus; all information was stored in DN which was converted to radiance with a linear equation (3). The linear equation 3.13¹² is given as:

$$Y = mx + b$$

(Equation.3.16)

Where,

Y=TOAr (Top of Atmosphere) radiance - the radiance measured by the sensor

m= Radiance multiplicative value

x= Raw band

b= Radiance additive value

b. Conversion from Radiance to Brightness Temperature

By applying the inverse of the Planck function, thermal bands radiance values were converted to brightness temperature value using equation 3.14.¹¹. This was satellite temperature in Kelvin²⁵.

$$B_t = \frac{K_2}{\left(\ln\left(\frac{K_1}{TOAr} + 1\right)\right)} \quad (\text{Equation 3.17})$$

where

Bt = ° Kelvin

TOAr =Top of Atmosphere radiance

K1 = calibration constant 1 (607.76 for TM), (666.09 for ETM+) and (774.89 for OLI band 10)

K2 = calibration constant 2 (1260.56 for TM), (1282.71 for ETM+) and (1321.08 for OLI band 10).

c. Surface Temperature (ST) Retrieval

ST was derived from TM6 and OLI 10 using emissivity corrected model:

$$St = \frac{T}{1 + \left(\frac{\lambda x T}{\rho}\right) \ln \varepsilon} \quad (\text{Equation 3.18})$$

Where,

St = ST

λ = wavelength of emitted radiance (11.345 for TM/ETM and 11.5 μm for OLI)

$\rho = h \times c / (1.438 \times 10^{-2} \text{ m K})$

σ = Boltzmann constant ($1.38 \times 10^{-23} \text{ J/K}$)

h = Planck's constant ($6.626 \times 10^{-34} \text{ J s}$)

c = velocity of light ($2.998 \times 10^8 \text{ m/s}$)

ε = denotes emissivity

3.12.4.1 Calculating Heat Island

Different points were obtained with the aid of GPS that was overlaid on the land surface temperature maps using the ArcGIS 10.5 to extract the temperature values for each of the points both rural and urban and this will give Urban Heat Island (UHI) using the formula;

$$\text{UHI} = T_u - T_r \quad (\text{Equation 3.19})$$

Where,

T_u represents urban temperature and T_r represents rural temperature.

3.12.5 Derivation of Normalized Difference Vegetation Index (NDVI)

NDVI was introduced in order to produce a spectral VI¹⁷ that separates green vegetation from its background soil brightness using Landsat digital data. It is expressed as the difference between the near infrared and red bands normalized by the sum of those bands. It is the most commonly used VI as it retains the ability to minimize topographic effects while producing a linear measurement scale. In addition, division by zero errors is significantly reduced. NDVI values will typically range between -1 and 1 where the higher the value, the healthier and denser the vegetation.

Moreover, values greater than 0.2 usually indicate vegetation, whereas values below 0.2 generally indicate soil, rock, or man-made materials. Water bodies typically give negative NDVI values¹⁷ can be used to create NDVI map³⁴.

$$NDVI = \frac{\rho_{NIR} - \rho_{Red}}{\rho_{NIR} + \rho_{Red}} \quad (\text{Equation 3.20})$$

Where,

ρ_{NIR} = near-infrared reflectance

ρ_{Red} = red reflectance

3.12.5.1 The Normalized Difference Built Index (NDBI)

The built-up land image can be produced using the NDBI¹⁷ with the equation 3.21.

$$NDBI = \frac{\rho_{MIR} - \rho_{NIR}}{\rho_{MIR} + \rho_{NIR}} \quad (\text{Equation 3.21})$$

Where

ρ_{MIR} = mid-infrared reflectance

ρ_{NIR} = near-infrared reflectance

The development of the index is based on the unique spectral response of built-up lands that have higher reflectance in *MIR* wavelength range than in *NIR* wavelength range.

3.12.6 Surface Temperature and LULC (NDVI and NDBI) Relationship

To investigate the effect of LULC on surface temperature, it is necessary to examine the changes of temperature with vegetation cover. In this study, regression analysis between the temperature images and the respective indices was carried out, based on 100 points that was collocated on both surface temperature and vegetation indices.

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Chapter Four

Results and Discussion of Findings

This chapter discussed the results and findings from the analysis of data presented from different sources such as climatic parameters (Rainfall, Maximum Temperature and Minimum Temperature), vegetation cover dynamics, demographic characteristics of the respondents, and adaptation strategies. In addition, it provides answers to research questions and testing of hypotheses. It discussed the effects of the forest biodiversity on the economic livelihood of the people living within and around forest environment¹. This was achieved by analyzing the data gathered by the use of livelihood assessment methodology involving quantitative and qualitative analysis, interpretation, cross-checking and synthesis². This becomes inevitable due to the nature of the objectives of the study and it is therefore desirable that the analysis follows a well-articulated procedure. The results presented on the social survey are the positive responses of the respondents.

4.1 Presentation of Decadal variability of rainfall, temperature, the anomaly and Trend

4.1.1 Rainfall Changes

The annual rainfall in Southwest Nigeria is over 3000mm from the very coastal area to less than 1500mm in the hinterland³². The period of rainy season in the Country has been witnessing reduction from 1941 when the onset and cessation of rainfall were regular to 1971 when late onset and early cessation of the rainy season started. since then, the duration and the length of the rainy season has remained shrinking, while the annual rainfall is about the same or even more, thereby giving rise to a high impact rainfall in form of flash floods⁶⁸. The years considered in the decadal trend in rainfall

and temperature was 30 years (1991-2020), to have three decades in all the study locations (1991-2000; 2001-2010; 2011-2020).

Tables 4.1-4.4 show the decadal rainfall anomalies in the study area. In Akure forest reserve, the rainfall normal was 1546mm, Ologe (1595mm), Gambari (1311mm) and Okoiro (1217mm) which was the baseline for the calculation of Standard Deviation and Rainfall Anomaly. The results are the yardstick for justifying the precipitation quality of the years, as such, classified as very dry, dry, humid and very humid. What precipitation quality and quantity in each study location is relative.

Table 4.1: Estimated positive and Negative Decadal Rainfall anomaly Index for Akure Forest Reserve, Akure.

Study Location	Baseline Data (Standardized Normal) mm.	(STD)	Observed Annual Rainfall	R.A	Classification
Akure (Ondo Station) (1991-2000)	1546	247	1991(2096.6)	1.7	Humid
			1992 (1804)	0.8	Humid
			1993 (1655)	0.3	Humid
			1994 (2134)	1.8	Humid
			1995(2503.2)	3.0	Very Humid
			1996(1827.8)	0.9	Humid
			1997(2283.6)	2.3	Very Humid
			1998(1375.3)	-0.5	Dry
			1999(2101.2)	1.7	Humid
			2000(2069.1)	1.6	Humid
2001-2010	1546	325	2001(1516)	-0.1	Dry
			2002(1928)	1.9	Humid
			2003(1690)	0.7	Humid
			2004(1861)	1.5	Humid
			2005(1914)	1.8	Humid
			2006(1944)	1.9	Humid
			2007(2026)	2.3	Very Humid
			2008(2062)	1.5	Humid
			2009(2157)	3.0	Very Humid
			2010(1587)	0.2	Humid
2011-2020	1546	367	2011(1999.8)	1.2	Humid
			2012(1991.6)	1.2	Humid
			2013(1447.3)	-0.3	Dry
			2014(1544.8)	0.01	Humid
			2015(2518)	2.6	Very Humid
			2016(1588.2)	0.1	Humid
			2017(1645)	0.3	Humid
			2018(1997.6)	1.2	Humid
			2019(2258.6)	2.0	Very Humid
			2020(1439.5)	-0.6	Dry

Note: STD=Standard Deviation; R.A= Rainfall Anomaly

Source: Researcher's Derivation of Anomaly, 2022

Table 4.1 showed the decadal raw data for thirty (30) years computed and estimated for Akure forest reserve. The findings revealed that the area falls under wetness condition for the period of twenty (20) years, extreme wetness six (6) years and dryness, three (3) years within the period. The dryness signified apparent climatic

change of rainfall deficit and consequently affect crops and livelihood. However, 1995, 1997, 2009, 2015 and 2019 were estimated as extremely and very wet conditions that led to exacerbated flooding in the area which damaged hundred hectares of farmland and properties. The trend of this RA can also be examined at decadal level for comparison.

Table 4.2: Estimated positive and Negative Decadal Rainfall anomaly Index for Ologe Forest Reserve, Badagry.

Study Location	Baseline Data (Standardized Normal) mm.	(STD)	Observed Annual Rainfall	R.A	Classification
Badagry (Ikeja station) (1991-2000)	1595	292	1991(1610)	0.1	Humid
			1992(1671.8)	0.3	Humid
			1993(1188.4)	-1.4	Dry
			1994(1671.5)	0.3	Humid
			1995(1141.3)	1.6	Humid
			1996(1629.8)	0.1	Humid
			1997(1589.5)	0.01	Humid
			1998(1749.6)	0.5	Humid
			1999(926.5)	-2.3	Very Dry
			2000(1197.7)	-1.4	Dry
2001-2010	1595	190.1	2001(1125)	-2.5	Very Dry
			2002(1392.1)	-1.1	Dry
			2003(1802.3)	-1.1	Dry
			2004(1699.2)	0.6	Humid
			2005(1483.9)	-0.6	Dry
			2006(1516.9)	-0.4	Dry
			2007(1539.9)	-0.3	Dry
			2008(1553.7)	-0.2	Dry
			2009(1393.2)	-1.1	Dry
			2010(1669.5)	0.4	Humid
2011-2020	1595	297.3	2011(1748)	0.5	Humid
			2012(1557)	0.1	Humid
			2013(1726)	0.4	Humid
			2014(2117)	1.8	Humid
			2015(1182)	-1.4	Dry
			2016(1426)	-0.6	Dry
			2017(1615.6)	-0.1	Dry
			2018(1476)	-0.4	Dry
			2019(2096.4)	1.7	Humid
			2020(1412.7)	-0.6	Dry

Note: STD=Standard Deviation; R.A= Rainfall Anomaly
Source: Researcher's Derivation of Anomaly, 2022

Table 4.2 showed the decadal raw data for thirty (30) years computed and estimated for Akure forest reserve. The findings revealed that the area falls under wetnetness condition for the period of twenty (14) years, extreme dryness two (2) years and dryness, three (14) years within the period. The dryness signified apparent climatic change of rainfall deficit and consequently affect crops and livelihood. However, 1991 and 2001 were estimated as extremely and very dry conditions that led to exacerbated drought in the area which caused low crop yield, poverty and crop damage as a result of excessive heat in Ologe Forest Reserve. The trend of this RA can also be examined at decadal level for comparison.

Table 4.3: Estimated positive and Negative Decadal Rainfall anomaly Index for Gambari Forest Reserve, Ibadan.

Study Location	Baseline Data (Standardized Normal) mm.	(STD)	Observed Annual Rainfall	R.A	Classification
Gambari (Ibadan Station) (1991-2000)	1311	197	1991(1396.3)	0.4	Humid
			1992(1155.6)	-0.8	Dry
			1993(1574.8)	1.3	Humid
			1994(1095.9)	-1.1	Dry
			1995(1473.1)	0.8	Humid
			1996(1506.2)	1.0	Humid
			1997(1360)	0.2	Humid
			1998(1151.7)	-0.8	Dry
			1999(1640.3)	1.7	Humid
			2000(1178.4)	0.7	Humid
2001-2010	1595	212	2001(1133.6)	-0.8	Dry
			2002(1196.4)	-0.5	Dry
			2003(1304)	0.03	Humid
			2004(1006)	-1.4	Dry
			2005(1314)	0.01	Humid
			2006(1198.5)	-0.5	Dry
			2007(1079.3)	-1.1	Dry
			2008(1435.8)	0.6	Humid
			2009(1504)	0.9	Humid
			2010(1702.5)	1.8	Humid
2011-2020	1595	312	2011(1433.6)	0.4	Humid
			2012(1537.7)	0.7	Humid
			2013(1548.9)	0.7	Humid
			2014(1148.1)	0.8	Humid
			2015(1028.7)	-0.9	Dry
			2016(1349.7)	0.1	Humid
			2017(1362.5)	0.2	Humid
			2018(1389.6)	0.3	Humid
			2019(1784.9)	1.5	Humid
			2020(2130)	2.6	Very Humid

Note: STD=Standard Deviation; R.A= Rainfall Anomaly

Source: Researcher's Derivation of Anomaly, 2022

Table 4.3 showed the decadal raw data for thirty (30) years computed and estimated for Akure forest reserve. The findings revealed that the area falls under wetness condition for the period of twenty (20) years, extreme wetness six (1) years and dryness, three (8) years within the period. The dryness signified apparent climatic change of rainfall deficit and consequently affect crops and livelihood. However,

2020 was estimated as extremely and very wet conditions that led to exacerbated flooding in the area which damaged hundred hectares of farmland and properties. The trend of this RA can also be examined at decadal level for comparison.

Table 4.4: Estimated positive and Negative Decadal Rainfall anomaly Index for Okoiro Forest Reserve, Ogbomosho.

Study Location	Baseline Data (Standardized Normal) mm.	(STD)	Observed Annual Rainfall	R.A	Classification
Ogbomosho (Kwara Station) (1991-2000)	1217	247	1991(1469.4)	1.0	Humid
			1992(981.6)	-1.2	Dry
			1993(1177)	-0.2	Dry
			1994(1242)	0.1	Humid
			1995(1409.2)	0.8	Humid
			1996(945.3)	-1.1	Dry
			1997(1334.4)	0.5	Humid
			1998(1596.5)	1.5	Humid
			1999(1539.3)	1.3	Humid
			2000(993.3)	-0.9	Dry
2001-2010	1217	236	2001(697.7)	-2.2	Very Dry
			2002(957.1)	-1.1	Dry
			2003(1286.7)	0.3	Humid
			2004(1327.1)	0.4	Humid
			2005(1317.1)	0.4	Humid
			2006(1303.8)	0.4	Humid
			2007(1292.2)	0.3	Humid
			2008(1401.4)	0.8	Humid
			2009(1343.4)	0.5	Humid
			2010(924.3)	-1.2	Dry
2011-2020	1595	312	2011(1086.5)	-0.3	Dry
			2012(1079.1)	-0.3	Dry
			2013(1271.5)	0.1	Humid
			2014(2296.5)	2.1	Very Humid
			2015(1701.1)	0.9	Humid
			2016(2552.6)	2.6	Very Humid
			2017(1483)	0.5	Humid
			2018(2195)	1.9	Humid
			2019(2012.2)	1.5	Humid
			2020(1964.2)	1.4	Humid

Note: STD=Standard Deviation; R.A= Rainfall Anomaly

\ Source: Researcher's Derivation of Anomaly, 2022

Table 4.4 showed the decadal raw data for thirty (30) years computed and estimated for Akure forest reserve. The findings revealed that the area falls under wetnetness

condition for the period of twenty (17) years, extreme wetness six (2) years, dryness, three (8) years and extreme dryness of one (1) within the period. The dryness signified apparent climatic change of rainfall deficit and consequently affect crops and livelihood. However, 2014 and 2016 were estimated as extremely and very wet conditions that led to exacerbated flooding in the area which damaged hundred hectares of farmland and properties, while, 2001 was considered as extremely and very dry. The trend of this RA can also be examined at decadal level for comparison.

4.1.2 Analysis of Rainfall Characteristics in the Study Locations

Tables 4.5-4.8 present the Characteristics of the decadal variability of rainfall. It can be deduced from the from the table the following: Decades, Total Rainfall (TR), Decadal Changes (DC), Decadal Average, Standard Deviation (SD), Coefficient of Variation (CV) and the measure of the weather available for each decade. Thev concept of coefficient of variation revealed that the average amount of precipitation need not necessarily be a constraint to successfully carrying out an agricultural or water resources operation. It depends on what one has adapted to as practices or operating rules, be it low rainfall or high rainfall. The assurance should be, will the rain fall when needed or as expected? If not, CV of annual precipitation is an index of climatic risk, indicating a likelihood of fluctuation in reservoir storage or crop yield from year to year. The higher the CV, the more variable the year to year (inter-annual) rainfall of a locality is. In southwet region, the adaptation to high rainfall is expected in Badagry, Ibadan, and Akure than Ogbomosho because of differential ecological zone with crop specific production. Hence, what is classified in one location as humid(wetness) can be very humid(extreme wetness) or very dry(extreme dryness) in

another location. Wetness in this context is rainfall above standard normal (flood) and dryness is rainfall below standardized normal(drought).

Table 4.5: Analysis of Decadal Characteristics Feature of Rainfall in Akure

Forest Reserve

Decade	TR (mm)	DC (mm)	DA (mm)	S.De v	CV (%)	Very Dry	Dry	Humid	Very Humid
1991- 2000	19851 .9	-	1985.2	325	16.4	-	1998.	1991,1992,1 993,1994,19 96,1999,200 0	1995,199 7
2001- 2010	18689 .7	-1162	1869	208	11		2001	2002,2003,2 004,2005,20 06,2008,201 0	2007,200 9
2011- 2020	18430 .8	-258	1843	367	20		2013,202 0	2011,2012,2 014,2016,20 17,2018	2015,201 9

Cumulative rainfall for 30 years is 56,972.4 mm

Note: TF- Total Rainfall, DC- Decadal changes, DA-Decadal Averages, S.Dev- Standard deviation, LTA- Long Term Average, CV-Coefficient of variation.

Source: Researcher's Derivation of Anomaly, 2022

Tables 4.5 presents, the total amount of rainfall for the first, second and third decade with the values of 19,851.9mm, 18689.7mm and 18,430.8 mm respectively. It is obvious that the total decadal rainfall is decreasing from the first decade to second decade (-1162mm) and from the second decade to third decade (-258). As the level of changes is narrowing out, there is the tendency for the rainfall to increase in future. The decadal average has the same characteristic with the total decadal rainfall with the value of 1985.2mm, 1869mm and 1843mm for the first, second, and third decade respectively. The standard deviation for the first, second and third decades is 325, 208 and 367. This depicts that first and third decade, the data points are more dispersed from the mean while the second SD is closer the mean. As such the data result are always reliable with small SD. The Coefficient of variation is an indication of the magnitude of variability in rainfall. The CV is a measure of reliability or variability of

phenomena. The higher the CV, the greater the level of dispersion around the mean. CV of between 1% and 5% is a reasonable and ideal target for most application. In Akure Forest Reserve the CV for 1st 2nd and 3rd are 16.4%, 11% and 20% respectively, are higher than the ideal CV, which implies variability in the climatic data. The indication of wetness and dryness is shown in its magnitudes: very dry, dry, humid and very humid as shown in Table 4.5. In the first decade 1 year is dry, 7 years is wet, while 2 years is extremely wet (flood). In second decade, had the same as the first decade and lastly there were 2 years of dryness, 6 years of wetness and 2 years of extreme wetness.

Table 4.6: Analysis of Decadal Characteristics Feature of Rainfall in Ologe Forest Reserve in Badagry

Decade	TR (mm)	DC	DA	S.D ev	CV (%)	Very Dry	Dry	Humid	Very Humid
1991- 2000	14376 .2		1437 .6	291. 6	20	1999	1993,2000	1991,199 2,1994,19 95,1996,1 997,1998	
2001- 2010	15175 .8	799.6	1517 .6	190. 1	12.5	2001.	2002,2003, 2004,2005, 2006,2007, 2008,2009	2004	
2011- 2020	16359 .5	1183. 7	1636	297. 3	18		2015,2016, 2017,2018, 2020	2011,201 2,2013,20 14,2019	

Cumulative rainfall for 30 years is 45,911.5 mm

Note: TF- Total Rainfall, DC- Decadal changes, DA-Decadal Averages, S.Dev- Standard deviation, LTA- Long Term Average, CV-Coefficient of variation.

Source: Researcher's Derivation of Anomaly, 2022

Table 4.6: Analysis of Decadal Characteristics Feature of Rainfall in Gambari Forest Reserve.

As shown in Table 4.6, there was increasing trend in rainfall with decades as there were with decadal average. It is very obvious that the standard deviation varies also. The CV are above ideal of between 1-5% which is an implication of unreliability of rainfall. Here in this location in the first decade, there was 1 year of drought, 2 years of dryness, and 7 years of wetness. In the third decade, there was 1 year of drought, 8 years of dry and 1 year of wet. There is tendency for flood to sweep away the farmland in southwest Nigeria⁵⁹

Table 4.7: Analysis of Decadal Characteristics Feature of Rainfall in Gambari Forest Reserve in Ibadan.

Decade	TR (mm)	DC (mm)	DA (mm)	S.D ev	CV (%)	Very Dry	Dry	Humid	Very Humid
1991- 2000	13532 .5		1353. 3	197	14.6		1992,1994,1 998	1991,1993, 1995,1996, 1997,1999, 2000	
2001- 2010	12874 .8	-657.7	1287	212	16.5		2001,2002,20 04,2006,2007	2003,200 5,2008,20 09,2010	
2011- 2020	14713 .7	1838. 9	1471. 4	312	21.2		2015	2011,201 2,2013,20 14,2016,2 017,2018, 2019	2020

Cumulative rainfall for 30 years is 41,121 mm

Note: TF- Total Rainfall, DC- Decadal changes, DA-Decadal Averages, S.Dev- Standard deviation, LTA- Long Term Average, CV-Coefficient of variation.

Source: Researcher's Derivation of Anomaly, 2022

As shown in Table 4.7, variation in total rainfall was experience in the three decades as it affected the decadal average. The SD is not stable while the coefficient of variation is higher than the ideal of between 1-5%. In this location 3 years experienced dryness, while 7years experienced wetness.

Table 4.8: Analysis of Decadal Characteristics Feature of Rainfall in Okoiro Forest Reserve, Ogbomosho.

Decade	TR (mm)	DC	DA	S.D ev	CV (%)	Very Dry	Dry	Humid	Very Humid
1991- 2000	12638	-	1263 .8	247	19.5		1992,199 3,1996,20 00	1991,199 4,1995,19 97,1998,1 999	
2001- 2010	11850 .5	-787.5	1185 .05	236	20	2001	2002 2010	2003,200 4,2005,20 06,2007,2 008,2009	
2011- 2020	17641 .7	5791. 2	1764 .2	521	29.5		2011,201 2	2013,201 5,2017,20 18,2019,2 020	2014,201 6

Cumulative rainfall for 30 years is 42,130.2 mm

Note: TF- Total Rainfall, DC- Decadal changes, DA-Decadal Averages, S.Dev- Standard deviation, LTA- Long Term Average, CV-Coefficient of variation.

Source: Researcher's Derivation of Anomaly, 2022

In Table 4.8, decadal total rainfall fluctuates as the average. Also, the standard deviation for all the decades is not static. The CV were above the ideal of between 1-5% which indicated unreliability of rainfall. 4 years of dryness and 6 years of wetness were experienced in the first decade. In the second decade, 1 year of very dry, 2 years of dryness and 7 years of humid were experienced.

It was discovered that the cumulative rainfall for the study period (30 years) varied across the study location, Akure (56,972.4mm), Ologe (45,911.5), Gambari (41,121mm and Okoiro (42,130.2mm).

4.1.3 Impact of Rainfall and Temperature Anomaly on the Vegetation and Livelihood in the Study Location

The impact of an estimated Rainfall Anomaly Index (RAI) on agriculture/vegetation production and the way of lives of the Southwest Nigeria can be viewed in two perspectives namely; impact of wetness and dryness conditions on agriculture

production. The wetness conditions are defined in terms of excessive water as flood scenarios while the dryness conditions are described in terms of insufficient water as drought. Observation from this implies that there was disappointment of expectation in rainfall in each study location which is an indication of climate change⁵. Also, the high moisture demanding crops will suffer where dryness has taken over and where low water demanding crop are getting more than enough will also suffer from flood. This portends flash flood events, inundation of farmland, and increase in surface runoff which can lead to erosion of soil nutrients and reduction in agricultural output³. Climate change has affected rainfall distributions in Sub-Saharan Africa (SSA), as there is either more or less rainfall than the farmers are used to. Rainfall amount and period can no longer be predicted which can lead to heavy loses of farm land. Rainfall variation is predicted to continue to increase in the southern part of Nigeria with rising sea levels, exacerbating flooding and submersion of coastal land⁶²



Plate 4.1: The apparent effect of drought in one of the study area

Source: Field Photograph, 2021

4.1.4 Cumulative Annual Rainfall for the Study Area

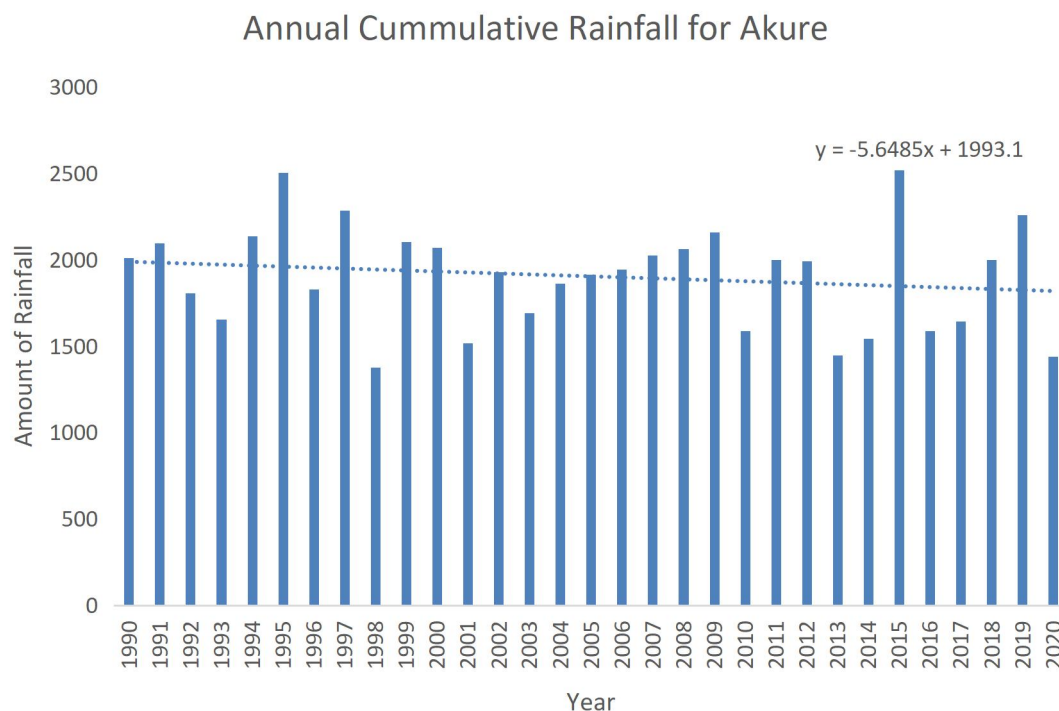


Figure 4.1: Rainfall Trend between 1990 and 2020 in Akure, Ondo State

Source: Researcher's Data Computation. 2022.

In Figure 4.1, the 31 years annual rainfall experienced surplus above standardized rainfall of 1546mm. Year 2015 had the highest rainfall value of 2518.4mm, while year 1995 had 2503.3mm then 1997 with the value of 2283.6mm. The years 1998, 2001, 2013, 2014 and 2020 with the value of rainfall 1375.3mm, 1516.6mm, 1447.3mm, 1544.3mm and 1439.5mm respectively fell short of standardized rainfall for the location. Hence, it is expected that the next decade's rainfall will be between 1500mm and 2000mm. But the rainfall trend is descending as shown in the chart.

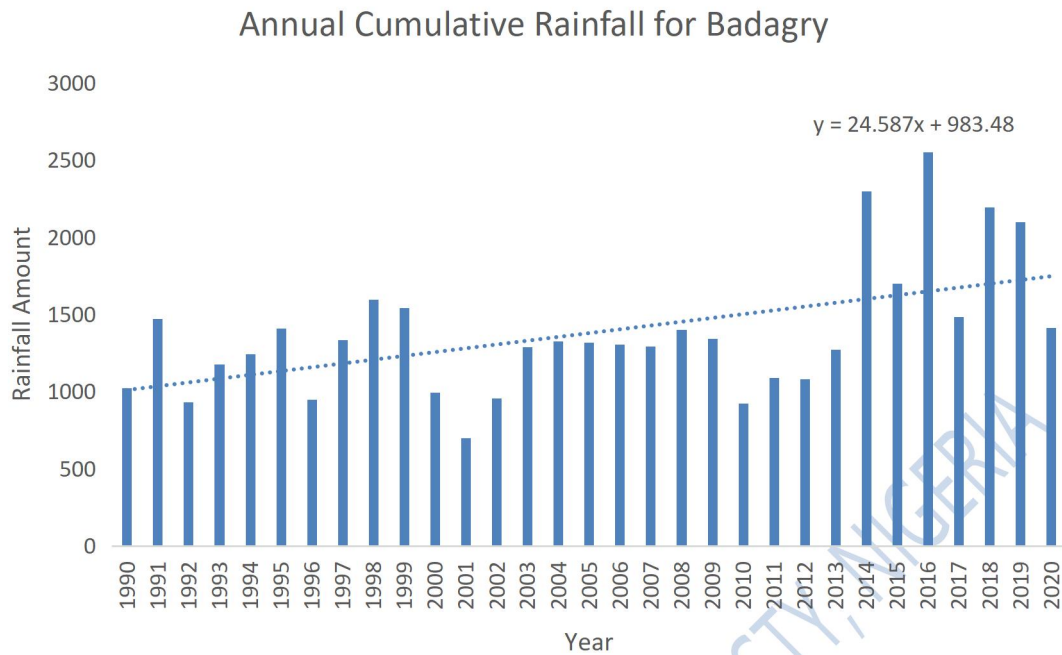


Figure 4.2: Bar Chart of rainfall between 1990 and 2020 in Badagry Lagos

Source: Researcher's Data Computation, 2022.

It is obvious from Figure 4.2, that rainfall amount for 31 years at a glance rose above 1600mm with the highest peak recorded in 2016 which has a rainfall amount of 2096.4mm. Additionally, rainfall amount for the last decade is not consistently high as the second decade. Looking at the first decade in the chart, 7 years of annual rainfall were above 1700mm. Overall the rainfall distribution was generally favourable to some crop development and supported crops that requires high spread of rainfall (Cereals). By implication, we should expect rainfall pattern to be above 1500mm in the next 10years. As shown in the chart, the rainfall pattern is ascending. More annual rainfall is expected in the next years to come.

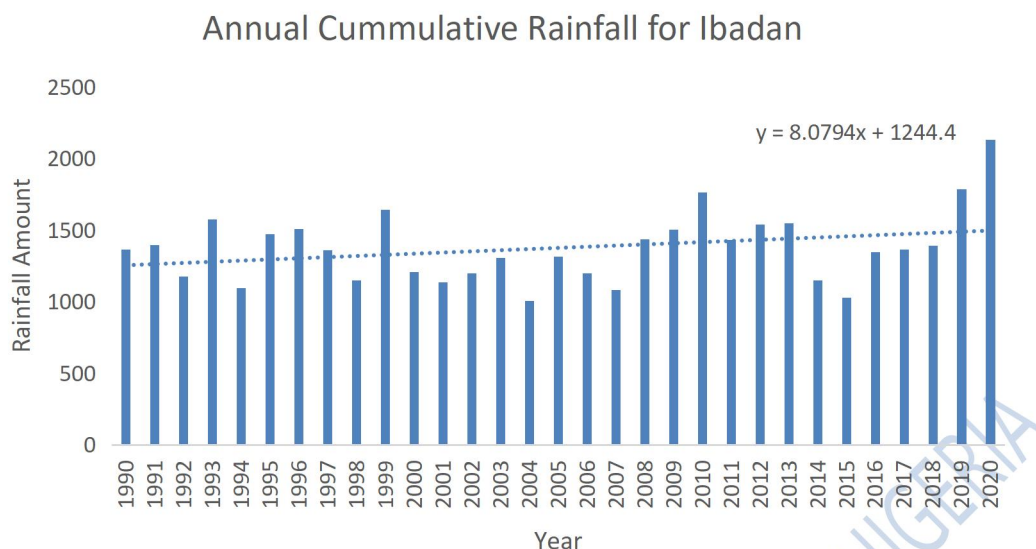


Figure 4.3: Rainfall trend between 1990 and 2020 in Ibadan, Oyo State
Source: Researcher's Data Computation, 2022.

Figure 4.3 shows the total rainfall trend in Ibadan between the years (1990-2020). Year 2020 had the highest rainfall amount. Followed by 2009 and closely followed by 1999 and 1993 which is almost at par. The least rainfall recorded was in the year 2004 and 2015 . According to the trend pattern, it is likely to have more rainfall in the years to come.

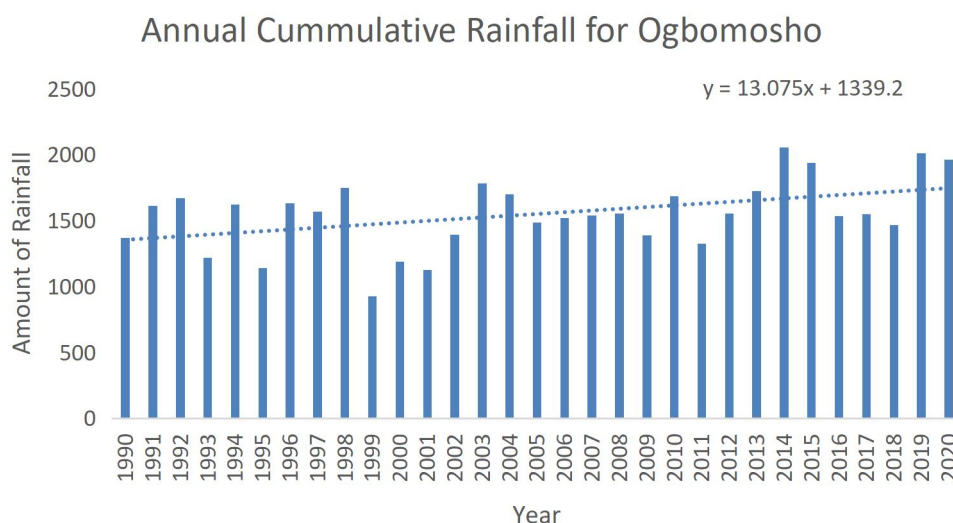


Figure 4.4: Rainfall trend between 1990 and 2020 in Ogbomosho, Oyo State
Source: Researcher's Data Computation, 2022.

Generally, the rainfall in this area is very low due to its geographic location (Guinea Savanna belt). The last decade (2010-2020) in the chart has the highest cumulative rainfall amount (17,641.7mm) and it rises consistently as illustrated in Figure 4.4. The year 2016 witnessed the highest rainfall amount in the last 30years with the value of 2552.6mm followed by 2014, and 2018 with the value of 2296.5mm and 2195mm respectively. From this trend it is expected that the study area would experience rainfall amount of between 1300mm and 1350mm in the next decade 2020-2029. More rainfall is expected in the years to come according to the trend line.

4.1.5 Cumulative Annual Rainfall for all the study

Locations

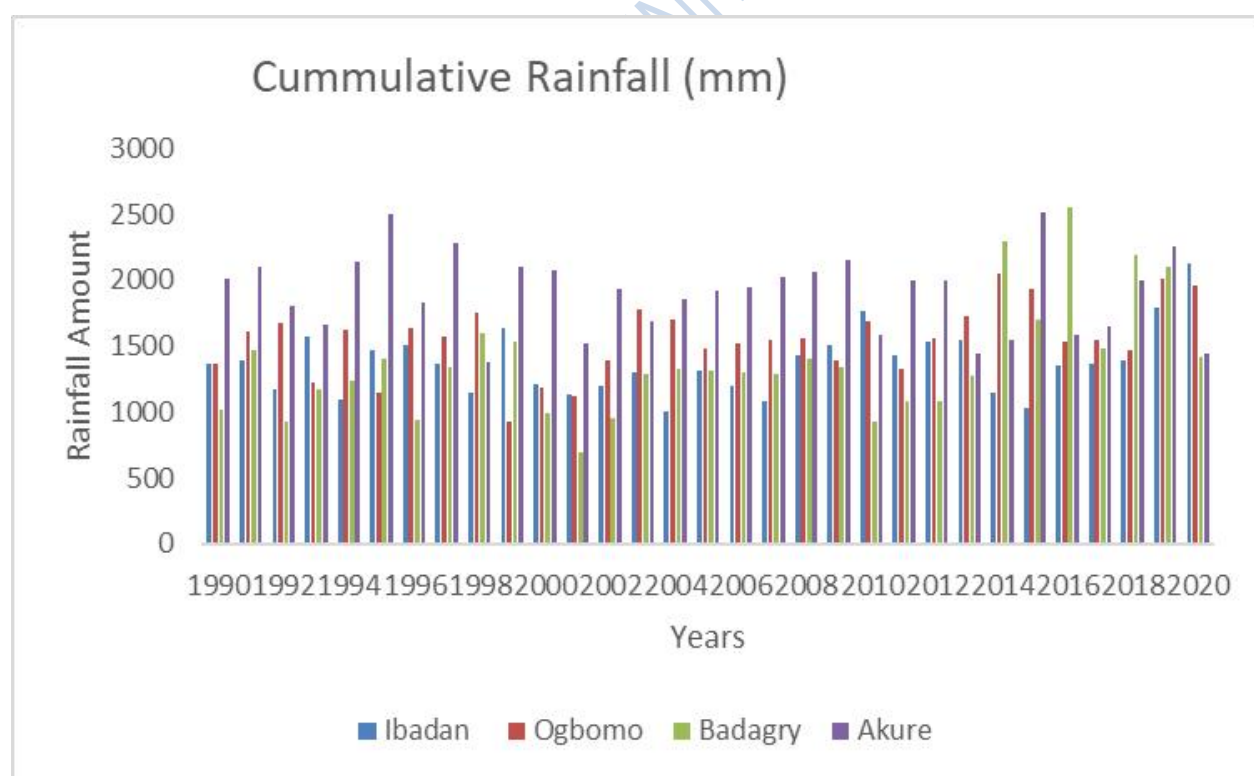


Figure 4.5 Integrated rainfall Chart for all the Study Locations

Source: Researcher's Data Computation, 2022.

The Figure 4.5, shows that Akure has the highest rainfall in all the study locations.

4.2 Temperature Changes

Energy is an important phenomenon which determines the well-being of any society and its scale of use determines the socio-economic development of any nation. Southwest Nigeria is generally characterized by a high temperature regime almost throughout the year by virtue of longitudinal and latitudinal position to the equator. It has a mean maximum temperature of about 32°C. However, the mean minimum temperature is 21°C. The analysis for the surface temperature data for the periods of 1990-2020 in the study area shows an increasing trend in annual mean maximum and minimum temperature over the last few decades⁶⁹

4.2.1 Temperature Anomaly for the Study Locations

The inter-annual temperature changes shown in Tables 4.9-4.12, display the disparity between the observed temperature and standardized normal for each study location. These tables revealed whether the temperature is rising or falling annually. In the tables there is Long-Term Average (LTA), Observed Temperature, Temperature Anomaly and remark. The temperature anomaly is the departure from a reference value of LTA. A positive anomaly signifies that the Observed temperature was warmer than the reference value, while a negative anomaly indicates that the observed temperature was cooler than the reference value.

Table 4.9: 30 Years Temperature Anomaly in Akure Forest Reserve (1991-2020)

Year	Akure Forest Reserve			Remark
	Long-Term Average Temperature	Observed Temperature	Temperature Anomaly	
1991	25.9	26.4	0.5	W
1992	25.9	26.5	0.6	W
1993	25.9	26.6	0.7	W
1994	25.9	26.5	0.6	W
1995	25.9	26.8	0.9	W
1996	25.9	26.8	0.9	W
1997	25.9	26.8	0.9	W
1998	25.9	27.5	1.6	W
1999	25.9	26.7	0.8	W
2000	25.9	26.9	0.6	W
2001	25.9	26.7	0.8	W
2002	25.9	26.8	0.9	W
2003	25.9	27.1	1.2	W
2004	25.9	27.0	1.1	W
2005	25.9	27.3	1.4	W
2006	25.9	27.3	1.4	W
2007	25.9	26.6	0.7	W
2008	25.9	27.1	1.2	W
2009	25.9	27.2	1.3	W
2010	25.9	27.8	1.9	W
2011	25.9	27.4	1.5	W
2012	25.9	27.2	1.3	W
2013	25.9	27.1	1.2	W
2014	25.9	27.1	1.2	W
2015	25.9	27.4	1.5	W
2016	25.9	27.2	1.3	W
2017	25.9	27.2	1.3	W
2018	25.9	26.9	1.0	W
2019	25.9	28.1	2.2	W
2020	25.9	27.5	1.6	W

Note: W=Warmer; C= Cooler; M= Moderate; LTA= Long-Term Average; TA= Temperature Anomaly

Source: Researcher's Data Computation, 2022.

Table 4.9 presents the state of temperature over 30 year period (1991-2020). The range of temperature anomaly was between 0.5 °C and 2.2 °C inter-annually, while the average departure was 1.3 °C. Temperature in all the years were warmer than long term Average (positive anomaly). 1991 had the least TA (0.5 °C) while 2019 had the highest temperature departure from the LTA.

Table 4.10 :30 Years Temperature Anomaly in Ologe Forest Reserve (1991-2020)

Year	Long-Term Average Temperature	Ologe Forest Reserve		Remark
		Observed Temperature ($^{\circ}\text{C}$)	Temperature Anomaly ($^{\circ}\text{C}$)	
1991	26.8	26.8	0	M
1992	26.8	27.2	0.4	W
1993	26.8	27.3	0.5	W
1994	26.8	26.9	0.1	W
1995	26.8	26.8	0	M
1996	26.8	26.7	-0.1	C
1997	26.8	27.5	0.7	W
1998	26.8	27.6	0.8	W
1999	26.8	26.9	0.1	W
2000	26.8	27.1	0.3	W
2001	26.8	27.2	0.4	W
2002	26.8	27.2	0.4	W
2003	26.8	27.1	0.3	W
2004	26.8	27.0	0.2	W
2005	26.8	27.5	0.7	W
2006	26.8	27.5	0.7	W
2007	26.8	27.4	0.6	W
2008	26.8	27.6	0.8	W
2009	26.8	27.8	1.0	W
2010	26.8	27.9	1.1	W
2011	26.8	28.0	1.2	W
2012	26.8	27.6	0.8	W
2013	26.8	27.7	0.9	W
2014	26.8	27.4	0.6	W
2015	26.8	27.7	0.9	W
2016	26.8	28.3	1.5	W
2017	26.8	28.1	1.3	W
2018	26.8	28.1	1.3	W
2019	26.8	26.9	0.1	W
2020	26.8	28.1	1.3	W

Note: W=Warmer; C= Cooler; M= Moderate; LTA= Long-Term Average; TA= Temperature Anomaly

Source: Researcher's Data Computation, 2022.

Table 4.10 presents the TA for Ologe Forest Reserve, Badagry. The picture of the state of temperature over 30 year period (1991-2020) was as follows: The range of temperature anomaly was between -0.1°C and 1.5°C inter-annually, while the average departure was 0.63°C . Temperature in all the years were warmer than Long-Term Average (positive anomaly), except 1996 (-0.1). there were two year of equilibrium temperature which include 1991 (0°C) and 1995 (0°C). That is, the LTA was the same as observed temperature. 1996 had the least TA (-0.1°C) while 2016 had the highest temperature departure from the LTA.

Table 4.11: 30 Years Temperature Anomaly in Gambari Forest Reserve (1991-2020)

Year	Gambari Forest Reserve			Remark
	Long-term Average	Observed Temperature	Temperature Anomaly	
1991	26.5	27.8	1.3	W
1992	26.5	27.5	1.0	W
1993	26.5	27.6	1.1	W
1994	26.5	27.6	1.1	W
1995	26.5	27.7	1.2	W
1996	26.5	28.0	1.5	W
1997	26.5	27.6	1.1	W
1998	26.5	27.7	2.5	W
1999	26.5	28.0	1.5	W
2000	26.5	28.3	1.8	W
2001	26.5	28.1	1.6	W
2002	26.5	28.4	1.9	W
2003	26.5	27.9	1.4	W
2004	26.5	28.3	1.8	W
2005	26.5	28.0	1.5	W
2006	26.5	28.1	1.6	W
2007	26.5	28.1	1.6	W
2008	26.5	28.3	1.8	W
2009	26.5	27.9	1.4	W
2010	26.5	28.5	2.0	W
2011	26.5	28.2	1.7	W
2012	26.5	27.7	1.2	W
2013	26.5	28.0	1.5	W
2014	26.5	28.0	1.5	W
2015	26.5	28.2	1.7	W
2016	26.5	28.4	1.9	W
2017	26.5	27.0	0.5	W
2018	26.5	27.2	0.7	W
2019	26.5	27.8	1.3	W
2020	26.5	25.5	-1.0	C

Note: W=Warmer; C= Cooler; M= Moderate; LTA= Long-Term Average; TA= Temperature Anomaly

Source: Researcher's Data Computation, 2022.

Table 4.11 presents the TA for Gambari Forest Reserve, Ibadan. The picture of the state of temperature over 30 year period (1991-2020) was as follows: The range of temperature anomaly was between -1.0 °C and 2.5 °C inter-annually, while the average departure from LTA was 1.39 °C. Temperature in all the years were warmer than Long-Term Average (positive anomaly), except 2020 (-1.0 °C). Year 2020 had the least TA (-1.0 °C) while 1998 had the highest temperature departure from the LTA (26.5 °C).

Table 4.12: 30 Years Temperature Anomaly in Okoiro Forest Reserve (1991-2020)

	Long-term Average Temperature	Okoiro Forest Reserve Observed Temperature	T.A	Remark
1991	26.1	26.6	0.5	W
1992	26.1	26.4	0.3	W
1993	26.1	26.5	0.4	W
1994	26.1	27.2	1.1	W
1995	26.1	27.2	1.1	W
1996	26.1	27.1	1.0	W
1997	26.1	27.0	0.9	W
1998	26.1	27.6	1.5	W
1999	26.1	27.1	1.0	W
2000	26.1	26.6	0.5	W
2001	26.1	27.3	1.2	W
2002	26.1	26.8	0.7	W
2003	26.1	26.7	0.2	W
2004	26.1	26.2	0.1	W
2005	26.1	26.6	0.5	W
2006	26.1	26.7	0.6	W
2007	26.1	27.0	0.9	W
2008	26.1	26.7	0.2	W
2009	26.1	27.3	1.3	W
2010	26.1	26.4	0.3	W
2011	26.1	27.2	1.1	W
2012	26.1	27.3	1.3	W
2013	26.1	27.3	1.3	W
2014	26.1	27.1	1.0	W
2015	26.1	26.8	0.7	W
2016	26.1	27.4	1.3	W
2017	26.1	27.8	1.7	W
2018	26.1	27.4	1.3	W
2019	26.1	26.9	0.8	W
2020	26.1	27.4	1.3	W

Note: W=Warmer; C= Cooler; M= Moderate; LTA= Long-Term Average; TA= Temperature Anomaly

Source: Researcher's Data Computation, 2022.

Table 4.12 presents the TA for Okoiro Forest Reserve, Ogbomosho. The picture of the state of temperature over 30 year period (1991-2020) was as follows: The range of temperature anomaly was between 0.1 °C and 1.7 °C inter-annually, while the average departure from LTA was 0.87 °C. Temperature in all the years were warmer than Long-Term Average (positive anomaly). Year 2004 had the least TA (0.1 °C) while 2017 had the highest temperature departure from the LTA (1.7 °C).

It is observed that there is variation in the spatial and temporal temperature anomalies across the study area. The study area cuts across different ecological zone drives by the same wind system (Southwest monsoon wind) but the effect were felt at different times. Also the level of anthropogenical activities and environmental structure (topography) can be a determinant of temperature differential. The total average (1991-2020) departure from standardised normal (1981 2010) in all the study location: Akure (1.13 °C); Ologe (0.63 °C); Gambari (1.4 °C) and; Okoiro (0.87 °C) signified global warming. Earth's global average surface Temperature in 2021 attached to 2018 was regarded as the sixth warmest temperature on record⁸. Continuing the planet's LTA warm trend, 0.85 °C global temperature was recorded against year 2021 which was above the average for NASA's baseline period. In recent times, temperature in Nigeria is persitently rising and falling caused by general global warming⁷⁰. According to Scientific understanding, the spatial and temporal fluctuations of air temperature are generated by natural and anthropogenic activities, such as population growth, deforestation, unsustainable agriculture and burning of fossil fuels⁷¹. The effect of the higher temperatures are worsening many types of disasters, including storms, floods, heat waves and droughts. A warmer climate creates an atmosphere that can collect, retain, and unleash more water changing patterns as to wet areas become wetter and dry areas become drier⁷².

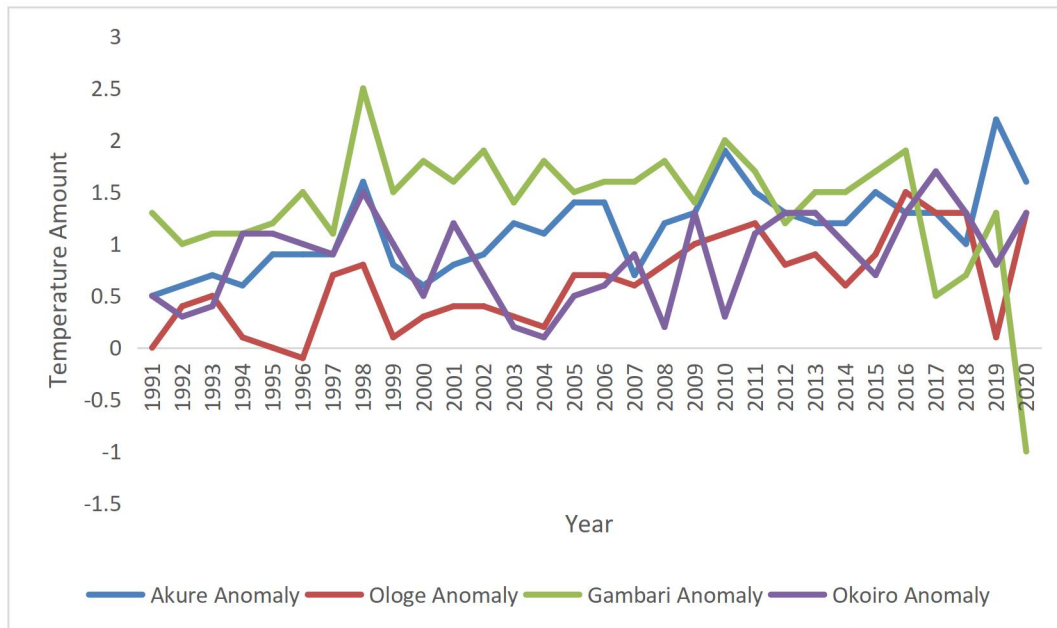


Figure 4.6: The temperature anomalies for the four locations

Source: Researcher's Data Computation, 2022.

The graph displays the trend of the disparity of temperature above and below the LTA temperature relative to each study location. There is no particular pattern but the yearly display irregular pattern. This follows the finding that the solar output experienced in 2000s resulted in an unusual deep solar radiation minimum between 2007 and 2009 was responsible for unabated increase in surface temperature. A researcher agreed with the estimate global temperature changes of $0.6 \pm 0.2^\circ\text{C}$ over 100 years, was due to the increase in GHG concentration for CO_2 from 282ppm by 1800 to 365ppm by 2000⁷³. Ologe has the lowest temperature changes as observed from Figure 4.6. The reason could be as a result of water body that brings cooling effect from breeze. In 2019, the temperature dropped even below expected temperature but not pronounced before taken its course sharply upward. The reason for the gentleness of the trend could be because of the afforestation going on in Badagry. In the period of study, the observed temperature is higher than the expected temperature which conforms to the findings from the respondent's perception from the field that there

has been high temperature for 20 years ago. In Gambari Forest Reserve, the temperature trend slope upward gently in the three decades. The rate of disparity from the expected is higher than Akure and Badagry (Figure 4.6).

Likewise, the temperature trends in Ogbomosho rises in the first decade (1991-2000), but fell in the second decade (2001-2010). In the third decade (2011-2020) it rose again (Figure 4.10). The observation in all the three decades, the observed temperature is higher than the expected.

Summarily, the charts show the disparity between the observed temperature and the standardized anomaly temperature in the four study areas. Researcher's findings revealed that the observed temperature increased when compared with the expected. This is an indication of global warming. The climate normal with reference period of 1981-2010 was used to drive home the reality of variability of the climatic parameters and the evidence of climate change.

The results of the comparison of expected and observed rainfall and temperature is a clear demonstration of a constant deviation from the expected average values (1981-2010), of these parameters indicating a change in what is known as the prevailing pattern, with its consequences as global warming, droughts and flood of varying intensities.

4.2.2 Decadal Means of Rainfall and Temperature Change Across the Study Area

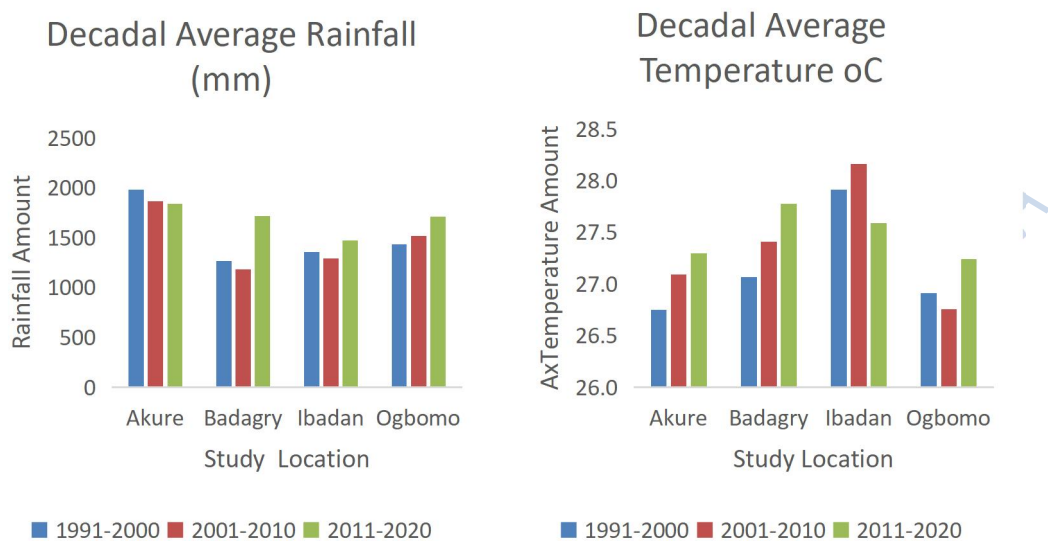


Figure 4.7: Decadal Changes in Rainfall and Temperature across the Study Area
Source: Researcher's Data Computation, 2022.

From the figures 4.7, decadal means rainfall and temperature are displayed in the chart. There are variabilities in the climatic data. In all the decades in Akure, the patterns of rainfall and temperature showed an opposite pattern. As the rainfall increases, the temperature is going down. The cooling effect of precipitation was felt. Other study locations did not display a specific pattern. This implies that rainfall increase is not a determinant of temperature decrease and vice versa. The patterns can be as a result of other environmental factors. From Figure 4.7, Akure showed the highest average rainfall in the first decade (1991-2000) with the value 1985.19mm and the least was recorded for Badagry in the second decade (2001-2010) with the value of 1185.05mm. Also, in Figure 4.12, the highest average decadal temperature was recorded for Ibadan in the second decade (2001-2010) with the value of 28.2°C, while the least

temperature was 26.8°C for Akure and Ogbomosho in the first and second decades respectively.

4.3 Time Plot for the Time Series Analysis of Rainfall and Temperature

Figures 4.8-4.19 show the time plot of the monthly rainfall, maximum temperature, and minimum temperature series for Akure, Badagry, Ibadan and Ogbomosho respectively from 1991 to 2020. The figure revealed that there is an irregular pattern in the data series. The mean is not constant throughout the series as it assumes a fairly stable mean, the data series has a trend variation. The figure also shows that the data series are stationary, that is, mean, variance and autocorrelation structure do not change overtime, therefore there is need to carry out a unit root test. Since decomposition procedures are used in time series to describe the trend and seasonal factors in a time series, hence, in this study, only trend and seasonal decompositions is considered. Figures 4.20-4.31 show the additive time series decomposition of the series into random, seasonal, trend and observed variation. The plot shows the observed series, the smoothed trend line, the seasonal pattern and the random part of the rainfall, high and low temperature series for the four regions studied.

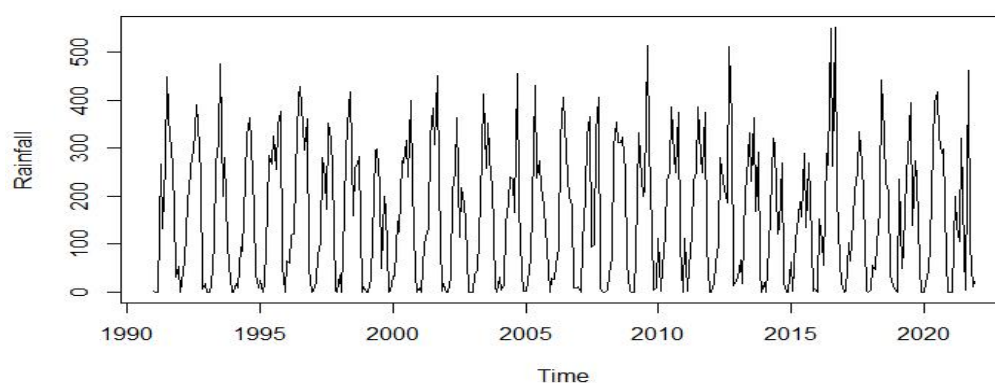


Figure 4.8: Time plot for monthly rainfall series for Akure

Source: Researcher's Data Computation, 2022.

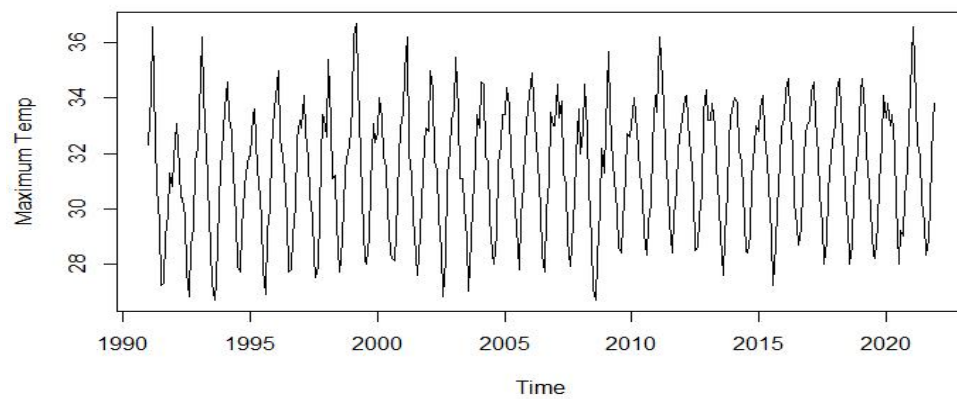


Figure 4.9: Time plot for monthly maximum temperature series for Akure
Source: Researcher's Data Computation, 2022.

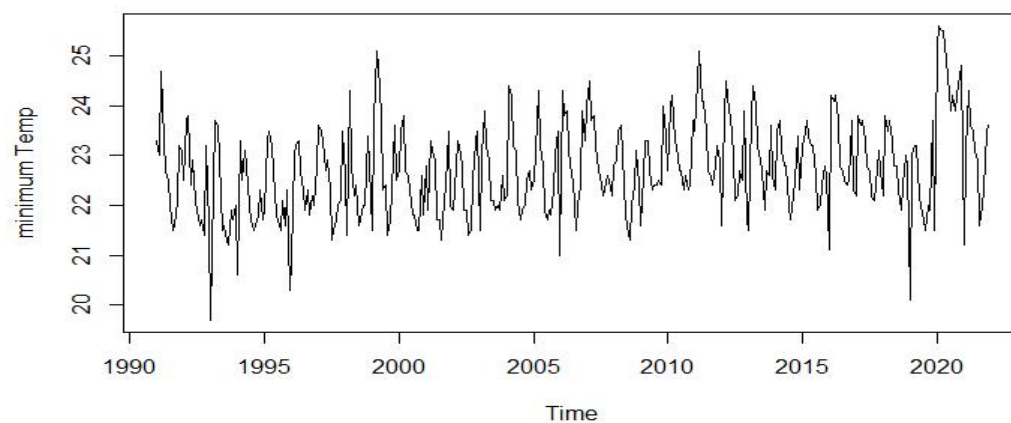


Figure 4.10: Time plot for monthly minimum temperature series for Akure
Source: Researcher's Data Computation, 2022.

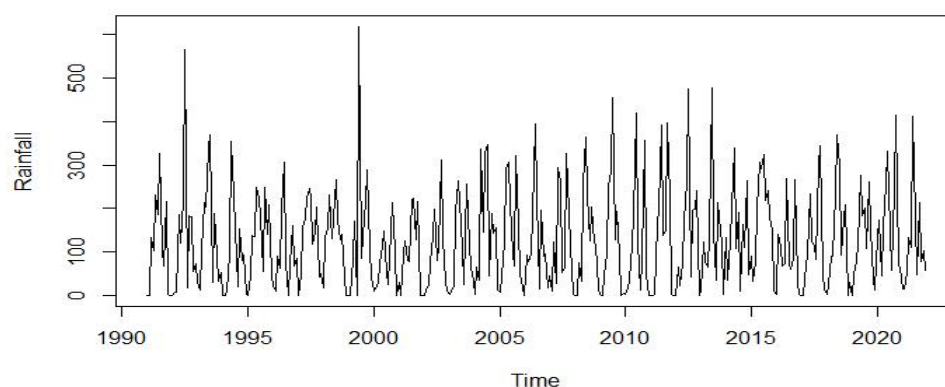


Figure 4.11: Time plot for monthly rainfall series for Badagry

Source: Researcher's Data Computation, 2022.

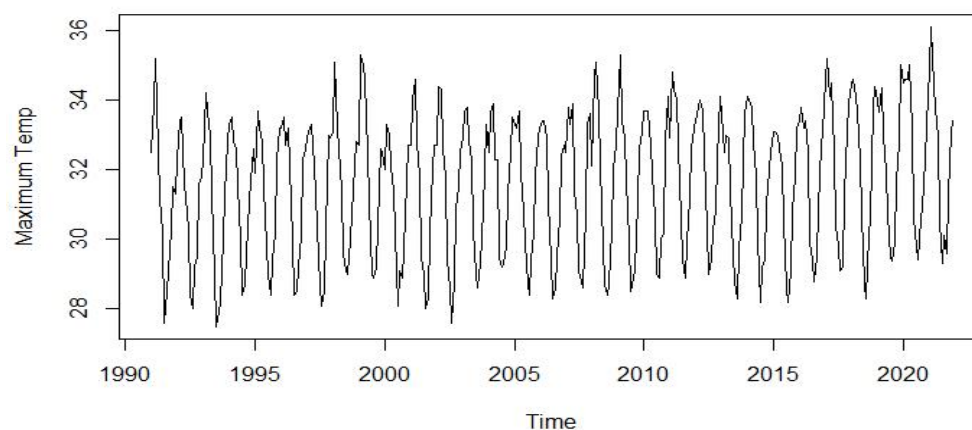


Figure 4.12: Time plot for monthly maximum temperature series for Badagry

Researcher's Data Computation, 2022.

Source: Researcher's Data Computation, 2022.

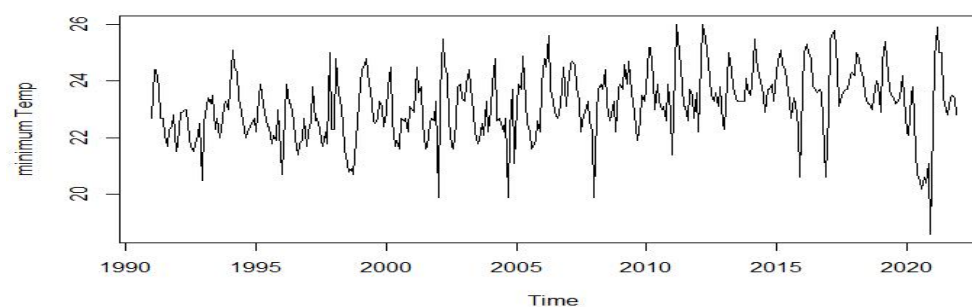


Figure 4.13: Time plot for monthly minimum temperature series for Badagry

Source: Researcher's Data Computation, 2022.

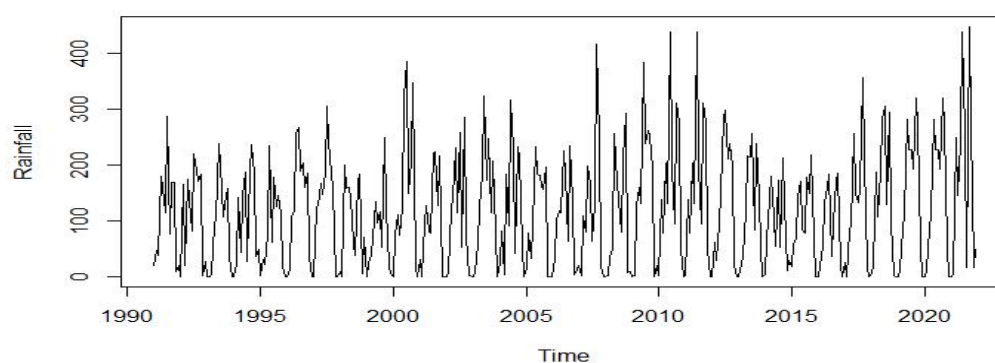


Figure 4.14: Time plot for monthly rainfall series for Ibadan

Source: Researcher's Data Computation, 2022.

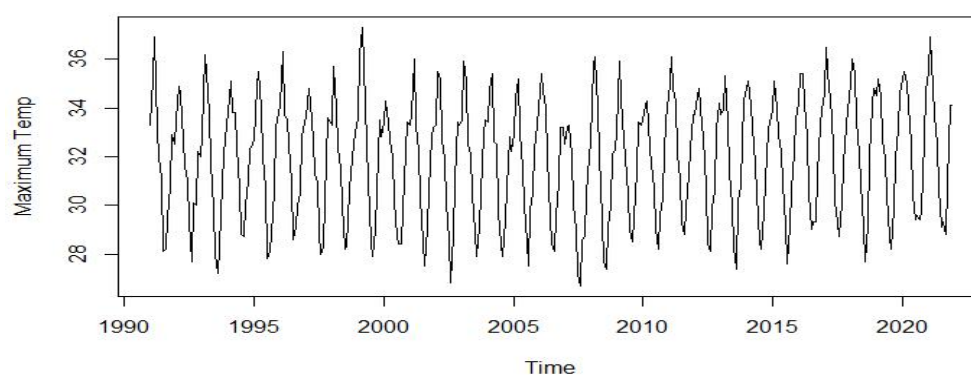


Figure 4.15: Time plot for monthly maximum temperature series for Ibadan

Source: Researcher's Data Computation, 2022.

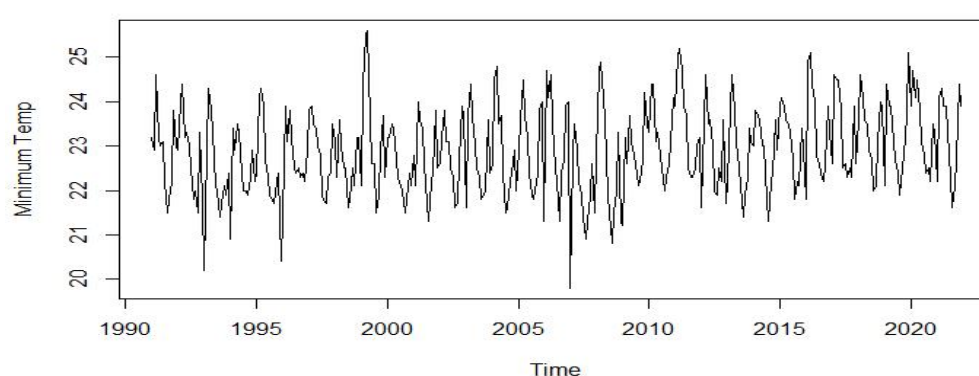


Figure 4.16: Time plot for monthly minimum temperature series for Ibadan

Source: Researcher's Data Computation, 2022.

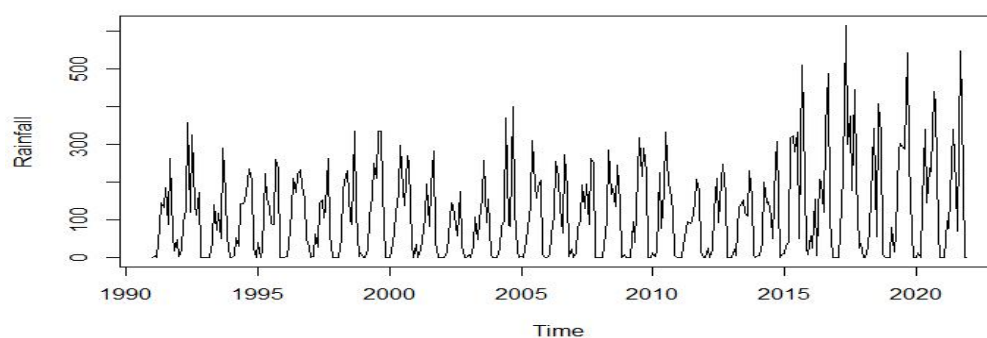


Figure 4.17: Time plot for monthly rainfall series for Ogbomosho

Source: Researcher's Data Computation, 2022.

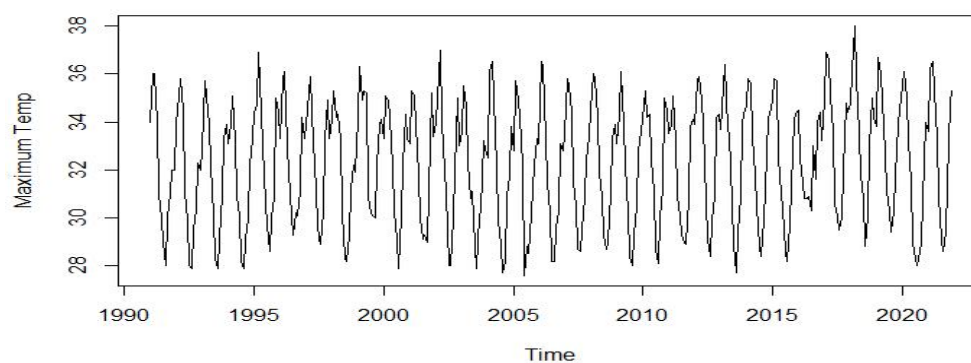


Figure 4.18: Time plot for monthly maximum temperature series for Ogbomosho

Source: Researcher's Data Computation, 2022

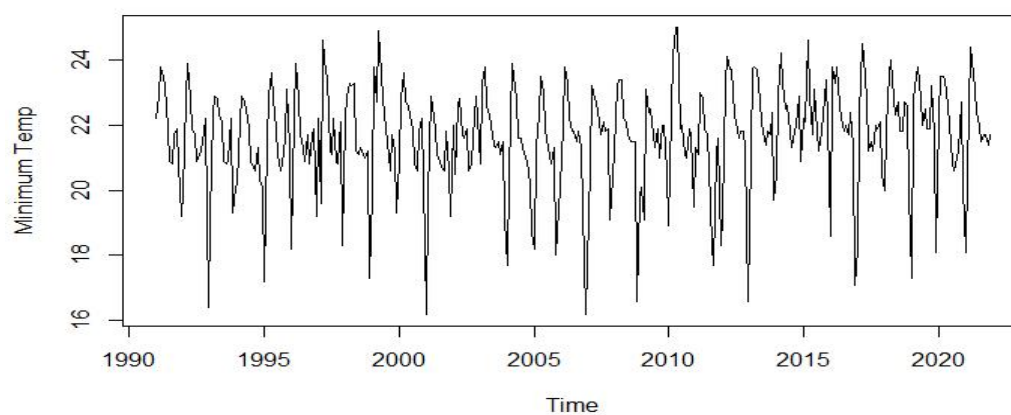


Figure 4.19: Time plot for monthly minimum temperature series for Ogbomosho

Source: Nigeria Meteorological Agency

Since trend, season, and cycle are the most common variations in data recorded through time, then, each of these patterns might affect the time series in different ways. So, choosing a forecasting model is premised on identifying patterns like trend and season to understand how each one behaves in the series. The decomposition procedure in Figures 4.20 – 4.31, analyze the trend and seasonal components of the rainfall and temperature series in separate plots: A time series plot of the original data. Detrend values are the data with the trend component removed. The detrend values are either the differences between the observed values and the trend values (additive model). Since the plot of the detrend data looks different from the original data, this means that a trend component exists in the data. Seasonally adjusted values are the data with the seasonal component removed. The seasonally adjusted values are either the differences between the observed values and the seasonal values (additive model). Also, since the plot of the seasonally adjusted data looks like the original data, then it is safe to conclude that seasonal component does exist in the data. This is shown in Figures 4.30– 4.41. The seasonally adjusted and detrend values are also called residuals. The residuals are the differences between the observed values and the predicted values. Examining the random plot to determine whether our model is adequate was also necessary as the residuals are meant to be randomly distributed with no obvious patterns and no unusual values. The results showed that the residuals were randomly distributed and the fitted models are adequate for prediction.

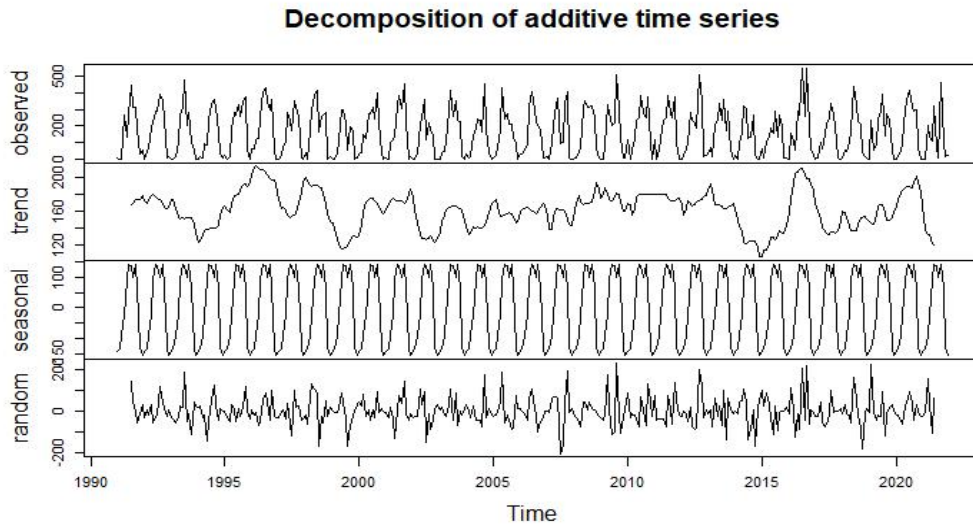


Figure 4.20: Decomposition of monthly rainfall series for Akure (random, seasonal, trend and observed)

Source: Researcher's Data Computation, 2022.

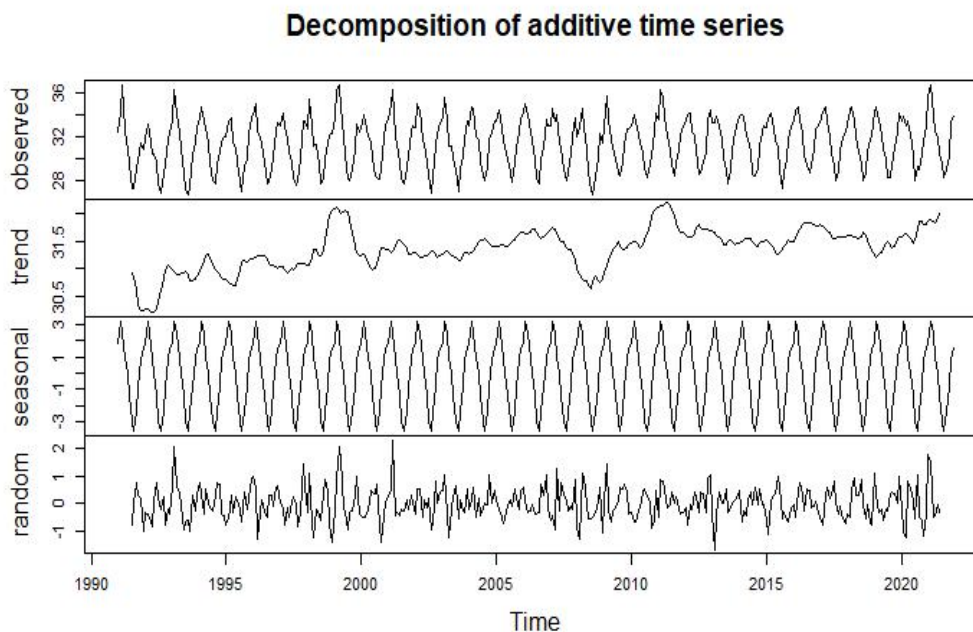


Figure 4.21: Decomposition of monthly maximum temperature series for Akure (random, seasonal, trend and observed)

Source: Researcher's Data Computation, 2022.

The plot above and below shows the original time series (top), the estimated trend component (second from top), the estimated seasonal component (third from top), and

the estimated irregular component (bottom). We see that the estimated trend component in Akure rainfall series shows a small decrease in 1991, followed by a steady increase in about 1993. Hence, the feature of the decomposition is in four levels namely, Observed – the actual data plot; Trend – the overall upward or downward movement of the data points; Seasonal – any monthly/yearly pattern of the data points; and Random – unexplainable part of the data.

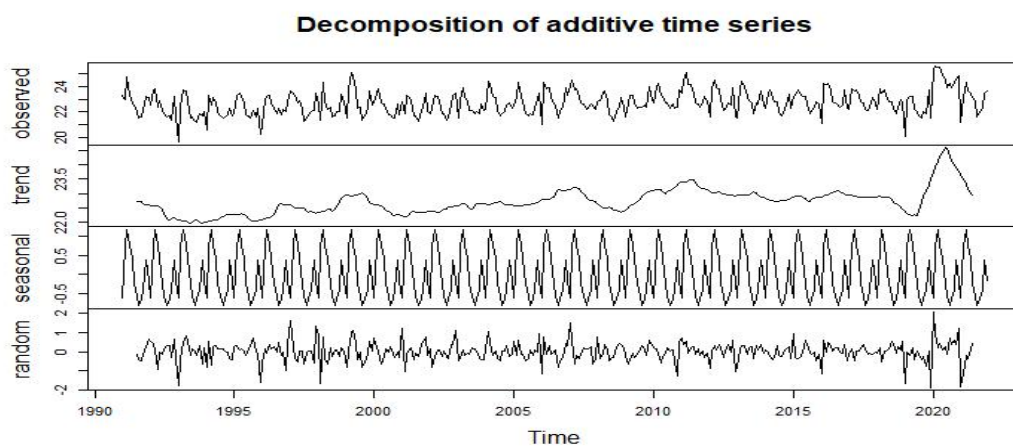


Figure 4.22: Decomposition of monthly minimum temperature series for Akure (random, seasonal, trend and observed)

Source: Researcher's Data Computation, 2022.

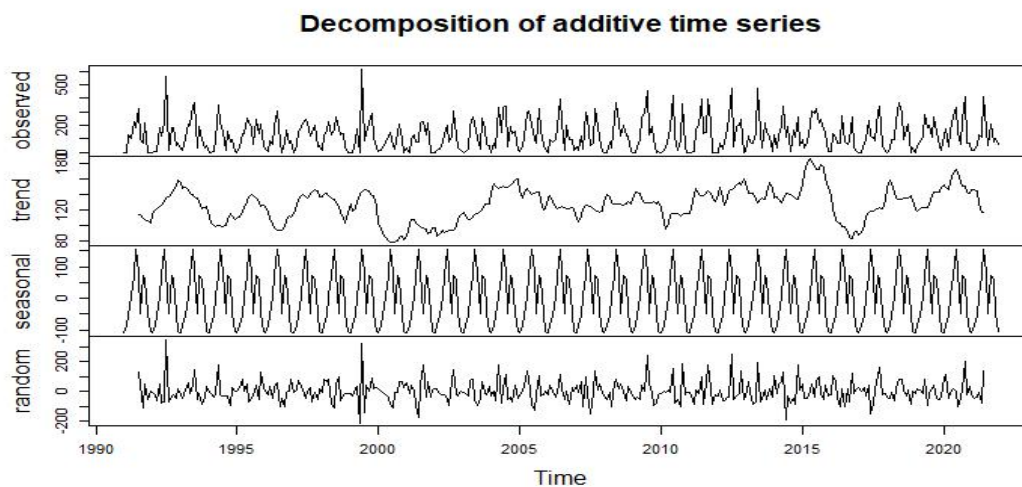


Figure 4.23: Decomposition of monthly rainfall series for Badagry (random, seasonal, trend and observed)

Source: Researcher's Data Computation, 2022.

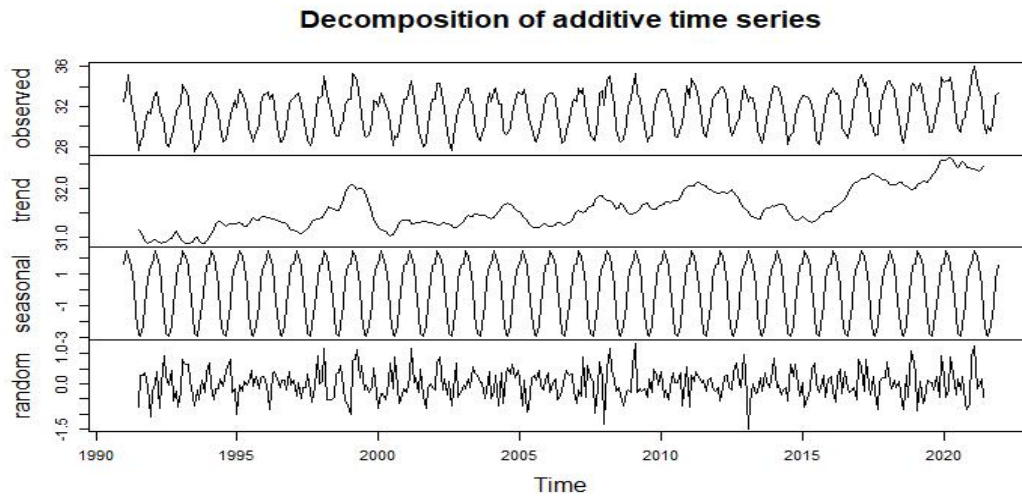


Figure 4.24: Decomposition of monthly maximum temperature series for Badagry (random, seasonal, trend and observed)

Source: Researcher's Data Computation, 2022.

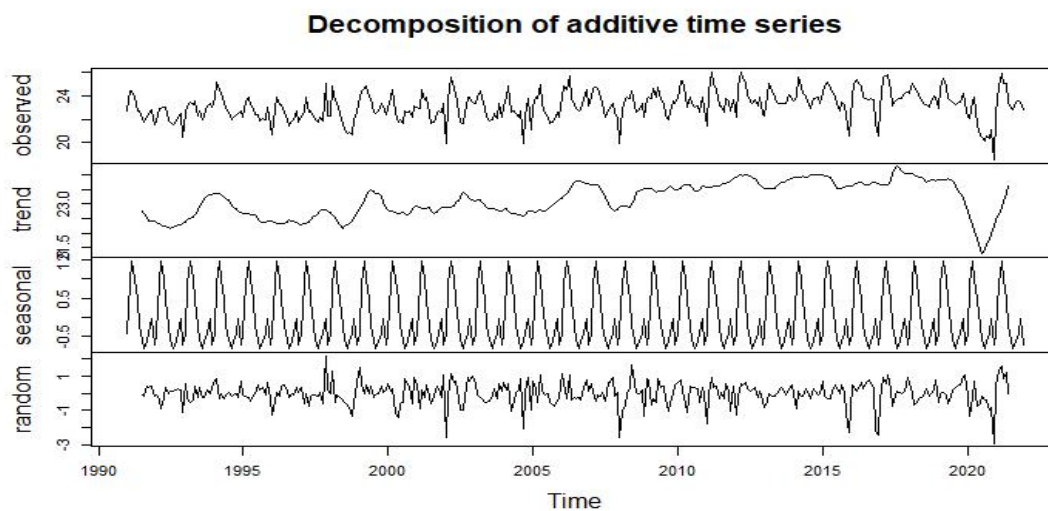


Figure 4.25: Decomposition of monthly minimum temperature series for Badagry (random, seasonal, trend and observed)

Source: Researcher's Data Computation, 2022.

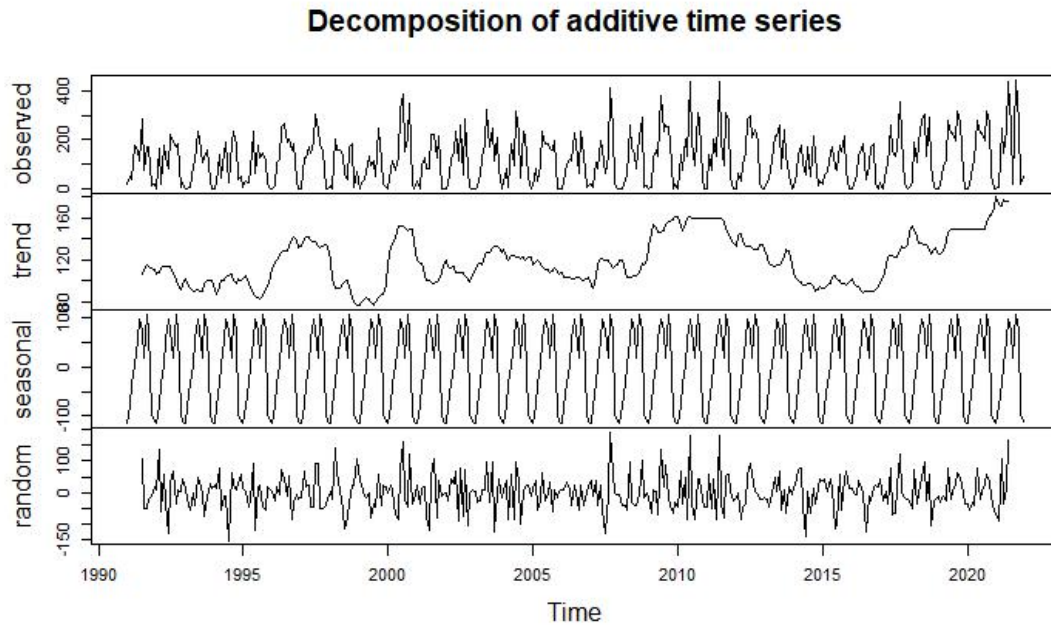


Figure 4.26: Decomposition of monthly rainfall series for Ibadan (random, seasonal, trend and observed)

Source: Researcher's Data Computation, 2022.

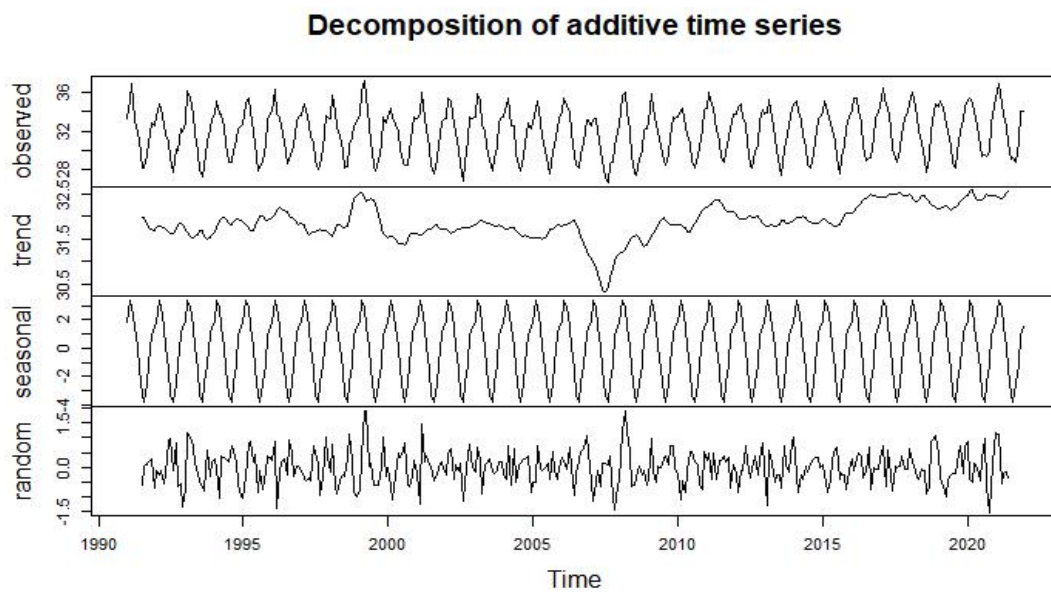


Figure 4.27: Decomposition of monthly maximum temperature series for Ibadan (random, seasonal, trend and observed)

Source: Researcher's Data Computation, 2022.

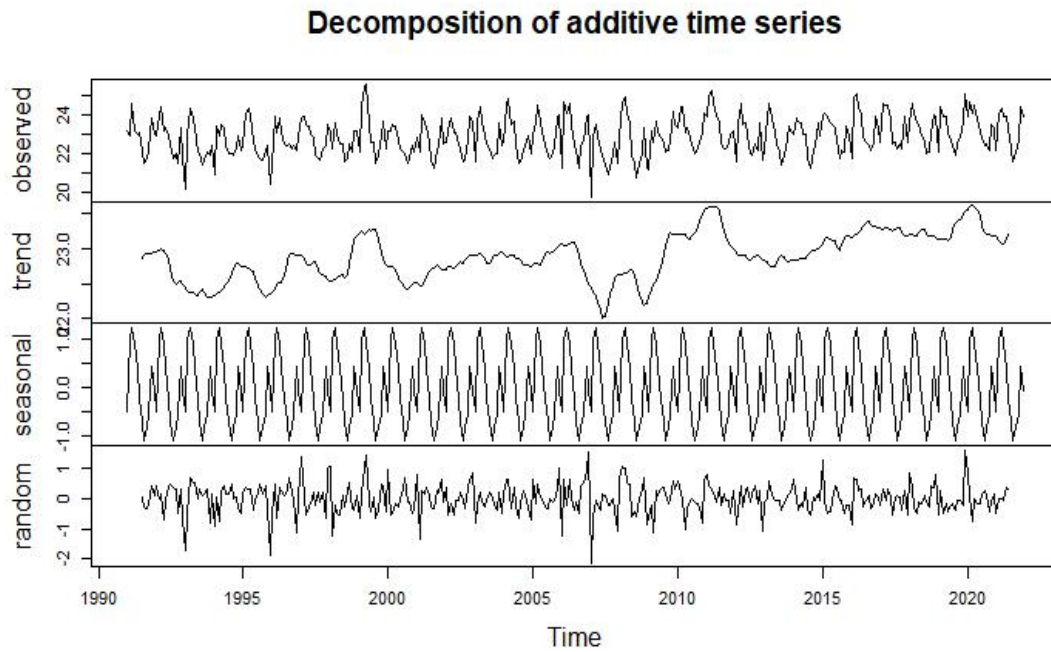


Figure 4.28: Decomposition of monthly minimum temperature series for Ibadan (random, seasonal, trend and observed)

Source: Researcher's Data Computation, 2022.

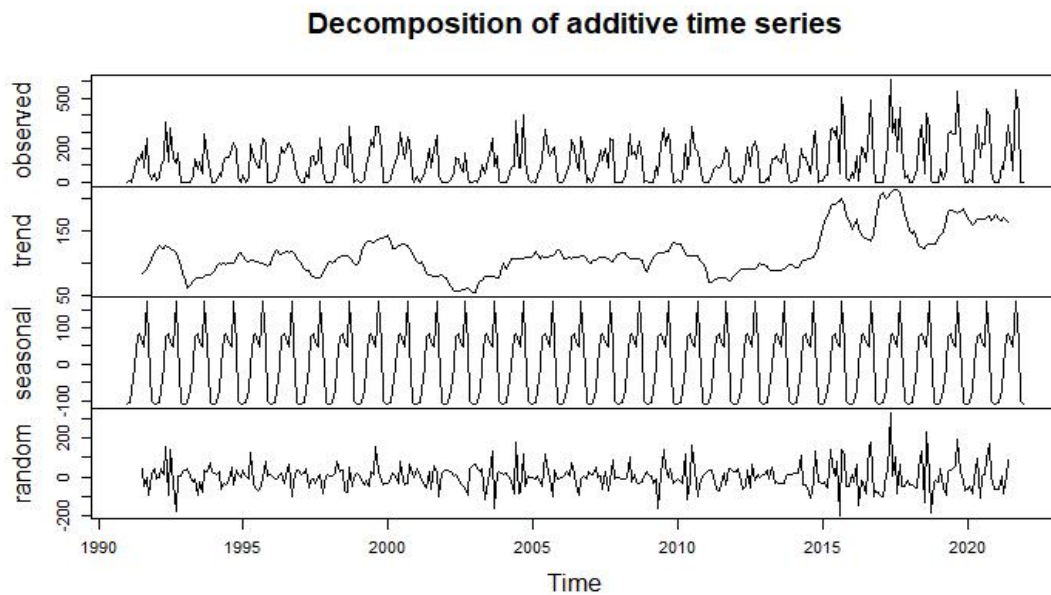


Figure 4.29: Decomposition of monthly rainfall series for Ogbomosho (random, seasonal, trend and observed)

Source: Researcher's Data Computation, 2022.

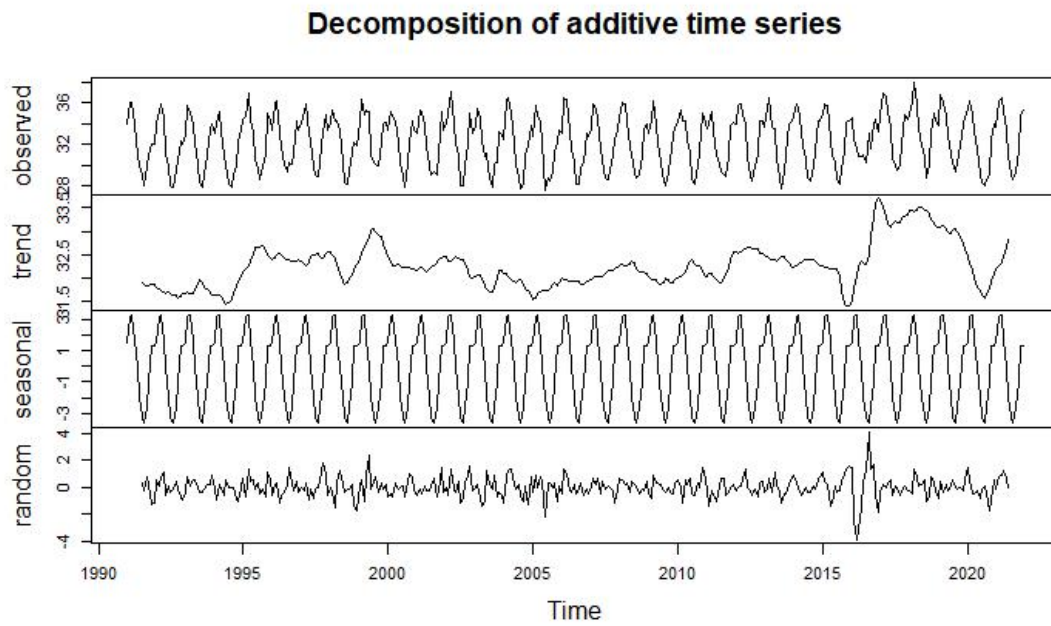


Figure 4.30: Decomposition of monthly maximum temperature series for Ogbomosho (random, seasonal, trend and observed)

Source: Researcher's Data Computation, 2022.

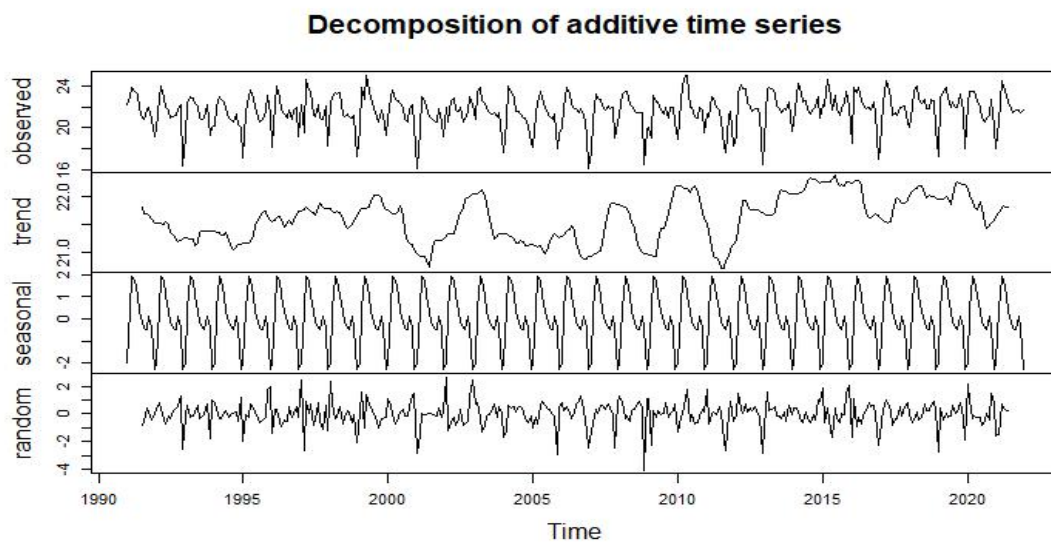


Figure 4.31: Decomposition of monthly minimum temperature series for Ogbomosho (random, seasonal, trend and observed)

Source: Researcher's Data Computation, 2022.

Observing these 4 Level graphs closely justified that data satisfies all the assumptions of SARIMA modeling, mainly, stationarity and seasonality. Next, we need to remove non-stationary part for ARIMA. To achieve stationarity: difference the data – compute the differences between consecutive observations; log or square root the series data to stabilize non-constant variance; if the data contains a trend, fit some type of curve to the data and then model the residuals from that fit. These were the procedures used in modeling. Unit root test was then used to find out that first difference or regression which should be used on the trending data to make it stationary. In Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test, small p-values suggest differencing is required.

4.3.1 Unit Root Test

Augmented Dickey Fuller test was carried out to test for the stationary in the data set

Table 4.13: Augmented Dickey Fuller Test for the series

Locations	Parameters	DF statistic	Lag- order	p-value	Seasonality	
					Decision	Order
Akure	Max. Temp.	- 11.412	7	0.01	Yes	1
	Min. Temp	- 7.8386	7	0.01	Yes	1
	Rainfall	- 11.907	7	0.01	Yes	1
	Max. Temp.	- 13.161	7	0.01	Yes	1
Badagry	Min. Temp	-10.3	7	0.10	No	1
	Rainfall	- 11.995	7	0.01	Yes	1
	Max. Temp.	- 11.178	7	0.01	Yes	1
	Min. Temp	-9.799	7	0.01	Yes	1
Ibadan	Rainfall	- 10.696	7	0.01	Yes	1
	Max. Temp.	- 11.589	7	0.01	Yes	1
Ogbomosho	Min. Temp	-10.3	7	0.01	Yes	1
	Rainfall	- 9.6658	7	0.01	Yes	1

Source: Nigeria Meteorological Agency

Table 4.13 suggest that the maximum temperature, minimum temperature and rainfall series for Akure, Badagry, Ibadan and Ogbomosho attained stationarity since the p -value (0.01) for the series are less than 5% level of significance. The Hegy test and Canova-Hansen test was carried out to determine seasonality and order at which the seasonal variation is stationary in the series. The table showed that there is seasonality in the series for all the regions with order 1 except for the minimum temperature

series for Badagry that does not attain stationarity which is likely due to the existence of water body among other unexplainable factors.

4.3.2 Model Identification

The Autocorrelation Function (ACF) was used to identify the probability time series models that best describes the series for Akure, Badagry, Ibadan and Ogbomosho. Figures 4.37-4.48 show the ACF plot of the series for rainfall, monthly maximum temperature and minimum temperature for Akure, Badagry, Ibadan and Ogbomosho respectively. The plots suggest that the highest attainable order for the Autoregressive Model (AR) and Moving Average (MA) are between 0 and 9. The number of attainable orders is determined by the number of significant spikes.

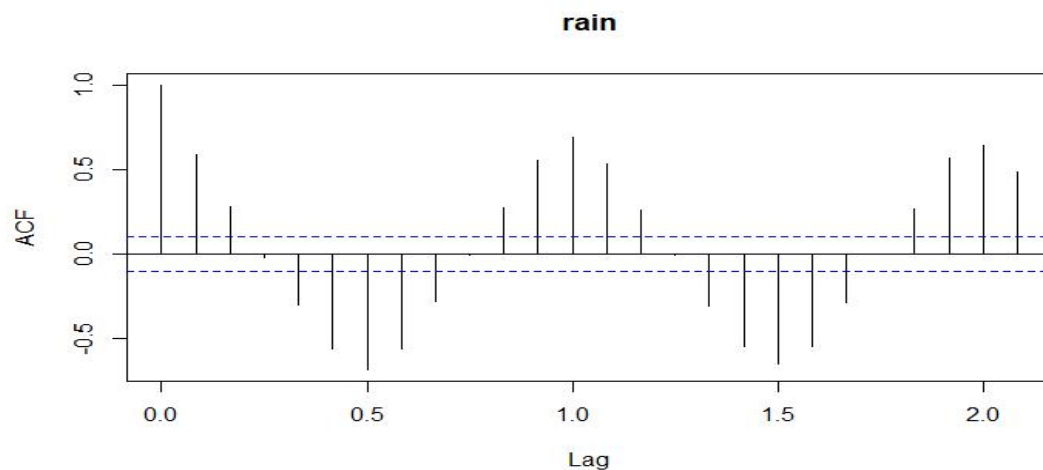


Figure 4.32: ACF plot of monthly rainfall series for Akure

Source: Researcher's Data Computation, 2022.

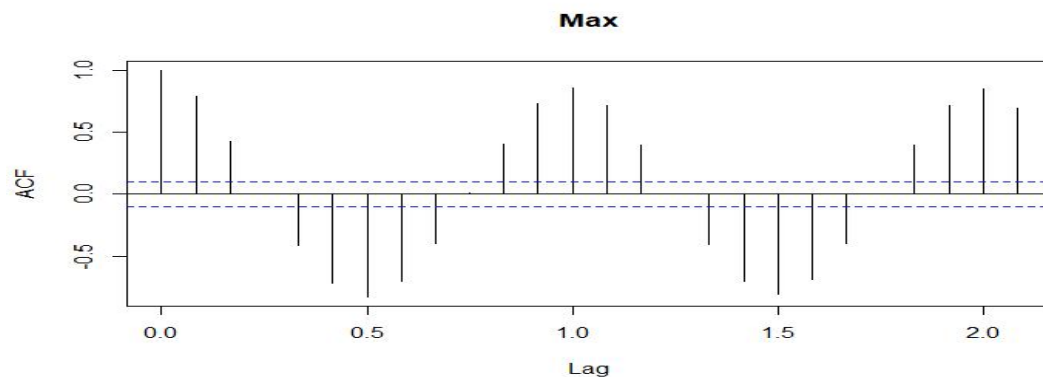


Figure 4.33: ACF plot of monthly maximum temperature series for Akure

Source: Researcher's Data Computation, 2022.

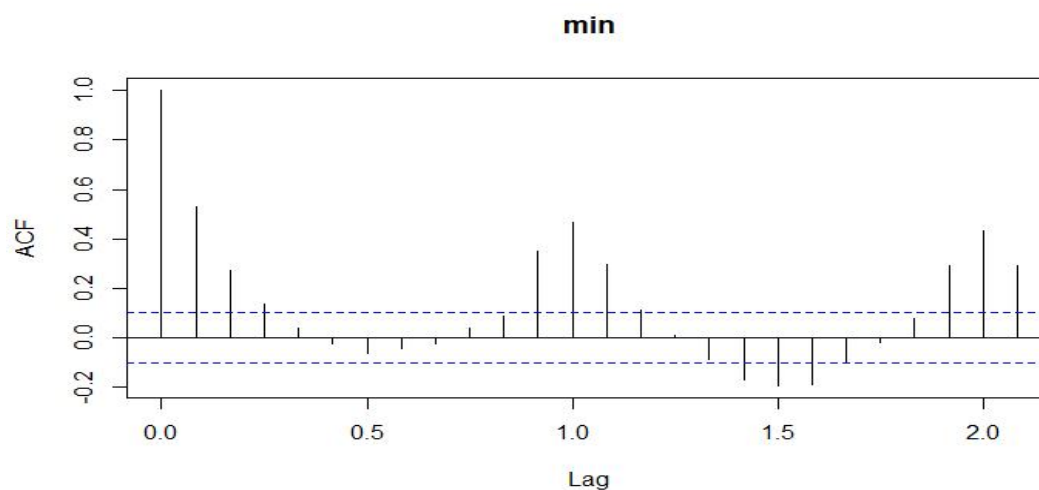


Figure 4.34: ACF plot of monthly minimum temperature series for Akure
Source: Researcher's Data Computation, 2022.

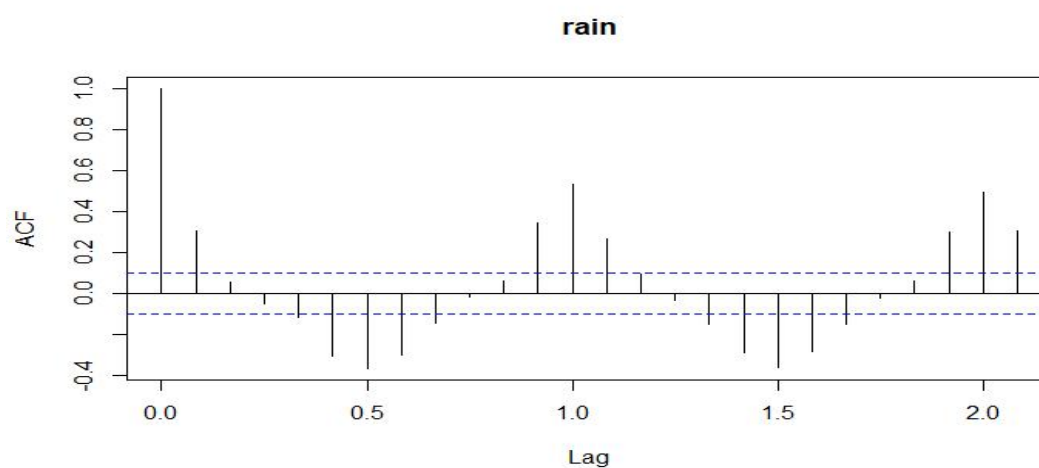


Figure 4.35: ACF plot of monthly rainfall series for Badagry
Source: Researcher's Data Computation, 2022.

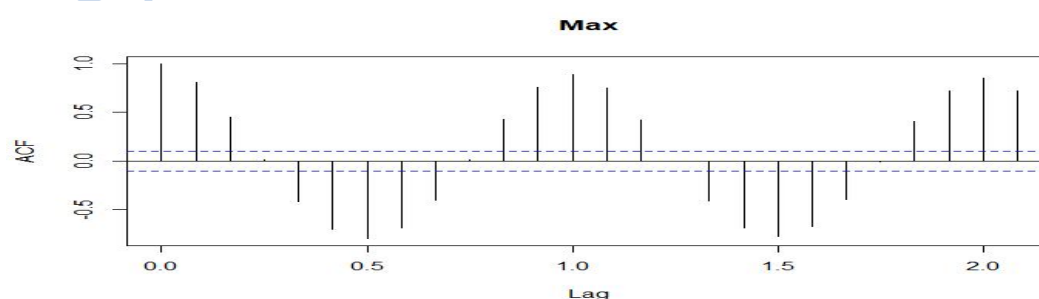


Figure 4.36: ACF plot of monthly maximum temperature series for Badagry
Source: Researcher's Data Computation, 2022.

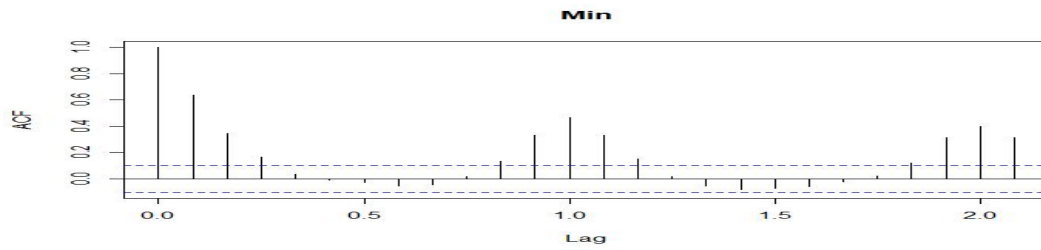


Figure 4.37 ACF plot of monthly minimum temperature series for Badagry
Source: Researcher's Data Computation, 2022.

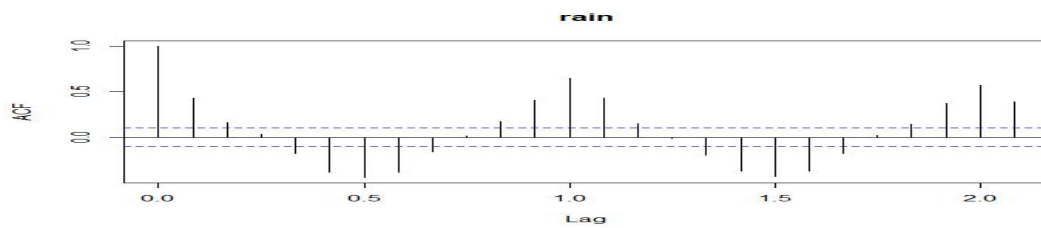


Figure 4.38: ACF plot of monthly rainfall series for Ibadan
Source: Researcher's Data Computation, 2022.

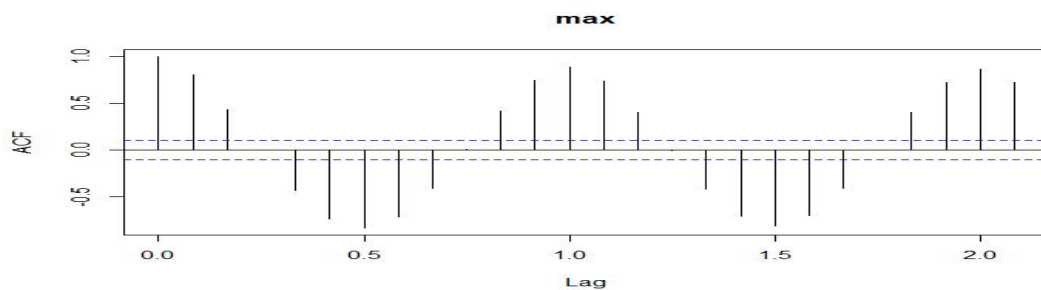


Figure 4.39: ACF plot of monthly maximum temperature series for Ibadan
Source: Researcher's Data Computation, 2022.

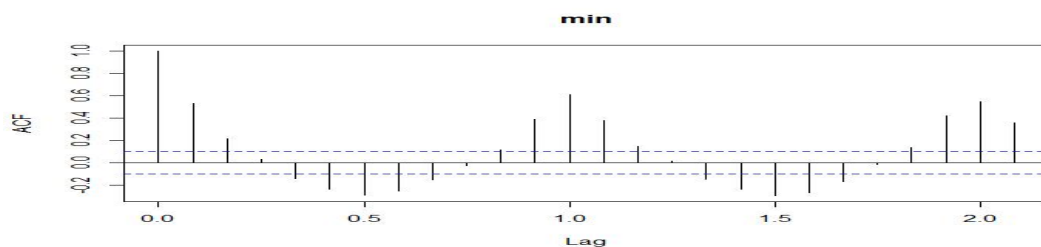


Figure 4.40: ACF plot of monthly minimum temperature series for Ibadan
Source: Researcher's Data Computation, 2022.

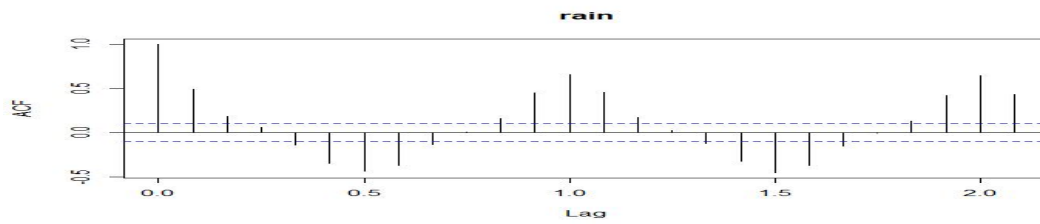


Figure 4.41: ACF plot of monthly rainfall series for Ogbomosho

Source: Researcher's Data Computation, 2022.

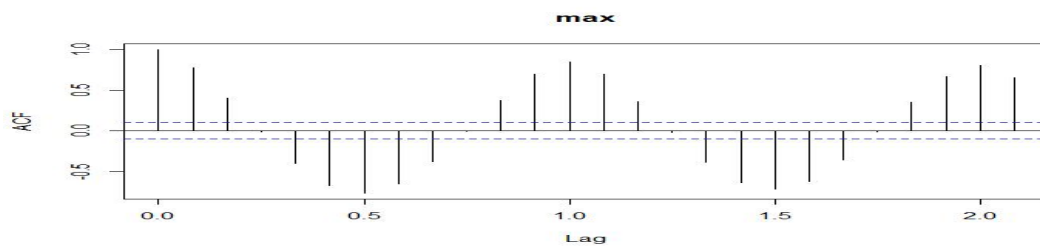


Figure 4.42: ACF plot of monthly maximum temperature series for Ogbomosho

Source: Researcher's Data Computation, 2022.

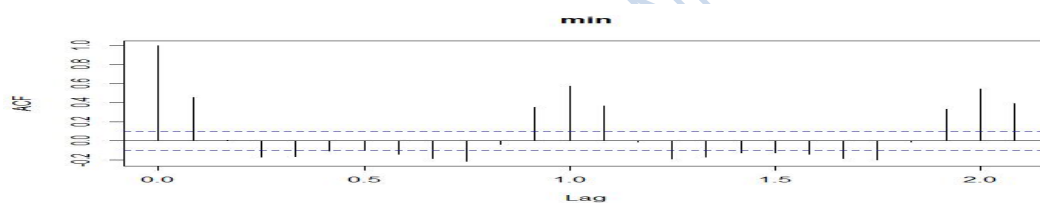


Figure 4.43: /CF plot of monthly minimum temperature series for Ogbomosho

Source: Researcher's Data Computation, 2022.

The Autocorrelation Function (ACF) Plot gives the autocorrelation at all possible lags. The autocorrelation at lag 0 is included by default which always takes the value 1 as it represents the correlation between the data and themselves. As we can infer from the graph above, the autocorrelation continues to decrease as the lag increases, confirming that there is no linear association between observations separated by larger lags. As can be seen from Figures 4.32 – 4.43, there are no significant negative spikes in the ACF plots (monthly, seasonal component) and in the Partial Auto-correlation Function (PACF) plots.

4.3.3 Parameter Estimation

After the stationarity of the data have been attained and the ACF and PACF have been examined, it was concluded that the data series follows Seasonal Autoregressive Integrated Moving Average (SARIMA) model. Tables 4.14 to 4.25 show the parameter estimation table for the model that best describe the monthly rainfall, maximum temperature, and minimum temperature series for Akure, Badagry, Ibadan and Ogbomosho respectively.

Table 4.14: Model Estimation of monthly rainfall series for Akure SARIMA (0, 0, 1) (1, 1, 0)₁₂

Model	MA1	SAR1					
Estimate	0.1047	-0.4581					
S.E	0.0493	0.0485					
Performance criteria	R ²	AIC	Log-likelihood	ME	RMSE	MAE	MASE
		4292.22	-2143.11	-1.1286	91.2691	63.881	0.8812

Source: Author's Analysis, 2022

Table 4.15: Model Estimation of monthly Maximum Temperature series for Akure SARIMA (0, 0, 1) (2, 1, 2)₁₂

Model	MA1	SAR1	SAR2	SMA1	SMA2		
Estimate	0.4229	-0.0803	0.0546	-0.8459	-0.0211		
S. E	0.0462	0.6018	0.0789	0.6002	0.5133		
Performance criteria	R ²	AIC	Log-likelihood	ME	RMSE	MAE	MASE
	0.4583	765.13	-376.56	0.1183	0.6613	0.4923	0.6601

Source: Author's Analysis, 2022

Table 4.16: Model Estimation of monthly Minimum Temperature series for Akure SARIMA (2, 0, 2) (0, 1, 2)₁₂ with drift

Model	AR1	AR2	MA1	MA2	SMA1	SMA2	Drift
Estimate	0.73	0.0693	-0.4588	0.0074	-0.7355	-0.5218	0.0021
S. E	0.332	0.2945	0.3338	0.2058	0.0526	0.0673	0.035
Performance criteria	R2	AIC	Log-likelihood	ME	RMSE	MAE	MASE
	0.43	737.74	-360.87	-0.0014	0.639	0.4426	0.6853

Source: Author's Analysis, 2022

Table 4.17: Model Estimation of monthly rainfall series for Badagry SARIMA (0, 0, 1) (0, 1, 1)₁₂

Model	SAR1						
Estimate	-0.4896						
S. E	0.0466						
Performance criteria	R2	AIC	Log-likelihood	ME	RMSE	MAE	MASE
		4293.37	-2144.69	0.9958	91.611	64.6244	0.8502

Source: Author's Analysis, 2022

Table 4.18: Model Estimation of monthly maximum temperature series for Badagry SARIMA (3, 0, 0) (2, 1, 1)₁₂

Model	AR1	AR2	AR3	SAR1	SAR2	SMA1	
Estimate	0.3325	0.0802	0.1645	0.0185	-0.0533	-0.856	
S.E	0.053	0.0549	0.0552	0.0649	0.0623	0.041	
Performance criteria	R2	AIC	Log-likelihood	ME	RMSE	MAE	MASE
	0.3016	614.77	-300.38	0.0813	0.5357	0.4163	0.7026

Source: Author's Analysis, 2022

Table 4.19: Model Estimation of monthly minimum temperature series for Badagry SARIMA (2, 0, 1) (0, 1, 1)₁₂

Model	AR1	AR2	MA1	SAR1			
Estimate	0.5864	0.0058	-0.9896	0.4018			
S.E	0.0535	0.0554	0.0078	0.0513			
Performance criteria	R2	AIC	Log-likelihood	ME	RMSE	MAE	MASE
	0.6891	924.49	-457.24	0.0398	0.8245	0.6029	0.7173

Source: Author's Analysis, 2022

Table 4.20: Model Estimation of monthly rainfall series for Ibadan SARIMA (1, 0, 0) (1, 1, 0)₁₂ with drift

Model	AR1	SAR1	Drift				
Estimate	0.0212	-0.4013	0.1709				
S. E	0.0528	0.0491	0.2357				
Performance criteria	R2	AIC	Log-likelihood	ME	RMSE	MAE	MASE
		4119.94	-2055.97	0.0533	71.71954	50.4694	0.9047

Source: Author's Analysis, 2022

Table 4.21: Model Estimation of monthly maximum temperature series for Ibadan SARIMA (3, 0, 0) (2, 1, 2)₁₂ with drift

Model	AR1	AR2	AR3	SAR1	SAR2	SMA1	SMA2	Drift
Estimate	0.4412	-0.0124	0.0565	-0.8496	-0.0009	-0.0698	-0.6897	0.0016
S. E	0.0532	0.0582	0.0541	0.1658	0.0732	0.1617	0.1337	0.0009
Performance criteria	R2	AIC	Log-likelihood	ME	RMSE	MAE	MASE	
	0.3984	718.06	-350.03	-0.0124	0.6139	0.4724	0.6555	

Source: Author's Analysis, 202

Table 4.22: Model Estimation of monthly minimum temperature series for Ibadan SARIMA (2, 0, 2) (2, 1, 0)₁₂ with drift

Model	AR1	AR2	MA1	MA2	SAR1	SAR2	Drift
Estimate	0.3265	0.2996	-0.0272	-0.2013	-0.5835	-0.4312	0.0014
S. E	1.5091	1.0665	1.5059	0.6172	0.0495	0.0484	0.0029
Performance criteria	R2	AIC	Log-likelihood	ME	RMSE	MAE	MASE
	0.4136	720	-352	-0.0011	0.6265	0.4518	0.7307

Source: Author's Analysis, 2022

Table 4.23: Model Estimation of monthly rainfall series for Ogbomosho SARIMA (1, 0, 1) (0, 1, 1)₁₂ with drift

Model	AR1	MA1	SMA1	Drift			
Estimate	0.8473	-0.7488	-0.8346	0.2027			
S. E	0.1417	0.1781	0.0423	0.1046			
Performance criteria	R2	AIC	Log-likelihood	ME	RMSE	MAE	MASE
		4126.39	-2058.2	-0.31	70.9634	48.1667	0.7931

Source: Author's Analysis, 2022

Table 4.24: Model Estimation of monthly maximum temperature series for Ogbomosho SARIMA (1, 0, 0) (1, 1, 0)₁₂ with drift

Model	AR1	SAR1	Drift				
Estimate	0.4683	-0.4191	0.002				
S. E	0.0466	0.0478	0.0056				
Performance criteria	R2	AIC	Log-likelihood	ME	RMSE	MAE	MASE
	0.9137	996.69	-494.34	0.00041	0.9364	0.7014	0.7956

Source: Author's Analysis, 2022

Table 4.25: Model Estimation of monthly minimum temperature series for Ogbomosho SARIMA (1, 0, 0) (1, 1, 0)₁₂ with drift

Model	MA1	SAR1					
Estimate	0.1671	-0.4794					
S. E	0.0518	0.0469					
Performance criteria	R2	AIC	Log-likelihood	ME	RMSE	MAE	MASE
		1178.13	-586.06	0.0037	1.2071	0.8326	0.8703

Source: Author's Analysis, 2022

ARIMA is a model that can be fitted to time series data to predict future points in the series. MA(q) stands for moving average model, the q is the number of lagged forecast error terms in the prediction equation. SARIMA is seasonal ARIMA and it is used with time series with seasonality.

The AR stands for autoregressive and refers to using lagged values of our target variable to make our prediction. For example, we might use today's, yesterday's, and the day before yesterday's sales numbers to forecast tomorrow's sales. That would be an AR (3) model as it uses 3 lagged values to make its prediction.

The I stand for integrated. It means that instead of taking the raw target values, we are differencing them. For example, our sales prediction model would try to forecast tomorrow's change in sales (i.e., tomorrow's sales minus today's sales) rather than just tomorrow's sales. The reason we need this is that many time series exhibit a trend, making the raw values non-stationary. Taking the difference makes our Y variable more stationary.

The MA stands for moving average. A moving average model takes the lagged prediction errors as inputs. It's not a directly observable parameter unlike the others (and it's not fixed as it changes along with the models in others parameters). At a high

level, feeding the model's errors back to itself serves to push it somewhat towards the correct value (the actual Y values).

SARIMA models are ARIMA models with a seasonal component. As Per the formula SARIMA(p,d,q) x (P,D,Q,s), the parameters for these types of models are as follows:

p and seasonal P: indicate number of autoregressive terms (lags of the stationaries' series)

d and seasonal D: indicate differencing that must be done to stationaries' series

q and seasonal Q: indicate number of moving average terms (lags of the forecast errors)

s: indicates seasonal length in the data

Two approaches were taken to determine the ideal SARIMA parameters: ACF and PACF plots, and a grid search. The ACF and PACF plots were used as a starting point to narrow down to a few potential parameters, and then a grid search was used to identify the best parameters as shown in Tables 4.2.2 – 4.2.13

For ease of interpretation SARIMA (1,0,1)_s x (0,1,1)₁₂:

p = 1 and P = 0 (significant positive spikes in ACF and PACF plots)

d = 0 and D = 1 (first difference and seasonal difference)

q and Q both equal 1 (significant negative spikes, PACF decay is more gradual)

s equal to 12 (monthly seasonal component)

Using these parameters, the model was fit to the data, and then a new set of ACF and PACF plots of the model's residuals was evaluated.

With a starting point of (1,0,1) x (0,1,1)₁₂, a grid search was set up to test a number of different parameter combinations. It's worth looking at models where p = 0,1, or 2 and q = 1 or 2. A metric that can be used to compare the relative quality of each model is AIC (Akaike Information Criterion), which is an estimator of out-of-sample

prediction error; a lower AIC score indicates a more predictive model as stated in Tables 4.19 – 4.30

4.3.4 Model Diagnostic

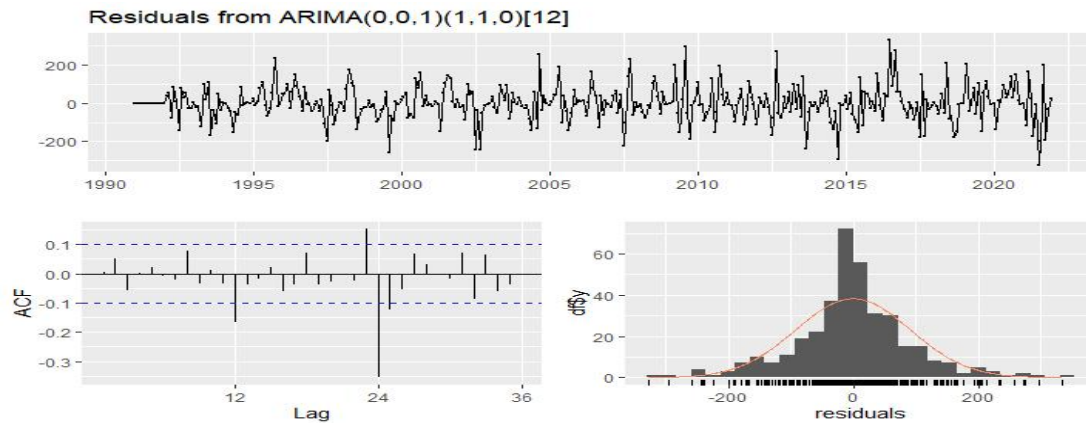


Figure 4.44: Residual diagnostic for Rainfall in Akure.

Source: Author's Analysis, 2022.

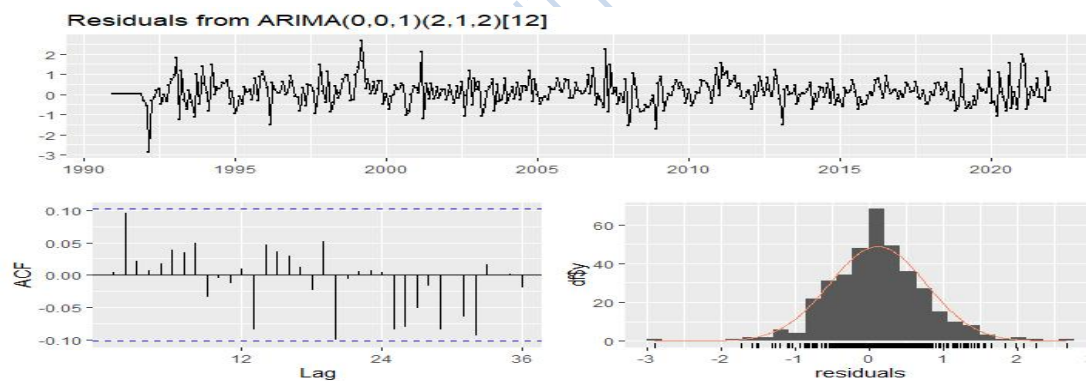


Figure 4.45: Residual diagnostic for Maximum Temperature in Akure

Source: Author's Analysis, 2022.

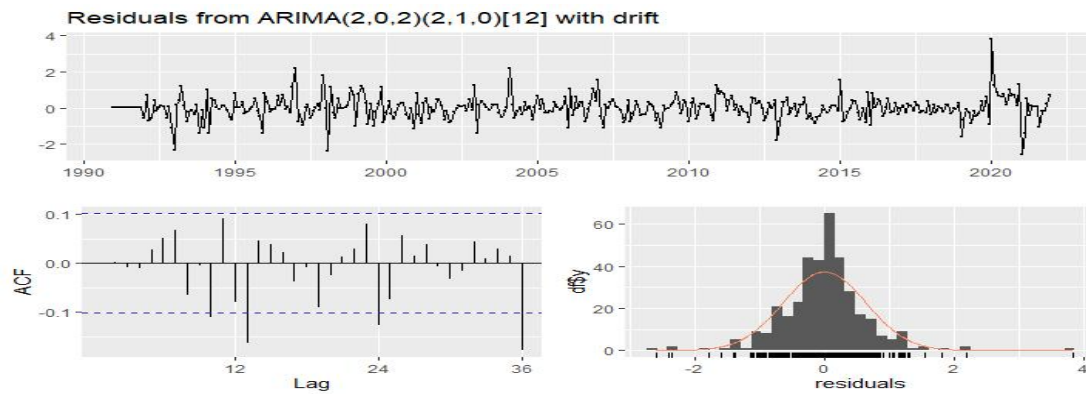


Figure 4.46: Residual diagnostic for Minimum Temperature in Akure

Source: Author's Analysis, 2022

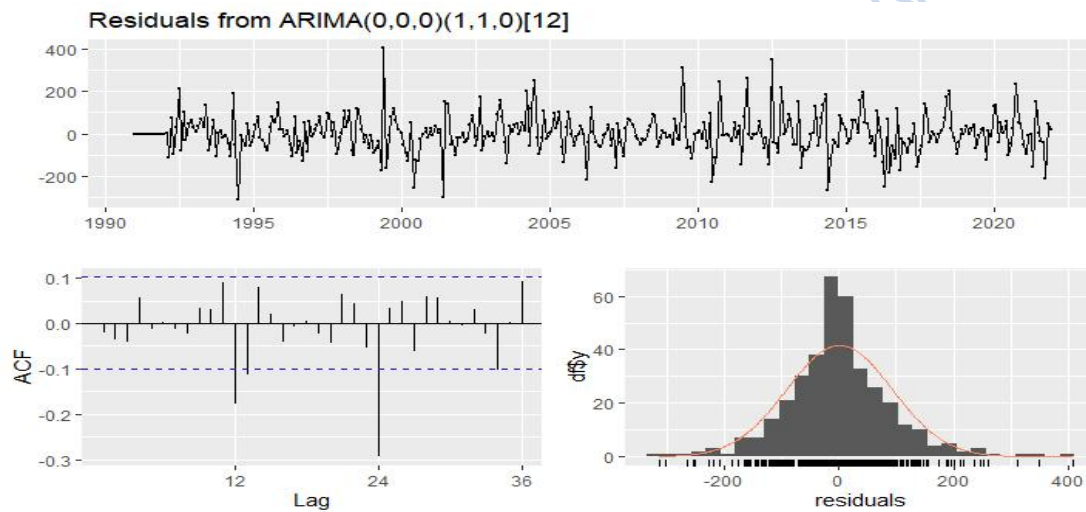


Figure 4.47: Residual diagnostic for Rainfall in Badagry

Source: Author's Analysis, 2022

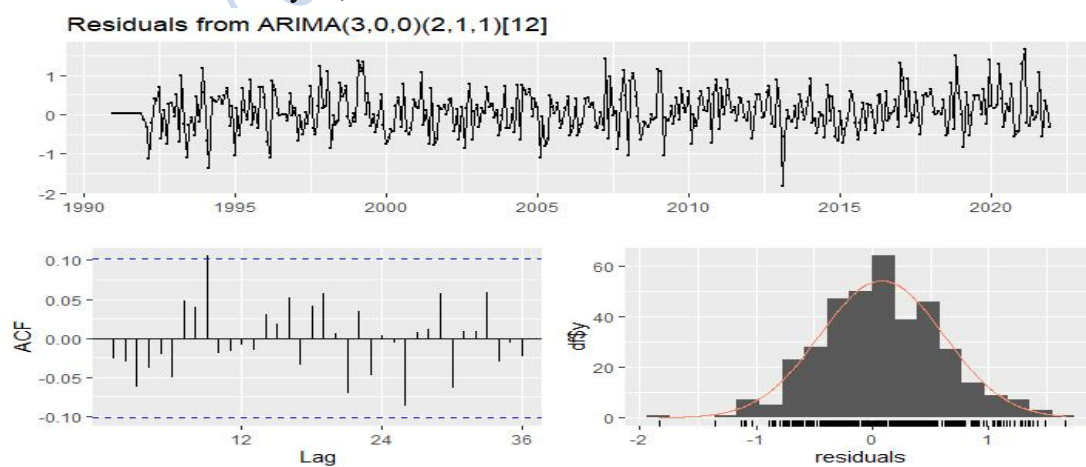


Figure 4.48: Residual diagnostic for Maximum Temperature in Badagry

Source: Author's Analysis, 2022

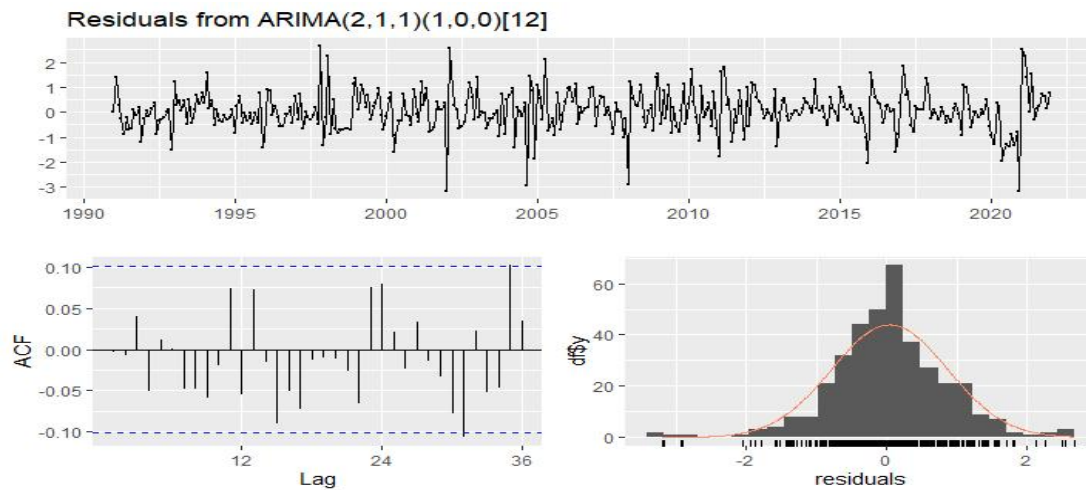


Figure 4.49: Residual diagnostic for Minimum Temperature in Badagry
Source: Author's Analysis, 2022

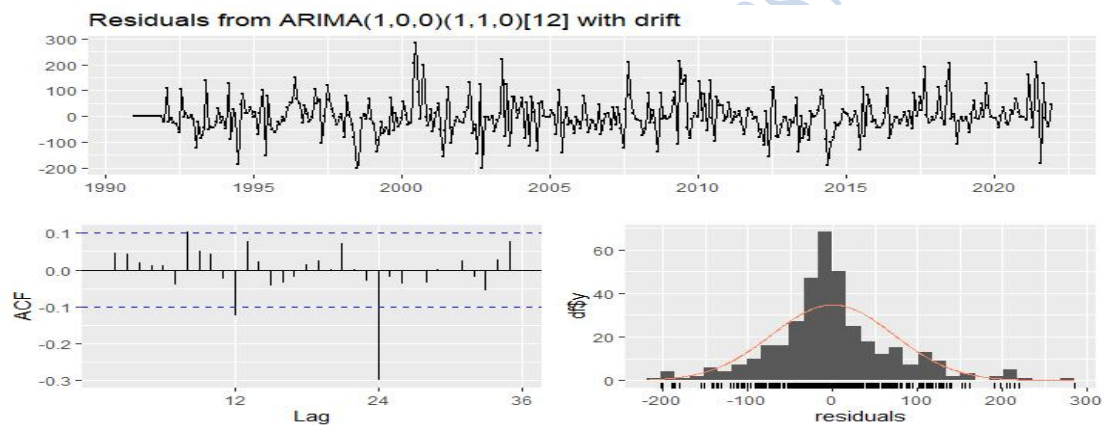


Figure 4.50: Residual diagnostic for Rainfall in Ibadan
Source: Author's Analysis, 2022

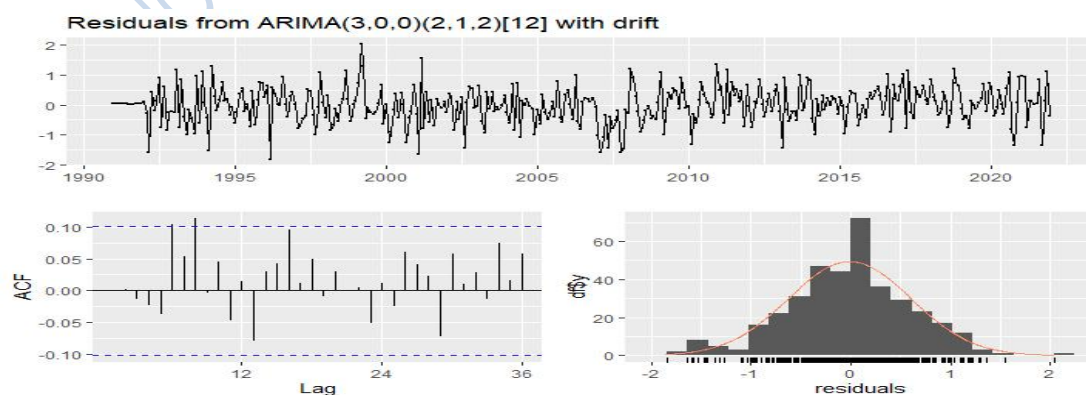


Figure 4.51: Residual diagnostic for Maximum Temperature in Ibadan
Source: Author's Analysis, 2022

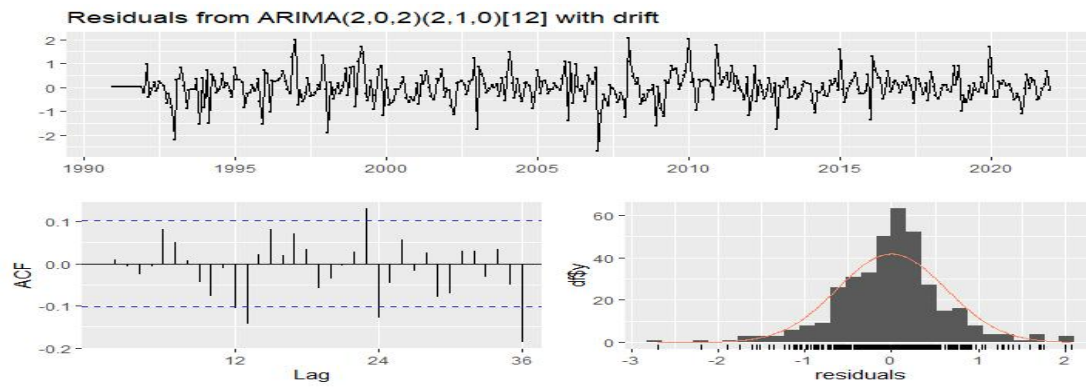


Figure 4.52: Residual diagnostic for Minimum Temperature in Ibadan

Source: Author's Analysis, 2022

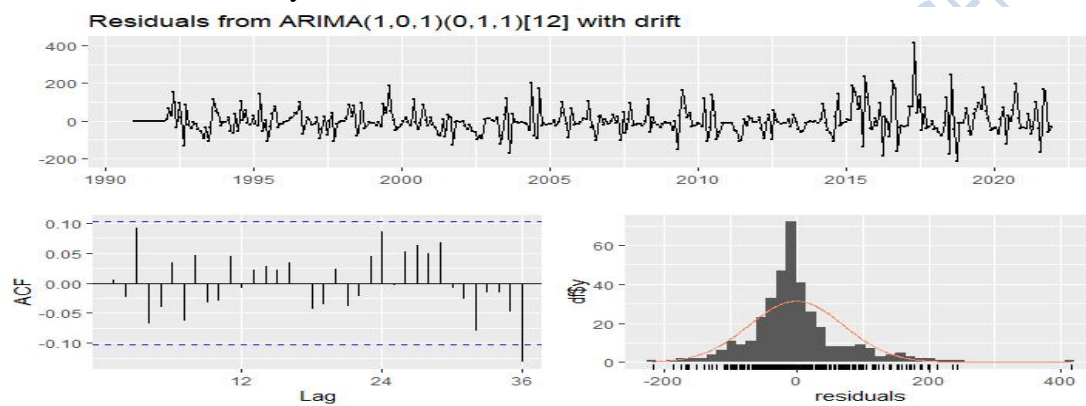


Figure 4.53: Residual diagnostic for Rainfall in Ogbomosho

Source: Author's Analysis, 2022

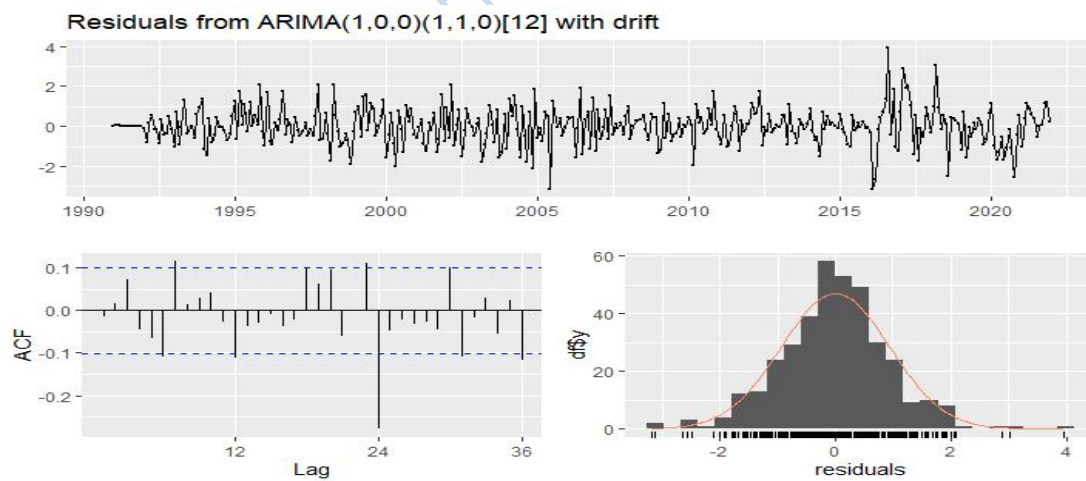


Figure 4.54: Residual diagnostic for Minimum Temperature in Ogbomosho

Source: Author's Analysis, 2022

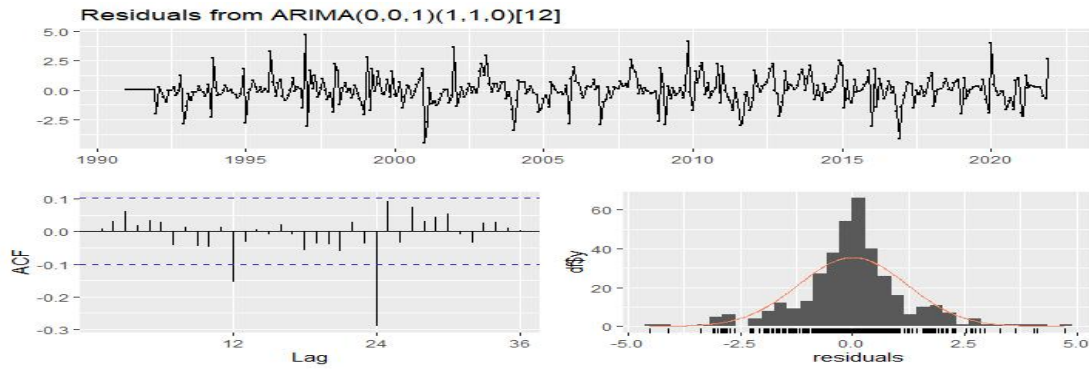


Figure 4.55: Residual diagnostic for Maximum Temperature in Ogbomosho

Source: Author's Analysis, 2022

Figures 4.44 – 4.55 present the diagnostic plots of the residual generated from the time series model. It contains the residual plots, Autocorrelation Function plot and histogram to show the normality of the residual generated from the time series analysis. The entire residual plot showed that the error is normal with the histogram displaying normality of the residual structure thereby suggestive of a good prediction from the time series models obtained.

4.3.5 Forecasting

Here the forecasts chart for 2021-2040 are plotted as a red line, and the 95% prediction interval as a blue area (Appendices XII-XIX). The ‘forecast lower confidence bound and upper confidence bound of Rainfall and average temperature are calculated as the observed values minus predicted values, for each time point. The forecast for the time period was calculated from the original time series, which is 1991-2020 for the rainfall and temperature data. As mentioned above, one measure of the accuracy of the predictive model is the sum-of-squared-errors (SSE) for the n-sample forecast errors as stated in Table 4.61 to 4.72. The in-sample forecast errors are stored in the named element “residuals” of the list variable returned by forecast. If the predictive model cannot be improved upon, there should be no correlations between forecast errors for successive predictions. In other words, if there are correlations between forecast errors

for successive predictions, it is likely that the simple exponential smoothing forecasts could be improved upon by another forecasting technique. Temperature values is predicted to be in its highest every February of the forecasted years in Akure with February 2022 having the highest forecasted temperature of 34.7°C. In the same vein, Rainfall values were predicted to be highest around September of every year of prediction. Badagry maintained the same line of forecast for temperature but a shift to June in its rainfall forecast. The highest volume of rainfall is then expected to occur around June of all the forecast years (Appendices XI-XIV).

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Table: 4.26 Showing predictive analysis of annual rainfall for the year 2021-2040 obtained from the moving average annual rainfall of the year 1990-2020 for Akure.

Year	Observed Rainfall (mm)	Forecast Year	Forecast Rainfall (mm)	Lower Confidence Bound (Rainfall)	Upper Confidence Bound (Rainfall)
1991	2096.6	2021	1810.0	1196.6	2423.47
1992	1804.9	2022	1803.6	1187.02	2420.12
1993	1655.6	2023	1797.1	1177.38	2416.82
1994	2134.6	2024	1790.6	1167.70	2413.57
1995	2503.2	2025	1784.2	1157.98	2410.36
1996	1827.8	2026	1777.7	1148.20	2407.19
1997	2283.6	2027	1771.2	1138.39	2404.07
1998	1375.3	2028	1764..8	1128.53	2401.00
1999	2101.2	2029	1758.3	1118.62	2397.97
2000	2069.1	2030	1751.8	1108.67	2394.99
2001	1516.6	2031	1745.4	1098.67	2392.05
2002	1928.1	2032	1738.9	1088.63	2389.16
2003	1690.2	2033	1732.4	1078.54	2386.31
2004	1861.5	2034	1726	1068.41	2383.51
2005	1914.7	2035	1719.5	1058.23	2380.75
2006	1944.9	2036	1713.0	1048.01	2378.04
2007	2026.8	2037	1706.6	1037.75	2375.36
2008	2062.1	2038	1700.1	1027.44	2372.74
2009	2157.7	2039	1693.6	1017.09	2370.15
2010	1587.1	2040	1687.2	1006.70	2367.61
2011	1999.8				
2012	1991.6				
2013	1447.3				
2014	1544.8				
2015	2518.4				
2016	1588.2				
2017	1645				
2018	1997.6				
2019	2258.6				
2020	1439.5				

Source: Processed Meteorological Data

Table 4.26 revealed the twenty (20) annual prediction of rainfall for Akure. It is observed that most of the predictive years data are above the observed data. The lower confidence rainfall bound data are all below the observed rainfall data while the upper confidence bound rainfall data are higher than the observed rainfall data except the year 1995 (2503.2mm). Upper confidence is the 95% assurance that the rainfall in the predictive years will occur.

Table 4:27 Showing predictive analysis of Average Temperature for the year 2021-2040 obtained from the moving Average Temperature of the year 1991-2020 for Akure.

Year	Observed Average Temperature	Year	Forecast Average Temperature	Lower Confidence Bound (Temperature)	Upper Confidence Bound (Temperature)
1991	26.4	2021	27.5	26.9	28.1
1992	26.5	2022	27.6	27.0	28.1
1993	26.6	2023	27.6	27.0	28.2
1994	26.5	2024	27.6	27.0	28.2
1995	26.8	2025	27.6	27.0	28.3
1996	26.8	2026	27.7	27.1	28.3
1997	26.8	2027	27.7	27.1	28.3
1998	27.5	2028	27.7	27.1	28.4
1999	26.7	2029	27.8	27.2	28.4
2000	26.9	2030	27.8	27.2	28.4
2001	26.7	2031	27.8	27.2	28.5
2002	26.8	2032	27.9	27.2	28.5
2003	27.1	2033	27.9	27.3	28.5
2004	27.0	2034	27.9	27.3	28.6
2005	27.3	2035	28.0	27.3	28.6
2006	27.3	2036	28.0	27.4	28.6
2007	26.6	2037	28.0	27.4	28.7
2008	27.1	2038	28.1	27.4	28.7
2009	27.2	2039	28.1	27.5	28.8
2010	27.8	2040	28.1	27.5	28.8
2011	27.4				
2012	27.2				
2013	27.1				
2014	27.1				
2015	27.4				
2016	27.2				
2017	27.2				
2018	26.9				
2019	28.1				
2020	27.5				

Source: Processed Meteorological Data

Table 4.27 revealed the higher temperature in the predictive years, lower confidence bound and upper confidence bound above the observed data in Akure.

Table 4.28 Showing predictive analysis of annual rainfall for the year 2021-2040 Obtained from the Moving Average Annual Rainfall of the Year 1990-2020 for Badagry.

Year	Observed Rainfall	Forecast Year	Forecast Rainfall	Lower Confidence Bound	Upper Confidence Bound
1991	1464.4	2021	1437.4	624.8	2250
1992	931.6	2022	1462.0	645.3	2278.8
1993	1177	2023	1486.7	665.8	2307.6
1994	1242	2024	1511.4	686.2	2336.6
1995	1409.2	2025	1536.0	706.2	2365.6
1996	945.3	2026	1560.7	726.8	2394.6
1997	1334.4	2027	1585.4	747.1	2423.7
1998	1596.5	2028	1610.1	767.3	2452.9
1999	1539.3	2029	1634.7	787.4	2482.1
2000	993.3	2030	1659.4	807.4	2511.4
2001	697.7	2031	1684.1	827.4	2540.7
2002	957.1	2032	1708.7	847.3	2570.1
2003	1286.7	2033	1733.4	867.2	2599.6
2004	1327.1	2034	1758.1	887.0	2629.1
2005	1317.1	2035	1782.7	906.8	2658.7
2006	1303.8	2036	1807.4	926.5	2688.34
2007	1292.2	2037	1832.1	946.1	2718.0
2008	1401.4	2038	1856.8	965.7	2747.8
2009	1343.1	2039	1881.4	985.2	2777.6
2010	924.3	2040	1906.1	1004.7	2807.5
2011	1086.5				
2012	1079.1				
2013	1271.5				
2014	2296.5				
2015	1701.1				
2016	2552.6				
2017	1483				
2018	2195				
2019	2096.4				
2020	1412.7				

Source: Processed Meteorological Data

Table 4.28 showed the predictive upper confidence bound (rainfall) higher than the observed rainfall while the observed rainfall data (1464.4mm) is higher than the forecast year (1437.4mm) only in the year 1991.

Table 4.29 Showing predictive analysis of Average Temperature (°C) for the year 2021-2040 obtained from the moving Average of Average Temperature (°C) of the year 1991-2020 for Badagry.

Year	Observed Temperature (°C)	Forecast Year	Average Temperature(°C) Forecast	Lower Confidence Bound (Temperature)	Upper Confidence Bound (Temperature)
1991	26.8	2021	28.1	27.5	28.7
1992	27.2	2022	28.2	27.6	28.8
1993	27.3	2023	28.1	27.5	28.7
1994	26.9	2024	28.1	27.5	28.7
1995	26.8	2025	28.0	27.4	28.6
1996	26.7	2026	28.1	27.4	28.7
1997	27.5	2027	28.3	27.7	29.0
1998	27.6	2028	28.4	27.8	29.0
1999	26.9	2029	28.3	27.7	29.0
2000	27.1	2030	28.3	27.7	29.0
2001	27.2	2031	28.3	27.6	28.9
2002	27.2	2032	28.3	27.6	28.9
2003	27.1	2033	28.6	27.9	29.2
2004	27.0	2034	28.6	28.0	29.3
2005	27.5	2035	28.6	27.9	29.2
2006	27.5	2036	28.6	27.9	29.2
2007	27.4	2037	28.5	27.8	29.2
2008	27.6	2038	28.5	27.8	29.2
2009	27.8	2039	28.8	28.1	29.5
2010	27.9	2040	28.9	28.2	29.6
2011	28.0				
2012	27.6				
2013	27.7				
2014	27.4				
2015	27.7				
2016	28.3				
2017	28.1				
2018	28.1				
2019	26.9				
2020	28.1				

Source: Processed Meteorological Data

Table 4.29 shows the temperature value for Badagry in the forecast year, lower confidence bound and upper confidence bound to be higher than the observed temperature.

Table 4.30 Showing Predictive Analysis of Annual Rainfall for the Year 2021-2040 Obtained from the Moving Average Annual rainfall of the year 1991-2020 for Ibadan.

Year	Observed Rainfall	Forecast Year	Forecast Rainfall	Lower Confidence Bound (Rainfall)	Upper Confidence Bound (Rainfall)
1991	1396.3	2021	1655.4	1172.4	2138.5
1992	1173.6	2022	1664.3	1166.3	2162.4
1993	1574.8	2023	1673.2	1160.5	2185.9
1994	1095.1	2024	1682.1	1155.0	2209.2
1995	1471.1	2025	1691	1149.8	2232.1
1996	1506.2	2026	1699.9	1144.9	2254.9
1997	1360	2027	1708.7	1140.1	2277.4
1998	1148.1	2028	1717.6	1135.6	2299.7
1999	1640.5	2029	1726.5	1131.3	2321.8
2000	1208.4	2030	1735.4	1127.2	2343.7
2001	1133.6	2031	1744.3	1123.3	2365.4
2002	1196.4	2032	1753.2	1119.5	2386.9
2003	1304.5	2033	1762.1	1115.9	2408.3
2004	1006.6	2034	1771	1112.4	2429.6
2005	1314	2035	1779.9	1109.0	2450.7
2006	1198.5	2036	1788.8	1105.8	2471.7
2007	1079.3	2037	1797.7	1102.7	2492.6
2008	1435.8	2038	1806.5	1099.8	2513.3
2009	1504.1	2039	1815.4	1096.9	2534
2010	1762.5	2040	1824.3	1094.1	2554.5
2011	1433.6				
2012	1537.7				
2013	1548.8				
2014	1148.1				
2015	1028.7				
2016	1347.7				
2017	1362.5				
2018	1389.6				
2019	1784.9				
2020	2130				

Source: Processed Meteorological Data

Table 4.30 presents the rainfall (mm) in the forecast years, lower confidence and upper confidence to be higher than the observed rainfall data in Ibadan.

Table 4.31 Showing Predictive Analysis of Annual Average Temperature for the Year 2021-2040 Obtained from the Moving Average Annual Average Temperature of the year 1991-2020 for Ibadan.

Year	Observed Average Temperature	Forecast Year	Forecast Average Temperature	Lower Confidence Bound (Temperature)	Upper Confidence Bound (Temperature)
1991	27.8	2021	27.0	25.9	28.1
1992	27.5	2022	26.8	25.6	27.9
1993	27.6	2023	26.5	25.3	27.7
1994	27.6	2024	26.2	24.9	27.5
1995	27.7	2025	25.9	24.5	27.3
1996	28.0	2026	25.7	24.1	27.2
1997	27.6	2027	25.4	23.7	27.1
1998	29.0	2028	25.1	23.2	27.0
1999	28.0	2029	24.8	22.6	27.0
2000	28.3	2030	24.6	22.1	27.0
2001	28.1	2031	24.3	21.5	27.0
2002	28.4	2032	24.0	21.0	27.1
2003	27.9	2033	23.7	20.4	27.1
2004	28.3	2034	23.5	19.7	27.2
2005	28.0	2035	23.2	19.1	27.3
2006	28.1	2036	22.9	18.5	27.4
2007	28.1	2037	22.6	17.8	27.5
2008	28.3	2038	22.4	17.1	27.6
2009	27.9	2039	22.1	16.5	27.7
2010	28.5	2040	21.8	15.8	27.9
2011	28.2				
2012	27.7				
2013	28.0				
2014	28.0				
2015	28.2				
2016	28.4				
2017	27.0				
2018	27.2				
2019	27.8				
2020	25.5				

Source: Processed Meteorological Data

Table 4.31 shows that most of the temperature values in the observed data are higher than the forecast, lower confidence bound and upper confidence bound temperature($^{\circ}\text{C}$) in Ibadan.

Table 4.32 Showing Predictive Analysis of Annual Rainfall for the Year 2021-2040 Obtained from the Moving Average Annual rainfall of the year 1991-2020 for Ogbomosho

Year	Observe Rainfall	Forecast Year	Forecast Rainfall	Lower Confidence Bound (Rainfall)	Upper Confidence Bound (Rainfall)
1991	1610.1	2021	1823.8	1314.4	2333.3
1992	1671.8	2022	1836.4	1311.1	2361.7
1993	1218.4	2023	1849	1308.2	2389.7
1994	1624	2024	1861.5	1305.7	2417.4
1995	1141.3	2025	1874.1	1303.4	2444.8
1996	1629.3	2026	1886.7	1301.3	2472
1997	1568.2	2027	1899.2	1299.5	2498.9
1998	1748.6	2028	1911.8	1298	2525.6
1999	926.5	2029	1924.4	1296.6	2552.1
2000	1187.7	2030	1936.9	1295.5	2578.4
2001	1125.2	2031	1949.5	1294.5	2604.3
2002	1392.1	2032	1962.1	1293.7	2630.4
2003	1782.5	2033	1974.6	1293.1	2656.2
2004	1699.6	2034	1987.2	1292.6	2681.8
2005	1483.9	2035	1999.8	1292.3	2707.3
2006	1518.9	2036	2012.3	1292.1	2732.6
2007	1539.8	2037	2024.9	1292.0	2757.8
2008	1553.7	2038	2037.5	1292.1	2782.9
2009	1390.2	2039	2050.0	1292.2	2807.8
2010	1687.5	2040	2062.6	1292.5	2832.7
2011	1323				
2012	1556.1				
2013	1726.7				
2014	2055.1				
2015	1939.2				
2016	1536.7				
2017	1550.4				
2018	1468.6				
2019	2012.2				
2020	1964.2				

Source: Processed Meteorological Data

Table 4.32 shows the forecast years rainfall (mm) data and the upper confidence

higher than the observed rainfall (mm) data in the predicted years

Table 4.33 Showing Predictive Analysis of Annual Average Temperature for the Year 2021-2040 Obtained from the Moving Average Annual Average Temperature of the year 1991-2020 for Ogbomosho.

Year	Observed Average Temperature	Forecast Year	Forecast Temperature	Lower Confidence Bound (Temperature)	Upper Confidence Bound (Temperature)
1991	26.6	2021	27.2	26.5	27.9
1992	26.4	2022	27.2	26.5	27.9
1993	26.5	2023	27.2	26.5	27.9
1994	27.2	2024	27.2	26.5	27.9
1995	27.2	2025	27.2	26.5	28.0
1996	27.1	2026	27.3	26.6	28.0
1997	27.0	2027	27.3	26.6	28.0
1998	27.6	2028	27.3	26.6	28.0
1999	27.1	2029	27.3	26.6	28.0
2000	26.6	2030	27.3	26.6	28.1
1001	27.3	2031	27.4	26.6	28.1
2002	26.8	2032	27.4	26.7	28.1
2003	26.7	2033	27.4	26.7	28.1
2004	26.2	2034	27.4	26.7	28.1
2005	26.6	2035	27.4	26.7	28.2
2006	26.7	2036	27.5	26.7	28.2
2007	27.0	2037	27.5	26.8	28.2
2008	26.7	2038	27.5	26.8	28.2
2009	27.3	2039	27.5	26.8	28.2
2010	26.4	2040	27.5	26.8	28.3
2011	27.2				
2012	27.3				
2013	27.3				
2014	27.1				
2015	26.8				
2016	27.4				
2017	27.8				
2018	27.4				
2019	26.9				
2020	27.4				

Source: Processed Meteorological Data

As shown in table 4.33, nearly all the temperature (°C) values in forecast years and upper confidence bound are higher than the observed temperature values.

From the Tables 4.26-4.33 presenting rainfall and temperature, the data values are predicted to be higher than the observed values while the chat trends forecast show the tendency for rainfall and temperature rising in the next twenty (20) years. Also,

the predicted values of rainfall and temperature in all the study locations are higher than standardize normal. This is a revelation of flood disaster and drought occurrence in future which signify negative effect on agriculture/vegetation and livelihoods of the communities in the study area. This calls for precautionary measures to be taken by all the stake holders such as government and Non-Governmental Organization, to avert the likely peril that may arise in Southwest Nigeria. Policy measures that can support adaptation should be put in place to forestall unexpected crisis while extension services be strengthened to assist the farmers in cushioning these effects in Southwest Nigeria. This is corroborated by the finding that the frequent heavy downpours during the raining seasons have been attributed to global warming in Southwest Nigeria^{12***}

4.4 Time Series Analysis of Vegetation Cover and Land Surface Temperature (LST) Based on Satellite Remote Sensing

The result presented in the LULC in the four study locations differ from one another because of different environmental characteristics and what may be visible to satellite imagery in each forest reserve. For example, the satellite imagery can reveal any phenomena visible to satellite imagery but those that are under the trees may not be visible. Streams may not feature while rivers are presented as open water. Where there is thick forest, shrubs may not be visible. Settlement, roads and some human activities are presented as built up area. In some of the forest reserves, bare land may not be visible. These reasons accounted for the inconsistency in the classification of land use land cover presented in this study. What is very common to all the forest reserves are forest land and non-forest land in this research which will reveal the changes in vegetation over time. As such, the emphasis was on vegetation cover dynamics.

Table 4.34: Percentage Land use and Land cover change at Akure Forest Reserve between 1990 and 2020 (km²)

	1990	%	2000	%	2010	%	2020	%
	LULCt		LULCt		LULCt		LULCt	
	Area		Area		Area		Area	
Built	0	0	0.0783	0.106488	0	0	1	2
Up Area								
Bare	1	1	5.0625	6.885029	19	26	7	8
land								
Forest	73	99	68.3199	92.9	55	74	65	88
Land								
Open	0	0	0.0684	0.093024	0	0	1	2
Water								
Total	74	100	73.5291	100	74	100	74	100

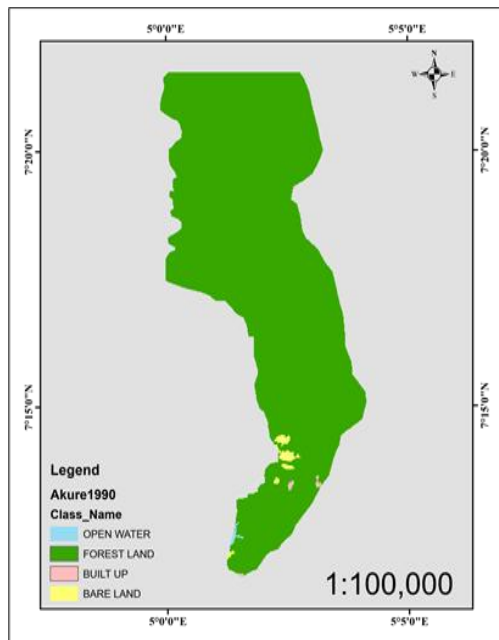
Source: Author's Analysis, 2022

Figure 4.56 shows the richness of this reserve as at 1990 and how it has lost its forest lands/vegetative cover over the time. Table 4.34 presents the proportion of land use land cover change in Akure Forest Reserve. In the early years, the forest reserve was almost covered completely with forest whose canopy overshadowed the existing water bodies (Fig 4.56). The forest reserve was completely free from enclaves, which characterized the reserve in most recent years, hence, about 2% increases in water body. The emergence of these enclaves accompanied with anthropogenic activities resulted into about 8% bare surface as potential human settlements in future if drastic action is not put in place to discourage the influx of people into the forest reserve. The built-up area in 1990 was 0%, and 0.1% in 2000. There was no additional built-up

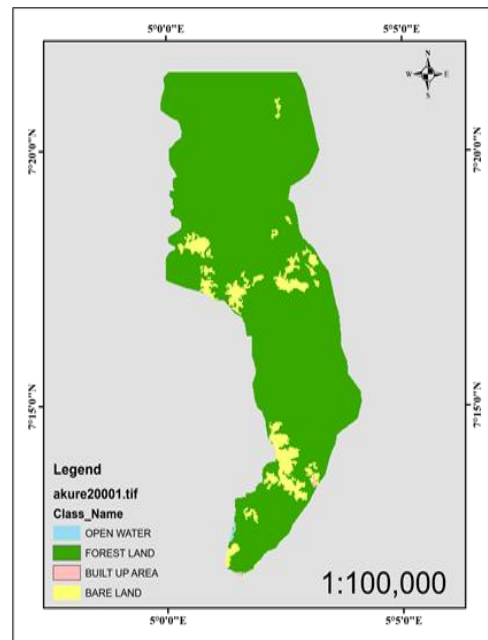
area in 2021 but in 2020 it increased to 1%. With respect to bare land there was an increase in the decades 1990, 2000 and 2010 from 1% to 7% and 26% respectively. The bare land later dropped to 8% in the last decade, 2020. The implication of this is that the farmers involved in farming and other activities in the last decade but in the previous decades, human activities were very scanty. The forest land as shown in the table above shows a decreasing trend in the first three decades 1990, 2000, and 2010 by 99%, 92.9% and 74% respectively. This later rose to 88% in 2020 which is a reflection of decrease in bare land percentage occupied. The total forest land loss over 31 years was 8km² (11%). In 1990, the total area was 73km² (99%) and in 2020, it was 65km² (88%). On the completion of the imageries, the digital classification was performed on the Landsat Scenes using the maximum likelihood supervised algorithm within *Idrisi Taiga* image processing software. This classified imagery provides guide to area of forest, built-up, open water, woodland and bare land. The temperature values in this reserve as at 1990 stood at 32.6°C for high and 20.0°C for low. This changed over the decades to 34.5°C and 21.9°C in 2020 for high and low, respectively. This is presented in Figure 4.57.



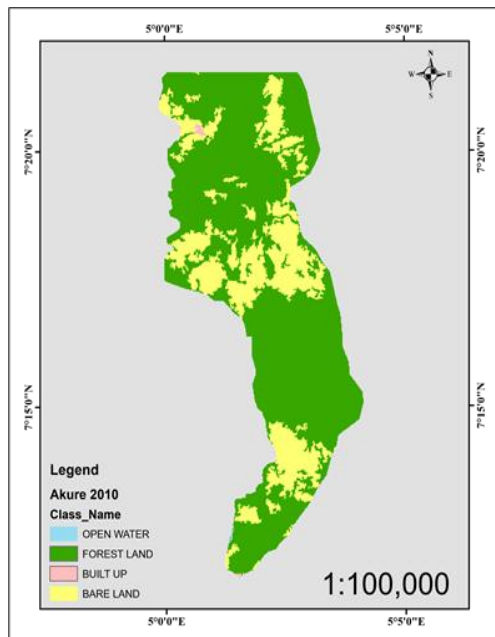
Plate 4.2: Bare land in the study location



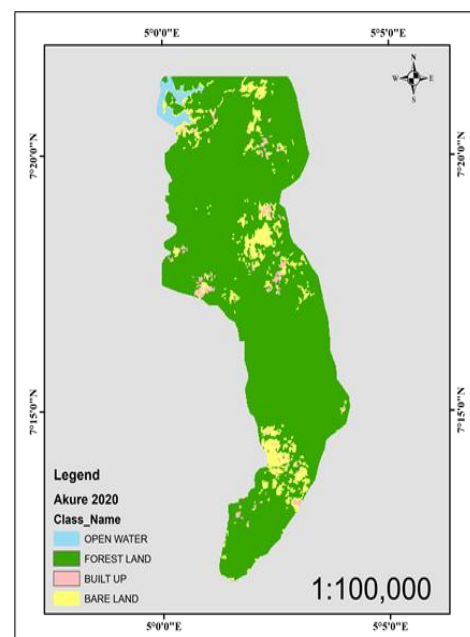
1990



2000



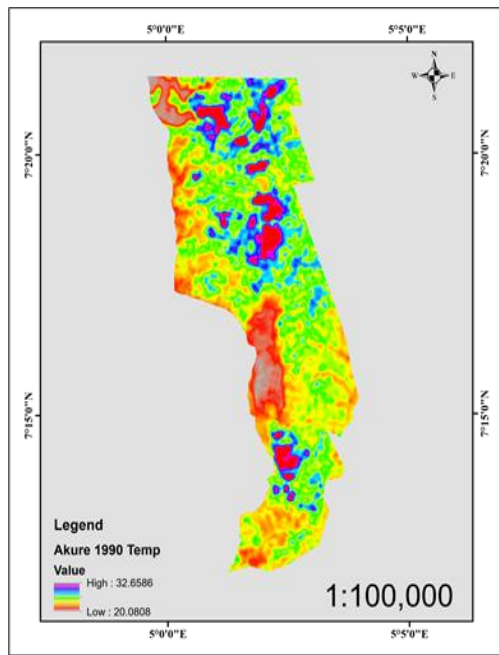
2010



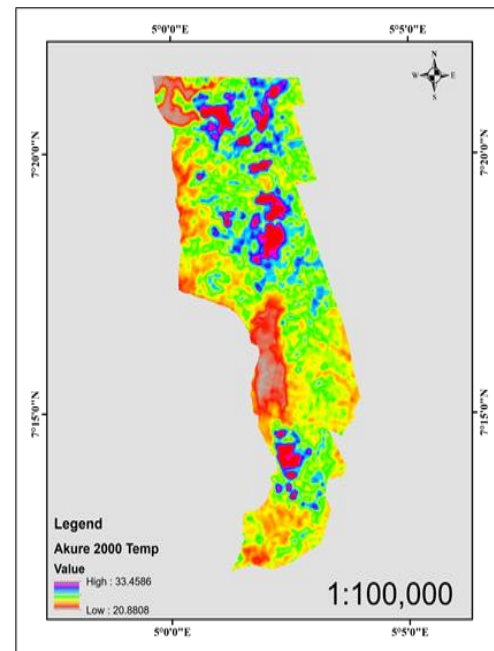
2020

Figure 4.56: Changes in Land use and Land cover change at Akure Forest reserve between 1990 and 2020.

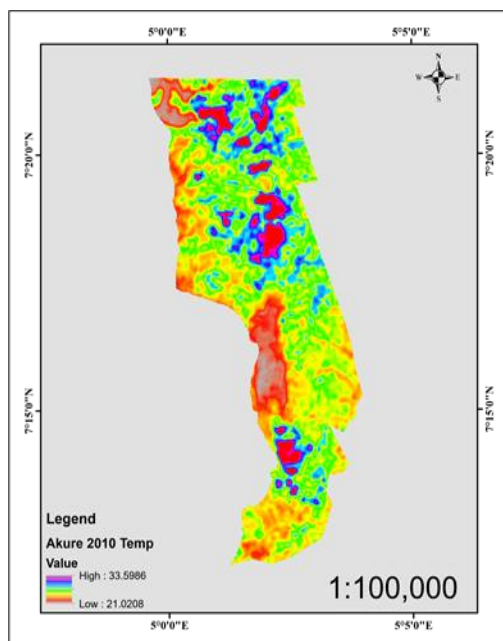
Source: Author's Analysis, 2022



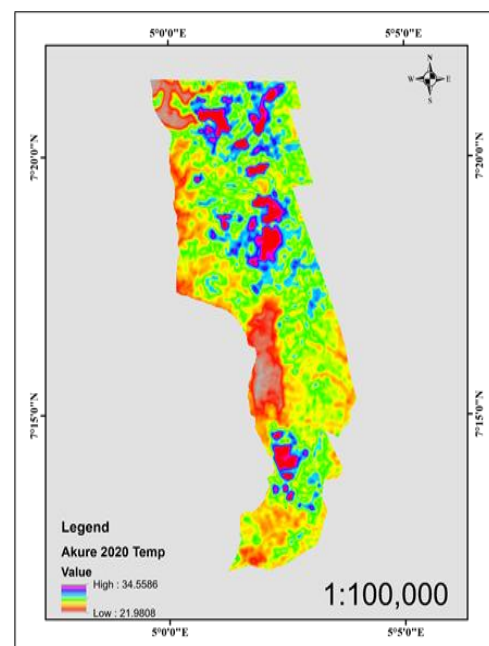
1990



2000



2010



2020

Figure 4.57: Changes in High and Low Land Surface Temperature (LST) at Akure Forest reserve between 1990 and 2020

Source: Author's Analysis, 2022

Table 4.35: Percentage Land use and Land cover change at Ologe Forest Reserve between 1990 and 2020 (km²).

	1990		2000		2010		2020	
	LULCt		LULCtif		LULCtif		LULCt	
	Area	%	Area	%	Area	%	Area	%
Open	12.4749	10.814712	11.7531	10.188971	11.0403	9.571032	12.6126	10.934769
Water								
Forest	4.833	4.189813	17.2305	14.937426	29.8602	25.886337	39.1077	33.9052747
Land								
Non-	98.0433	84.995475	86.3676	74.873603	74.4507	64.542632	63.6309	55.1661985
Forest								
land								
Total	115.3512	100	115.3512	100	115.3512	100.000001	115.3512	100.6242

Source: Author's Analysis, 2022

Table 4.35 presents the LULC changes for Ologe Forest Reserve in Badagry, Lagos. Out of the total area that is under the criterion of selection of the communities around the forest (115.351km²), the open water was observed to be reducing in the first three decades of 1990, 2000 and 2010 from 10.8%, to 10% and 9.6% respectively. But it increased to 10.9 % in 2020. The reason for this could be as a result of increase in rainfall that led to the increase in water in the ocean. In Ologe forest Reserve, there is a large water body that passes across the forest. Environmental conditions lead to the changes in water level. Relative to the Forest land use, the area coverage kept on increasing in percentages from 4% (1990) to 14.9% (2000), 25.8% (2010), and 33.9% (2020). The total forest land gained within 31 years was 34.3km² (29.7%). In 1990, the area coverage of forestland was 4.8km² and increased to 39.1km² (33.9%) in 2020. Despite the climate change and the encroachment in some areas into the forest, as observed and explained by the Forest official, the forest kept on increasing in area coverage due to afforestation programs embarked upon by Lagos State Government.

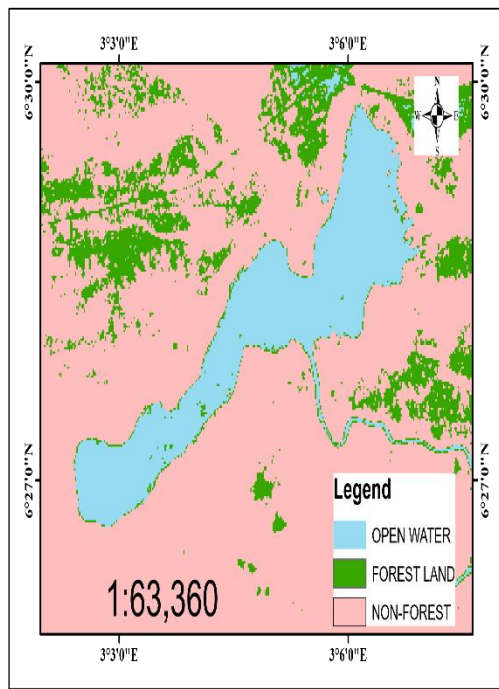
It was revealed from the field that the seedlings were planted as enrichment planting. That is replacing the original tree species in the exact location.

It was also found out that in the year 2021, there was collaboration with the Nigeria Conservation Foundation (NCF) which is the premier Non-Governmental Organization (NGO) dedicated to nature conservation and sustainable development in Nigeria. In the exercise, 1000 indigenous seedlings were planted. This year 2022, NCF has supplied 2000 indigenous seedlings during International Day of Forest (IDF) (March 21, 2022) to be planted in the forest reserve.

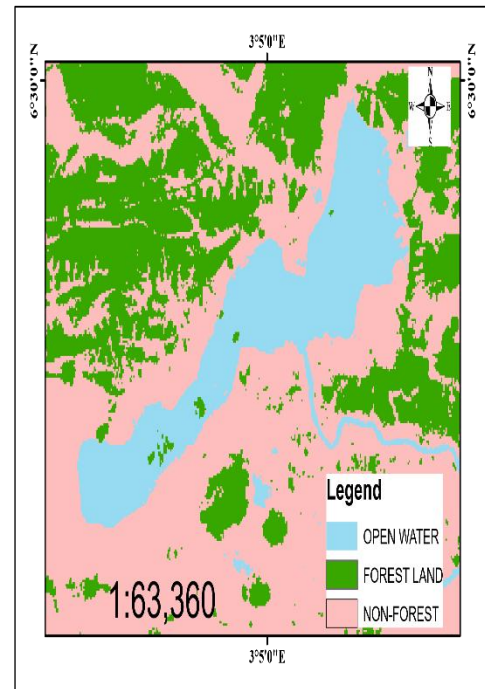
It was also gathered from the field that, about ten years ago, Federal government raised 1,000,000 seedlings in Lagos in which part were given to the communities, some were planted as amenity planting and some were giving to the populace for planting as a form of climate change impact amelioration.

This indirectly led to reduction in non-forest land from 84% (1990) to 74% (2000), 64% (2010), and 55% (2020) in those decades.

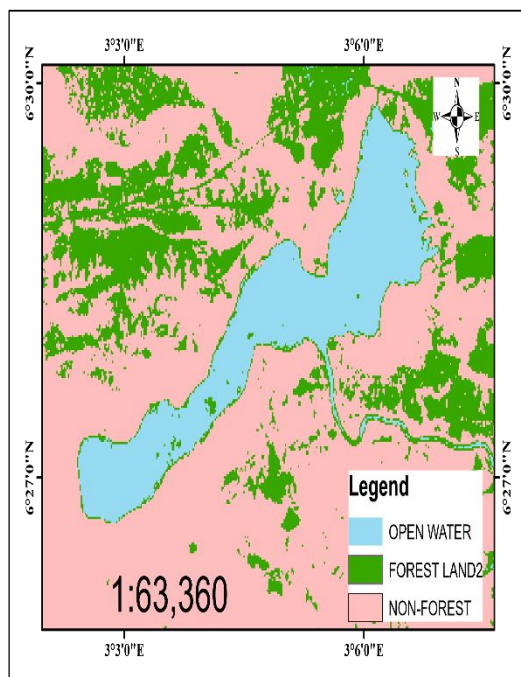
On the completion of the imageries, the digital classification was performed on the Landsat Scenes using the maximum likelihood supervised algorithm within *Idrisi Taiga* image processing software. This classified imagery provides guide to area of forest, built-up, open water, woodland and bare land. These are reported in Figures 4.58 and 4.59. Temperature values as at 2020 stood at 35.0°C and 21.7°C for high and low, respectively.



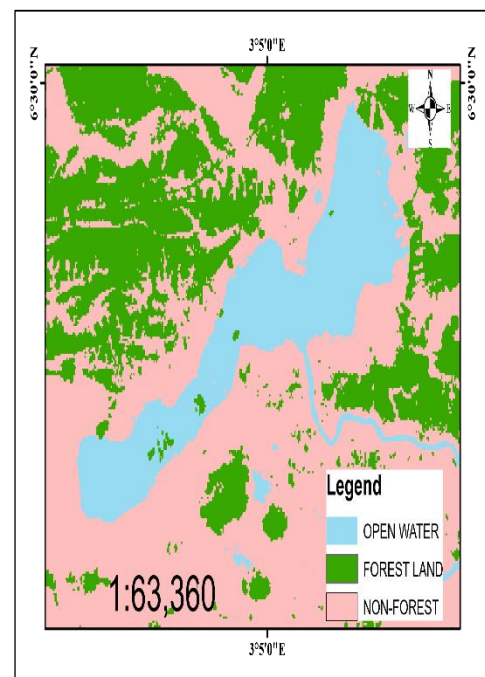
1990



2000



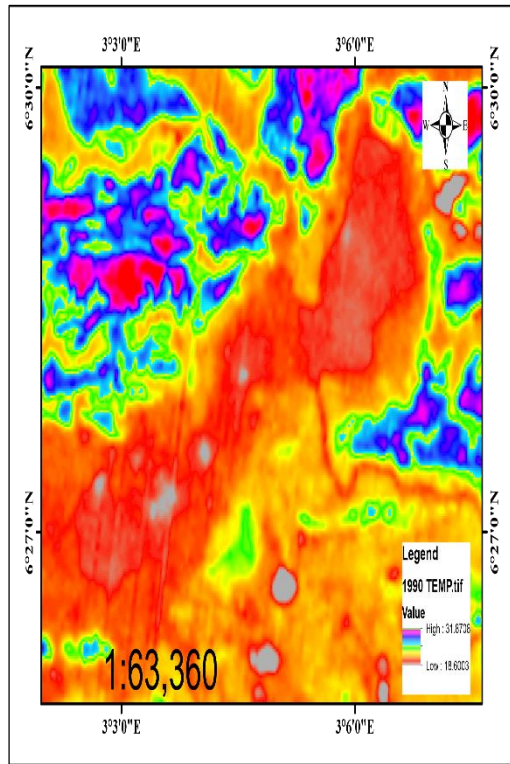
2010



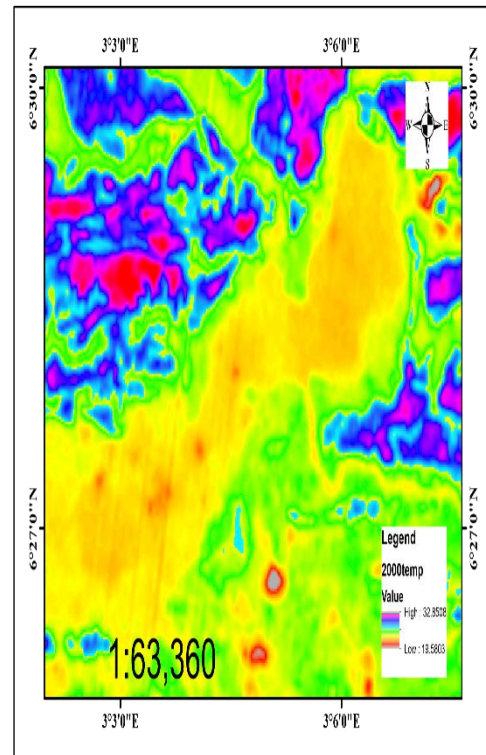
2020

Figure 4.58: Changes in Land use and Land cover change at Ologe Forest reserve between 1990 and 2020.

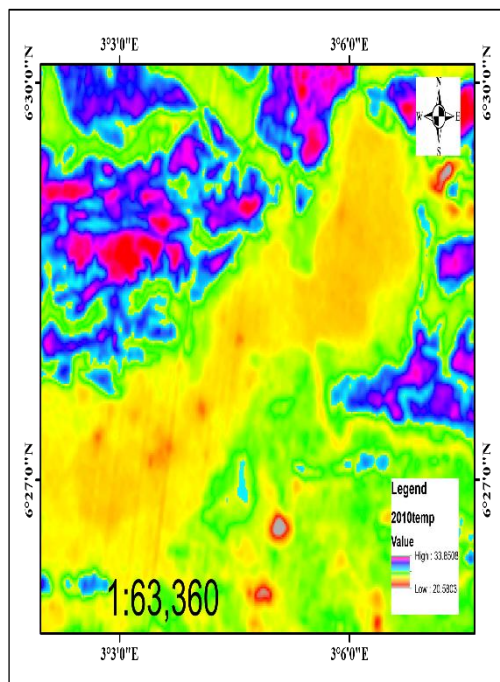
Source: Author's Analysis, 2022



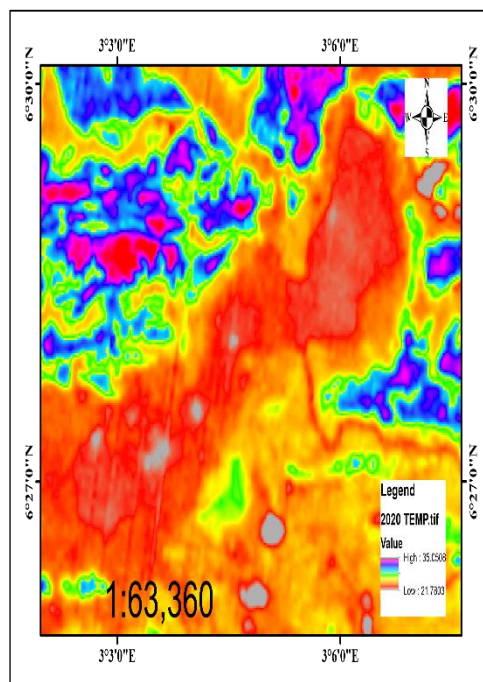
1990



2000



2010



2020

Figure 4.59: Changes in High and Low Land Surface Temperature (LST) at Ologe Forest reserve between 1990 and 2020

Source: Author's Analysis, 2022

From the Table 4.36, the area coverage of land use in Gambari Forest Reserve is presented. It is verified that out of 238.014 km² of the land, non-forest increased in percentage from 0.95%, 1.20%, and 12.70% in the decadal of 1990, 2000 and 2010, respectively. But there was sudden decrease in area occupied by non-forest to 4.90% in the last decade. The implication of this was as a result of afforestation in the year 2020. Area covered by shrubs was 11.75% of the total area. This follows the same trend with non-forest by increasing to 14.11% and 26.82% in the years 2000 and 2010 respectively, but decreased to 23.3% in the year 2020. The reason can be attached to the planting more tree crops in the last decade. The same pattern showed in the forest land that was increasing in percentage from 87.30% and 84.69% in the decade 1990 and 2000. There was a decrease in the plantation between the decade 2000 and 2010. On the completion of the imageries, the digital classification was performed on the Landsat Scenes using the maximum likelihood supervised algorithm within Idrisi Taiga image processing software. This classified imagery provided guide to area of forest, built-up, open water, woodland and bare land. Pictorial representation of this was shown in Figures 4.60 and 4.61. The heat signature also increased between 1990 and 2020 as clearly illustrated in Figure 4.61 with high and low temperature estimated to stand at 33⁰C and 24⁰C, respectively for year 2020. The implication of this is attached to illegal fellers that had the chance to intrude into the reserve. This later increased in the last decade 2010 and 2020 to 71.78%. Summarily, the total land area in 1990 was 207.77 km² (87.3%) and in the year 2020 it was 170 km² (71.8%). There was forest land loss of 36.97 km² (15.5%). In Gambari Reserve, it was gathered that there was cooperation between the forest dwellers and the Government in terms of security and practice of tungya farming. Government provided seedlings to the farmers to plant alongside their arable crops. Exogenous Factors affected the decrease

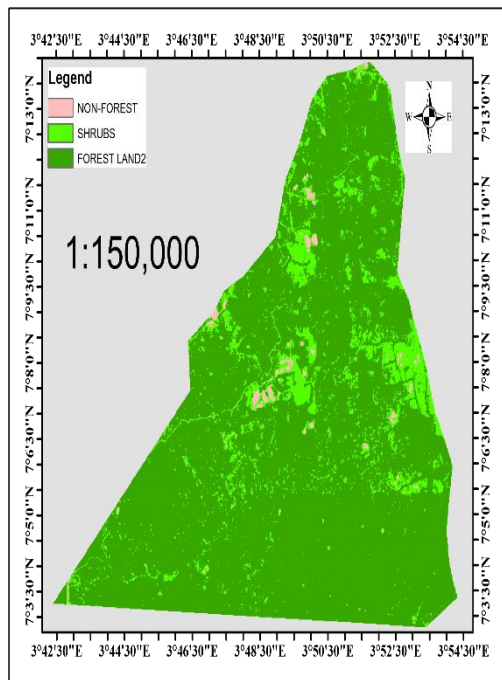
in the forest such as anthropogenic activities, cattle grazing and environmental conditions such as urbanization, farming activities, climate change (increase in temperature and decrease in rainfall) etc.

Table 4.36: Percentage Land use and Land cover change at Gambari Forest Reserve between 1990 and 2020(km²).

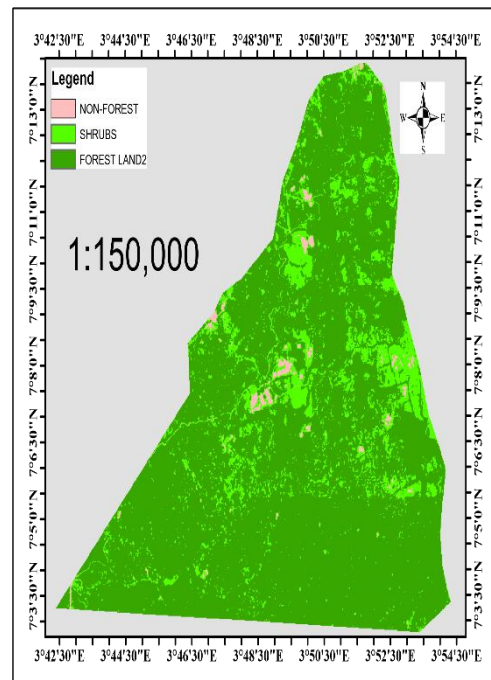
	1990		2000		2010		2020	
	LUL Ct		LUL Ct		LULCt		LULCt	
	Area	%	Area	%	Area	%	Area	%
Non-Forest Land	2.2707	0.95	2.8665	1.20	30.24	12.70	11.66	4.90
Shrubs	27.9648	11.75	33.579	14.11	63.84	26.82	55.51	23.3
Forest land	207.7785	87.30	201.5685	84.69	143.94	60.48	170.84	71.78
Total	238.014	100.00	238.014	100.00	238.014	100.00	238.014	100.00

Source: Author's Analysis, 2022

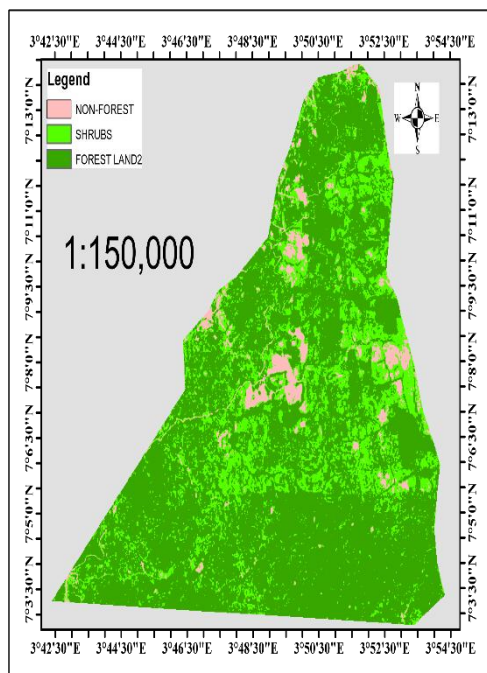
From Table 4.36, summarily, the total land area for forest land was 207.77 km² (87.30%) in 1990 while in 2020, it was 170.8 km² (71.78%). The forest land loss was 36.97 km² (15.52%).



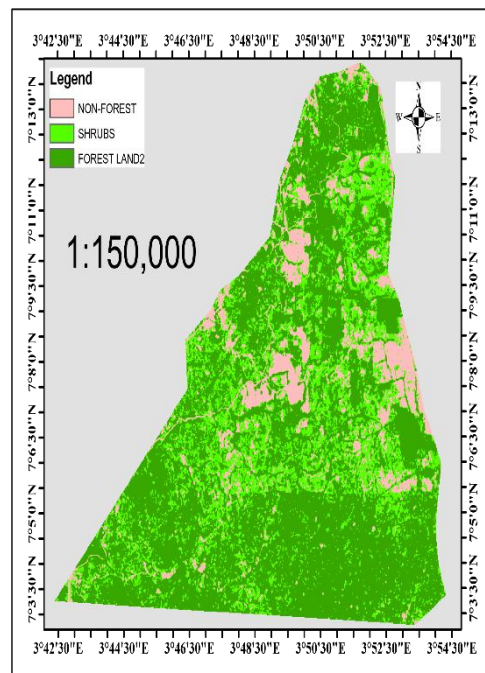
1990



2000



2010

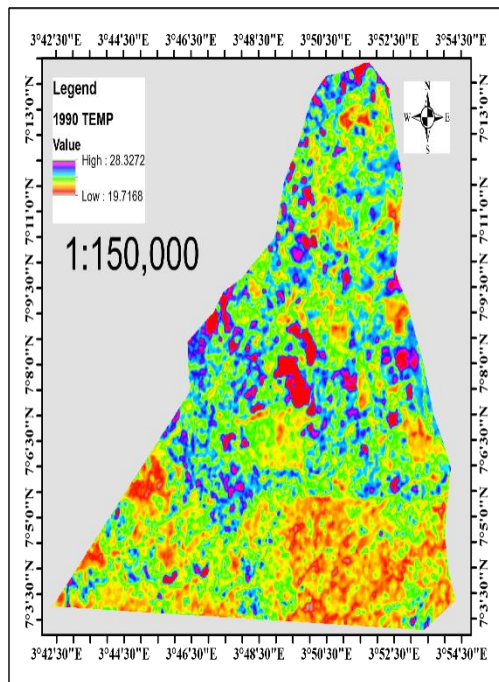


2020

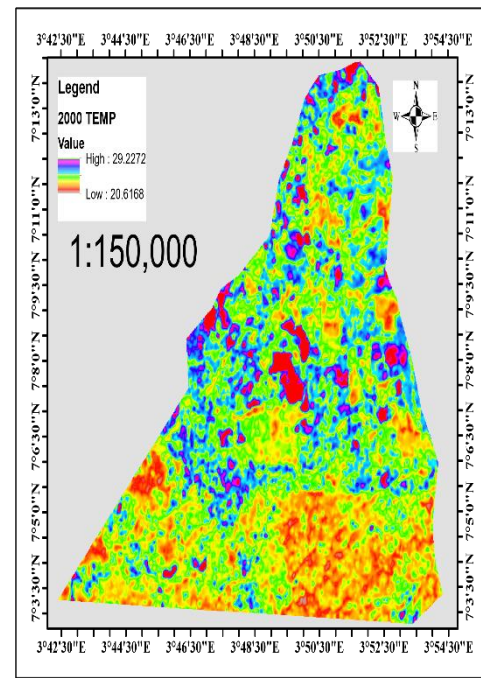
Fi

Figure 4.60: Changes in Land use and Land cover change at Gambari Forest Reserve between 1990 and 2020.

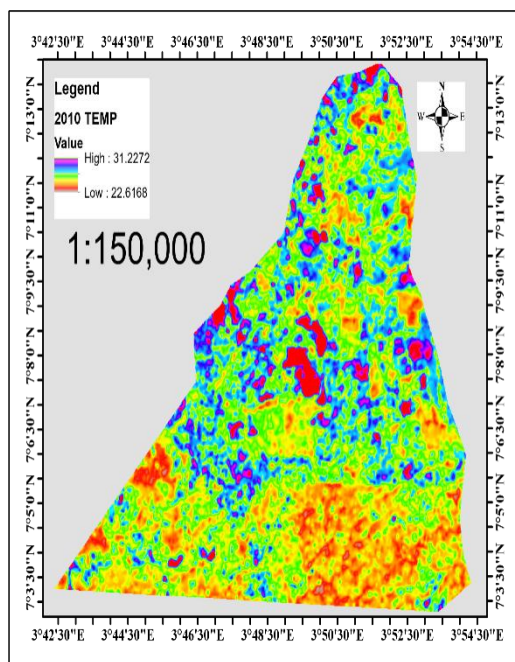
Source: Author's Analysis, 2022.



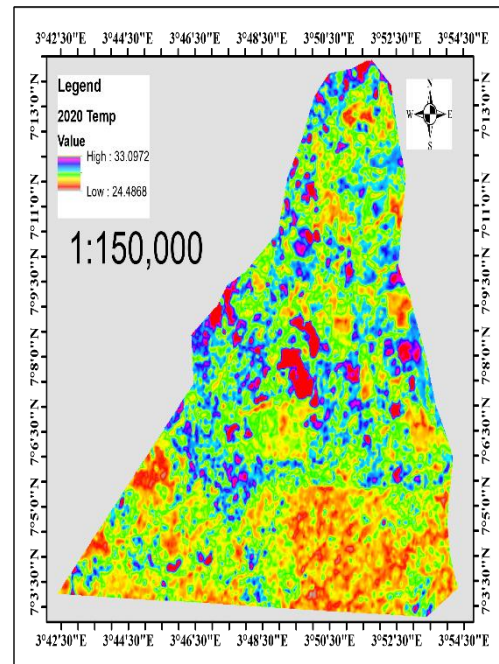
1990



2000



2010



2020

Figure 4.61: Changes in High and Low Land Surface Temperature (LST) at Gambari Forest reserve between 1990 and 2020

Source: Landsat imagery, 2021

Table 4.37: Percentage Land use and Land cover change at Okoiro Forest Reserve between 1990 and 2020 (km²)

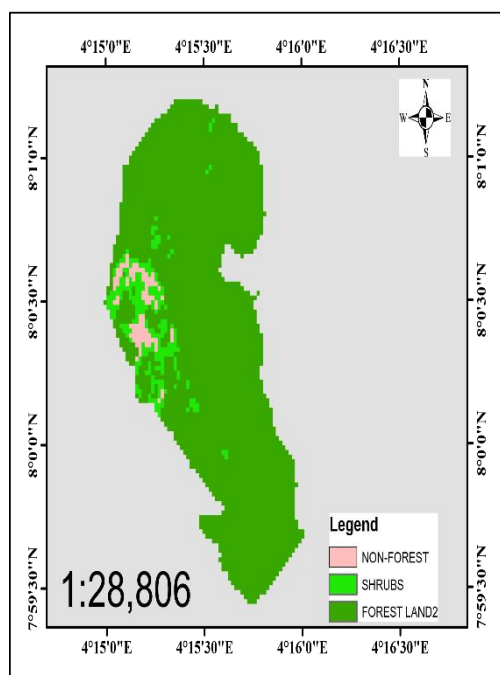
	1990		2000		2010		2020	
	LULCt		LULCt		LULCt		LULCt	
	Area	%	Area	%	Area	%	Area	%
Non-Forest Land	0.0873	2.621622	0.3033	9.108108	0.3915	11.75676	0.4176	12.54054
Shrubs	0.216	6.486486	0.198	5.945946	0.6273	18.8378	0.8199	24.62162
Forest Land	3.0267	90.89189	2.8287	84.94595	2.3112	69.40541	2.0925	62.83784
Total	3.33	100	3.33	100	3.33	100	3.33	100

Source: Author's Analysis, 2022

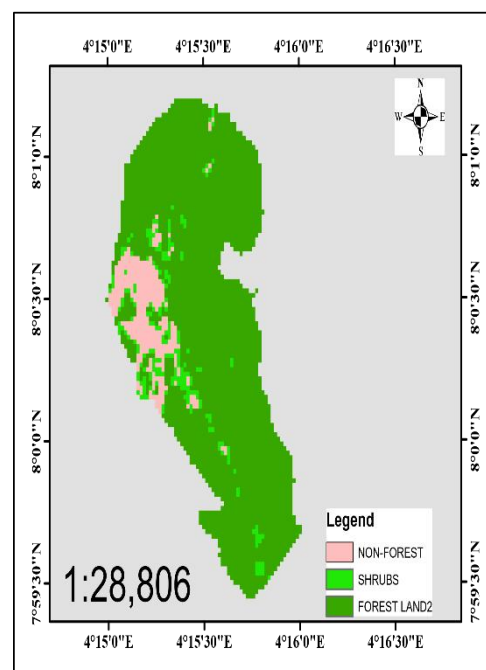
Table 4.37 presents the Land use Land cover (LCLU) percentage changes in Okoiro Forest Reserve in Ogbomosho from 1990 to 2020. It is observed that there was a continuous increase in the non-forest land use in the area as the percentages rose from 2.6% to 9%.to 11.8% and to 12.5% in the decades 1990, 2000, 2010 and 2020, respectively. The shrubs in the reserve showed an irregular pattern with decrease from 6.5% to 6% in 1990 and 2000, respectively for the area occupied. Then later increased to 19% and 24%. In 2010 and 2020 respectively. On the completion of the imageries, the digital classification was performed on the Landsat Scenes using the maximum likelihood supervised algorithm within Idrisi Taiga image processing software. This classified imagery provides guide to area of forest, built-up, open water, woodland and bare land. The pictorial representation of this alongside the changes in temperature were presented in Figures 4.62 and 4.63. The approximate high and low temperatures values of 33.7⁰C, 21.7⁰C in 1990 rose to 37.7⁰C and 26.1⁰C for high and low temperature values, respectively in 2020. The reason for the first decadal decrease in LCLU were the farmers, who were able to plant crops to some extent, hence the shrubs were cut down for farming practice. In the following decades, farmers faced a

lot of problems as gathered, by climate change effects and the disturbance by cattle rustlings that destroyed their crops and tree seedling that supposed to grow to mature stage. The forest land faced problems of environmental condition, for example climate change, anthropogenic activities and cattle trampling of the soils. Uncontrolled lumbering and forest exploitation including firewood procurement has been the order of the day. It is observed from the table how the forest kept on reducing from 91% to 85%, 69% and 62% in 1990, 2000, 2010 and 2020 respectively. The summary of forest land coverage between the period of study (1990-2020), as revealed in Table 4.37. showed that in 1990, the land area was 3.026 km² (90.9%) and in 2020, it was 2.09 km² (62.8%). The total loss of forestland was 0.936 km² (28.1%).

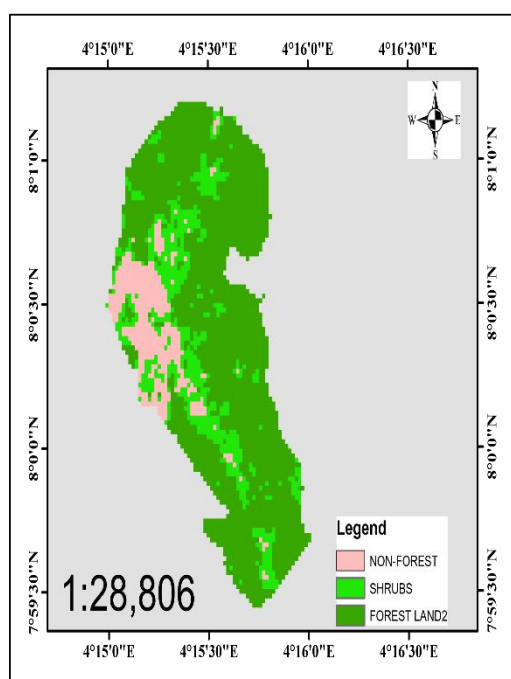
DO NOT COPY. LEAD CITY



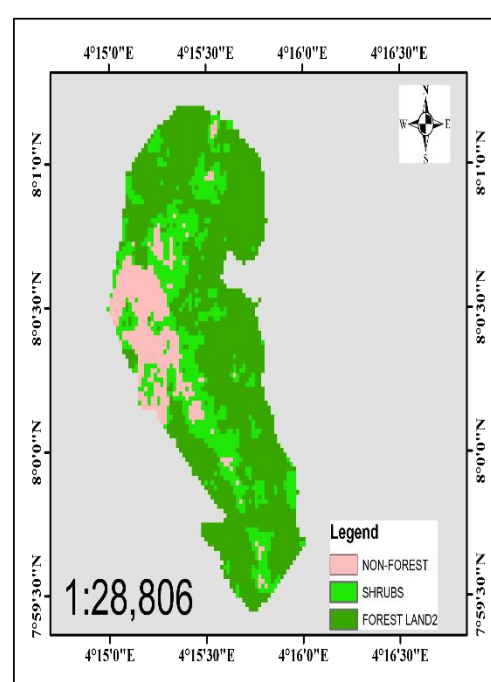
1990



2000



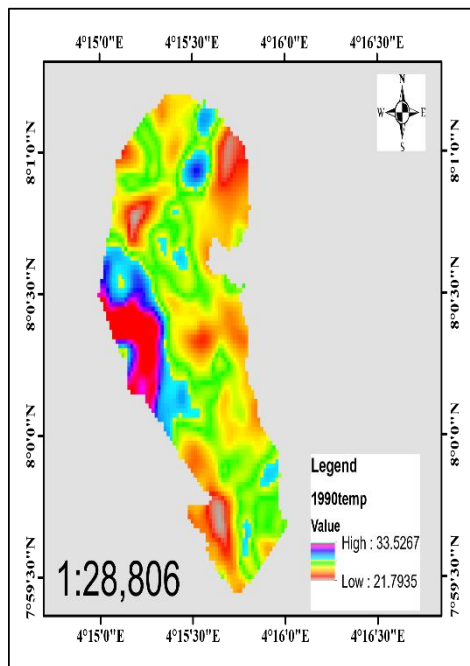
2010



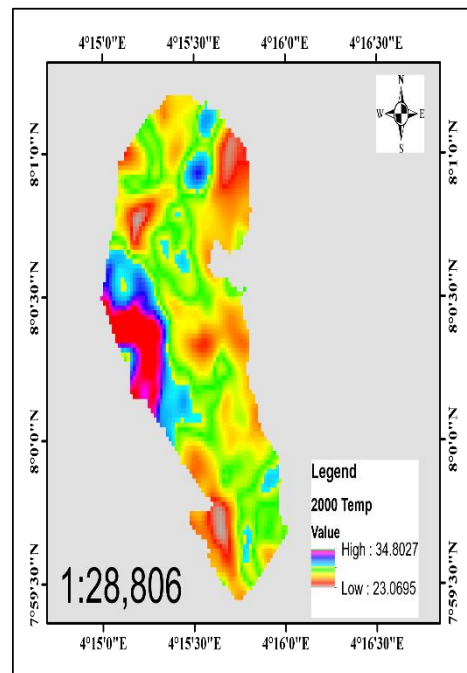
2020

Figure 4.62: Changes in Land use and Land cover change at Okoiro Forest reserve Ogbomosho between 1990 and 2020.

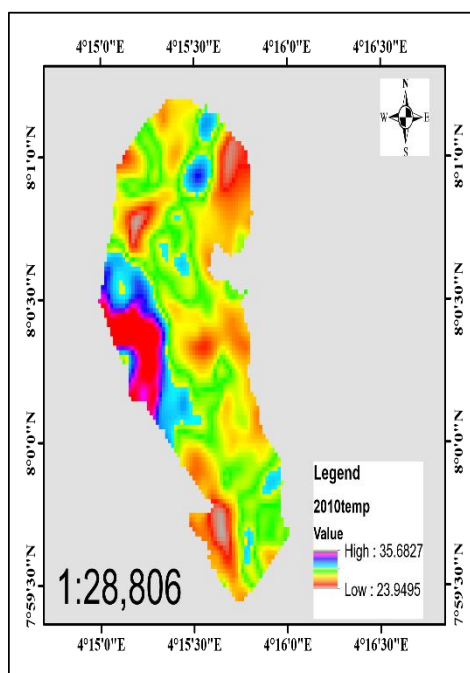
Source: Landsat imagery, 2021



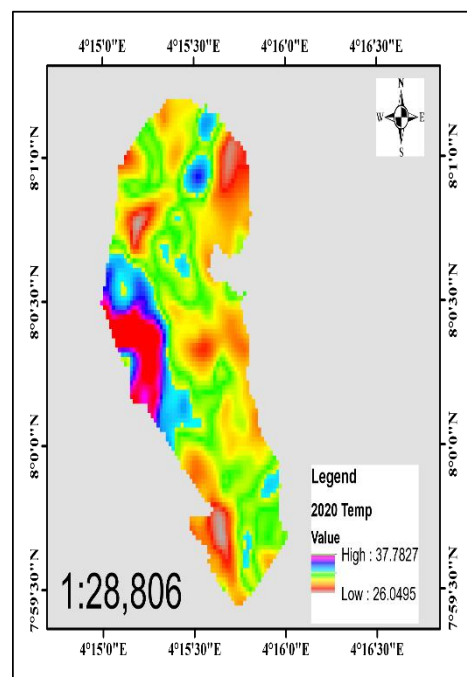
1990 Temperature



2000 Temperature



2010 Temperature



2020 Temperature

Figure 4.63: Changes in High and Low Land Surface Temperature (LST) at Okoiro Forest reserve between 1990 and 2020

Source: Landsat imagery, 2021

Figures 4.62 and 4.63 displayed the forestland and the Land Surface Temperature spatially and temporally. Spatially in 1990, Akure forest reserve has the greatest part of the land as forestland (99%), followed by Okoiro (90.9%), Gambari (87.3%), while Ologe (4.1%) had the least. In the same year, Okoiro had the highest temperature (27.6%), followed by Akure (26.4%), then Ologe (25.3%) and Gambari (24.0%). In the year 2000, all the reserves reduced in area coverage except Ologe forest reserve (14.9%). It was observed that there was an increase in temperature across the reserves even in Ologe where there was an increase in forest land (26.3°C). In the year 2010, the forestland kept on reducing in all the forest reserves but in Ologe, there was a different report (25.9%). Observing the trend of temperature, it was realized that the temperature also increases across board. Finally, in the last decade, there was a continuous degradation of forestland in all the forest reserves with Ologe forest reserve an exemption (33.9%), while temperature was increasing in all the reserves despite the increase in forestland in Ologe Forest Reserve. Temporally, as shown in Table 4.38, in Akure forest reserve, it is observed that after the reduction of forest land (68.3%), in the decade 2000, there was an effort to increase the forestland through afforestation to 74.0% and 88% in the decade 2020 but could not meet up with the coverage at the initial stage. With Ologe forest reserve, there was a steady increase in forestland until the last decade. Also, in Gambari forest reserve, the degradation continues until the last decade when there was a step-up in forestland (71.8%) from 60.4%. Finally, in Okoiro, degradation of the forestland continued even until the last decade, 2020. What this portends is that there was climate change which resulted to global warming in Southwest Nigeria. With intensive afforestation program going on in some forest reserves, it did not impact positively on reducing temperature. Since increase in the temperature is the yardstick for deciding global warming

occurrence. Vegetation Cover Dynamics (VCD) as gathered from the indicators correlated positively with year rainfall mean (mm) and negatively with observed yearly/decadal temperature. The positive correlation of rainfall with vegetation cover dynamics is connected to the decrease evaporation rate in the rainy season which has no impact on the normal function of plants photosynthesis resulting in increased vegetation cover dynamics. Human activities such as burning of fossil fuel, industrialization and urbanization affected the decadal mean VCD³.

Table 4.38 Forest Land and Average Land Surface Temperature (LST) Across the Study Area.

Year	Value Label		Forest Reserves			
			Akure	Ologe	Gambari	Okoiro
1990	Forest	Land	99.0	4.1	87.3	90.9
	(%)					
2000	LST (°C)		26.4	25.3	24.0	27.6
	Forest	Land	68.3	14.9	84.7	84.9
2010	(%)					
	LST (°C)		28.9	26.3	24.9	28.9
2020	Forest	Land	74.0	25.9	60.4	69.4
	(%)					
2020	LST (°C)		29.8	27.3	26.9	29.8
	Forest	Land	88.0	33.9	71.8	62.8
2020	(%)					
	LST (°C)		31.9	28.4	28.8	31.9

Source: Author's Analysis, 2022

Climate change is expected to change and relocate plant species distributions; plant community composition and diversity; vegetation structure (e.g., biomass, leaf area); and ecosystem processing of carbon, nutrients, and water. This will affect the ecosystem services functions enjoy by humans and animals. These vegetation sensitivity to rainfall and temperature change (Table 4.38) will be the result of many lower-level vegetation responses, including changes in net plant carbon uptake, use of water by plant, plant growth and biomass allocation, competitive interactions among the tree species, and responses to disturbances⁷. There are three salient factors that influence vegetation dynamics, these include, climate change, environmental and climatic components among others¹³. Combination of these factors can have great

impact on the water balance by evaporation, interception and development strategy¹⁴. As a result, it can lead to vegetation degradation in a wide variety of ecosystem and biodiversity¹⁵. Knowledge of the dependence between vegetation and climate change is required to investigate the dynamics of vegetation which may offer an opportunity to characterize vegetation response to climate change (VRC) that has three key vegetation indicator responses¹⁶. The three keys include, sensitivity effect of vegetation response, the sensitivity effect on vegetation productivity and their distribution, with climate variability and change in place¹⁷.

4.4.1 Satellite Average Land Surface Temperature Changes for the Study Area

(°C)

Table 4.39 Satellite Average Land Surface Temperature (LST) Changes for the Study Area (°C)

Forest	1990	2000	Difference	%	2010	Difference	%	2020	Difference	%
Reserve				Increase			Increase			Increase
Akure	26.4	27.2	+0.8	+3.0	27.3	+0.1	+0.4	28.3	+0.1	+3.6
Ologe	25.3	26.3	+1.0	+4.0	27.3	+1.0	+3.8	28.4	+1.1	+4.0
Onigambari	24.0	24.9	+0.9	+3.8	26.9	+2.0	+8.0	28.8	+1.8	+6.9
Okoiro	27.6	28.9	+1.3	+4.7	29.8	+0.9	+3.1	31.9	+2.1	+7.01

% -Percentage

Source: Land Surface Temperature Retrieval from Satellite Imagery, 2021.

From Table 4.39, the average satellite Land Surface Temperature (LST) in the four locations were increasing temporally and spatially under this study. Temporally, in Akure forest reserve, there was positive increase in temperature within the decades between 1990-2000 (3.0%), 2000-2010 (0.4%) and 2010-2020 (3.6%). Ologe forest reserve also recorded positive increase in temperature in the same decades. 1990-2000 (4.0%), 2000-2010 (3.8%), 2010-2020 (4.0%); Gambari forest reserve 1990-2000 (3.8%), 2000-2010 (8.0%), 2010-2020 (6.9%) and Okoiro forest reserve, 1990-2000 (4.7%), 2000-2010 (3.1%), and 2010-2020 (7.01%).

Spatially, the highest temperature difference across the study area was 4.7% in Okoiro in the year 1990-2000, while the least was 3.0% in Akure forest reserve in the same decade. In the second decade 2000-2010, Gambari forest reserve had the highest with 8%, while the least goes to Akure (0.4%) forest reserve. So also, in the last years 2010-2020, Okoiro had the highest temperature changes of 7.01% and Ologe forest reserve had the least temperature changes with the value of 3.6%. The observation in the temperature changes within and across the study area was the presence of variability. In the decades also, the last decades temperature changes were also greater than the first decade within each study area. The indication of this result is that spatially, the highest temperature percentage was recorded for both Okoiro and Gambari forest reserves while the least temperature percentage was recorded for both Akure and Ologe Forest reserves. The presence of water bodies in both forest reserves could be a driver to low temperature. Also, topography can be additional advantage to low temperature in Akure forest reserve.

The difference in the temperature for 31 years revealed clearly that the temperature has increased which is the evidence of global warming in Southwest Nigeria. There are differences in Maximum temperature between 1990, 2000, 2010, and 2020 in Gambari forest reserve, Akure forest reserve, Okoiro Forest reserve and Ologe Forest reserve are 4.7⁰C, 4.3⁰C, 1.9⁰C and 3.15⁰C respectively, while the Minimum temperature differences are 4.8⁰C, 1.98⁰C, 4.2⁰C and 3.2⁰C respectively (Tables 4.40-4.43)

Table 4.40: Akure Forest Reserve Retrieved Temperature (°C)

Temperature	1990	2000	2010	2020
Low	20.00	20.8	21.0	22.0
High	32.7	33.5	33.6	34.6

Source: Satellite Data 2021

Table 4.41: Akure Forest Reserve Retrieved Temperature (°C)

Temperature	1990	2000	2010	2020
Low	18.6	19.6	20.6	21.7
High	31.9	32.9	33.9	35.0

Source: Satellite Data 2021

Table 4.42: Akure Forest Reserve Retrieved Temperature (°C)

Temperature	1990	2000	2010	2020
Low	19.7	20.6	22.6	24.4
High	28.3	29.2	31.2	33.1

Source: Satellite Data 2021.

Table 4.43: Akure Forest Reserve Retrieved Temperature (°C)

Temperature	1990	2000	2010	2020
Low	21.7	23.0	23.9	26.0
High	33.5	34.8	35.7	37.8

Source: Satellite Data 2021.

Across the study locations, it is observed that as the vegetation densities are decreasing, temperature kept on increasing at a high rate except in Ologe forest reserve that had slow rate increase in temperature. The reason for this could be afforestation program and water availability. But the fact has been established that the global warming has impact on regional environment.

4.5 Impact of Climate Change and Observed Vegetation Cover Dynamics Pattern on the Livelihood of the Selected Communities of the Study Area Over thirty years, Using Respondents' Perceptions.

In the field survey conducted, only positive response of the respondents was used for ascertaining their perceptions. The Pearson's chi square test in SPSS was used to determine whether the data are statistically significant different from what was expected.

4.5.1 Demographic Characteristics of Sampled Households

Results on the respondents' biodata in Table 4.44 showed that majority of them (28.0%) are from Akure, followed by Gambari (24.7%), Okoiro (24.0%), and Badagry (23.3%). However, the observed variation in respondents' age across forest reserve showed the Pearson Chi-square not statistically significant ($\chi^2 = 12.346$ and $p = 0.055$). While others are significant at $p = 0.000$. One can therefore say that the presence of the forest reserves does not attract any peculiar age group. The age category with the highest percentage of respondents was 41-60¹⁸. Considering the largest age in the communities, this age brackets have settled in the community for over 20 years and have decided to fend for their family in the area. Also implies higher economic effect, which create useful labor for crop production sub-sector that demands more labor. This sub-sector is in need of active labor for better performance. The age 61 and above are not that active probably being moved out from the village for better care. While the age 30-40 have the chance of getting better job outside the rural areas if there should be any little distraction.

The composition of gender in the study locations revealed that Okoiro had the largest male (31%), followed by Akure (30.4%), Gambari (23.2%) and Ologe (14.9%). There were more female in Ologe forest reserve (48.6%) than other forest reserves as shown in Table 4.44 Most female engaged in fishing industry. It was asserted that most of the households' heads in Nigeria were male^{19,20}. Regarding the area of residence, Ologe community lived in sub-urban (66%) and rural (59.8%). The remaining

communities in other forest reserves are in the rural-rural. There is an encroachment of building into Ologe forest reserve because of high cost of living in Lagos. Many of the respondent were from the rural-rural as presented in table 4.44.

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Table 4.44 Socio-demographic Characteristics of the Respondents (%)

Demographic Variables	Value Labels	Forest Reserves (%)			
		Akure (N=71)	Ologe (N=76)	Gambari (N=62)	Okoiro (N=66)
Age Groups	30-40	39.7	19.0	17.5	23.8
	41-60	20.2	30.6	23.7	25.4
	61 above	20.5	30.8	30.8	17.9
Gender	Male	30.4	14.9	23.2	31.5
	Female	15.9	48.6	23.4	12.1
Area of Residence	Sub-Urban	4.2	66.7	8.3	20.8
	Rural	24.1	59.8	0.0	16.1
	Rural-rural	28.0	5.5	37.8	28.7
Education level	None	28.7	29.9	27.6	13.8
	Primary	27.0	36.5	20.3	16.2
	Secondary	15.7	22.2	23.1	38.9
	Tertiary	100.0	0.0	0.0	0.0
Marital Status	Married	19.4	30.0	24.5	26.2
	Single	71.4	14.3	14.3	0.0
	Separated	64.7	11.8	5.9	17.6
	Divorced	42.9	21.4	28.6	7.1
Professional level	Semi-professional	17.4	47.8	0.0	34.8
	Lesser-Professional	16.7	5.6	11.1	66.7
	Skilled	27.1	18.8	25.9	28.2
	Non-Skilled	27.0	29.1	28.4	15.6
Occupation	Hunter	0.0	0.0	100.0	0.0
	Gatherer	39.5	20.9	27.9	11.6
	Subsistence				
	Farming	23.3	27.0	22.8	27.0
	Trader	60.0	0.0	20.0	20.0
	Forest product processor	0.0	100.0	0.0	0.0
Monthly Income (#)	Below 5000	0.0	0.0	9.4	90.6
	5000-10000	29.8	25.8	25.8	18.5
	11000-20000	19.8	44.2	29.1	7.0
	21000 above	42.4	21.2	12.1	24.2
Length of Stay (years)	Below 5	42.9	0.0	42.9	14.3
	6-10	20.8	37.5	25.0	16.7
	11-20	20.0	30.0	17.1	32.9
	21 Above	30.8	25.0	29.8	14.4

Language spoken	Yoruba	23.7	27.4	25.7	23.2
	English	80.0	0.0	0.0	20.0
	Hausa	25.0	0.0	25.0	50.0
	Igbo	0.0	0.0	100.0	0.0
	Egun	25.0	45.8	0.0	29.2

Source: Author's Field Survey, 2021

Ologe forest reserve community shares the largest people that don't have formal education (29.9%), followed by Akure forest reserve community (28.7%). Highest in primary school education is Ologe (36.5%), Okoiro has the highest in term of secondary school education (38.9%) while it is only in Akure that a Higher National Diploma graduate was interviewed (100%). Significant number of the respondent that are married is recorded in Ologe forest reserve community (30%), while the least is recorded in Akure forest reserve communities (19.4%). Observation from the field revealed that the most of the household heads were illiterate and did not possess even basic education. This may create difficulty in expanding new technology, as uneducated people are not always willing to adopt new technologies. Major share of the single was found in Akure forest reserve communities (71%), while none was recorded for Okoiro forest reserve community. Ologe and Gambari have equal share of (14.3%). The highest number of separated (64.7%) and divorced (42.9%) respondents were recorded for Akure forest reserve community. The result of this marital status is an indication of commitment to potential willingness to increase yield if there is an opportunity²¹.

In terms of profession, Gambari has the largest of semi-profession (47.8%) and none skilled (29.1%), Okoiro with lesser-profession (66.7%) and skilled (28.2%). What the researcher discovered from the field was that majority of the respondents were illiterate because of their educational level and vulnerability to changes in their environment. Concerning occupation of the respondents, 100% were found to be

hunter in Gambari compared to other locations. The largest number of respondents were found to be gatherer of NTFP and NTFP in Akure FR (39.5%). Almost equally shared number of respondents engaged in farming activities, Akure (23.3%), Ologe (27%), Gambari (22.8%) and Okoiro (27%). Relating to trading Akure Forest Reserve (FR) community has the lion share of (60%) and in forest product processing Ologe community was the only place with (100%). The majority of the respondents engaged in subsistence farming because of poverty level they found themselves. This is corroborated by the establishment of Structural Adjustment Program (SAP) in 1986 that classified Nigeria to be identified internationally as a poor nation. With the introduction of the program, the scourge of poverty became rampant and obvious among the people. There was an increase in the rate of poverty from 43.0% in 1986 to 62.2% in 1997^{22,23}. Agricultural produces in Nigeria is mostly rain fed. Unpredictable rainfall variation makes it difficult for farmers to plan their operations^{24,25}.

Monthly income ranged from below 5,000 naira and more than 20,000 naira. Significant number of respondents were in the category of below 5000-naira income while in all the study locations, they clustered round between 6,000 and 10,000 income (Table 4.44). This revealed the level of vulnerability to acquisition of improved farm implements and other useful materials for farm support. There were few respondents in the category of 11000-20000 which was found in Gambari FR (44.2%) while 42.4% was above-21,000 naira in Akure FR compared to other study locations. Significant part of rural population (69%) depends on forest resources for agriculture and monetary income by gathering forest products for sale for their livelihoods²⁶. Climate change will affect income groups, classes, occupation, age and gender in varying ways²⁷. The high vulnerability of the agricultural sector to climate

change will continue to affect women disproportionately as a larger percentage of women are poor farmers who rely on small-scale and rain-fed agricultural²⁸.

Majority of the respondents have spent between 5 to more than 20 years in the environment. Between 6-10 years, Ologe has the highest (37.5%) responses, 11-20 years of stay, Okoiro has the highest (32.9%) while 21 and above year of stay was recorded only for Akure Forest reserve (30.8%). Finally, majority of the respondents were Yoruba. The Pearson Chi-square statistical test showed significance difference ($p < 0.005$) in all the study areas which indicated that the variations hold in all the locations.

4.5.2 Information about the Knowledge of Land use/Land Cover Change in the Study Area.

This section revealed the portion that the land use such as cropland, pasture land, forest land, population and urbanization as the factors leading to land use change took in all the study locations.

Table 4.45: Respondent's Distribution in Percentage by Settlement Category about the factors responsible for Land use Land Cover Change.

Settlement Category	Forest Reserves Villages (%)			
	Akure (71)	Ologe (76)	Gambari (62)	Okoiro (66)
Cropland	47.2	50.5	59	54
Pasture land	59.1	66.7	30.5	42.8
Forest land	45.8	73.9	38.3	79.6
Population	57	56.6	37.8	48.7
Urbanization	43.5	54.2	73.2	31.2

Source: Author's Field Survey 2021

Table 4.45 showcase the various land use that are responsible for land cover change. Gambari (59%) has the highest response for cropland, followed by Okoiro (54%) and the least is Akure (47.2%). The land use concerning crop land, the Pearson Chi-square showed Statistically significant ($p=0.027$) in all the study locations. They all practiced agriculture as a form of living. For pastureland Ologe (66.1%) has the largest response, followed by Gambari (59.1%) and the least Okoiro (30.5%). The Pearson's Chi-square test was statistically significant ($X^2 = 38.027$; $p=0.000$). Regarding forest land Okoiro (79.6%) had the greatest response while Ologe (73.9%) followed by Akure (45.8%) and the least is Gambari (38.3%) ($X^2 = 65.336$; $p= 0.000$). the indication of this is that there was different land use for pastureland, forest land and urbanization across the study locations. Also, as regards to population contribution to land use change, Akure (57%) and Ologe (56.6%) responses are the highest, while the least response came from Gambari (37.8%), the Pearson's Chi-square test showed no statistically significant difference ($p=0.443$) across the study locations. And finally, the contribution of urbanization to land use showed, Gambari (73.2%), followed by Ologe (54.2%), Akure (54.2%) and the least was Okoiro (31.2%). Here, the land use

relating to urbanization were not similar across the study locations with result of Pearson's Chi-square test ($p=0.000$). Judging from the responses from various categories of land use contribution to land cover change, observations from the field revealed nearly all the respondents from all the study location agreed that cropland has great impact on land cover change. Also, response was positive alongside other settlement category such as Forest Land, Population and Urbanization (Table 4.45). The pastureland in this scenario was illegal in the forest land. It was not the inhabitants in the communities that engaged in cattle rearing but illegal inhabitant that were armed and ready to fight the legal occupants as reported by the households. This portends that the problem caused by cattle rearing is very enormous. The aftermath of human-induced conversion of forest land to non-forest land uses which include annual cropland, pasture or rangelands, perennial plants, urban lands are the effect of land cover change and deforestation.

4.5.3 Perceptions on Negative Effects of Climate on the Assets Sustaining

Livelihoods (DFID's model)

These are physical events that occurred through variability of climatological phenomena (hydro-meteorological or oceanographic) that can harm human health, livelihoods, or natural resources (water resources, forest, agricultural land etc). Potentially hazardous atmospheric phenomena include, thunderstorms, drought, rain, lightning, wind, temperature extremes, air pollution, and climatic change. The climate hazard in this context affect natural, human, physical, social and financial capitals (Table 4.46). The social hazard encompasses all the factors which are independent of climatic hazard that are exposed to the outcome of hazard event. In this context the environmental variables such as settlements, individual, cultural, customs, and other

physical environment as they relate to human systems, including factors such as topography and river engineering schemes, which mediate the outcome of flood events, and groundwater reserves which may mediate the outcome of a meteorological drought to make amend for lack of rain through irrigation.

Table 4.46: Perceptions of the Respondents on the Effects of Sustainable Capitals on their Livelihoods.

Climate Hazards	Forest Reserves by Communities			
	Akure (N=71)	Ologe (N=76)	Gambari (N=62)	Okoiro (N=66)
Natural	27.6	29.9	27.6	14.0
Physical	22.7	23.2	23.3	23.3
Social	29.6	17.6	38.0	14.8
Financial	25.1	26.3	25.5	23.1

Source: Author's Field Survey 2021

Table 4.46 above shows the responses from the respondents in each community about the impact of climate hazard experienced in the study area. Concerning the natural (water shortage, forest, farmland), Large number of respondents in all the study location [Akure (27.6%), Ologe (29.9%), Gambari (27.6%) and Okoiro (14.0) forest reserves] consent to the fact that they were affected by the outcome of extreme weather and variability which include flood and drought, followed by its chains of damages. So also, extreme temperature that caused uneasiness to the inhabitant of the study locations. Concerning the physical hazard (health; kinds of diseases), in all the study locations, there was a serious complaint about malaria and heat rashes. The responses obtained were: in Akure (22.7%), Ologe (23.2%), Gambari (29.4%) and Okoiro (29.4%). Socially the responses were: Akure (29.6%), Ologe (17.6%), Gambari (38.0%) and Okoiro (14,0%). The phenomena affected socially included

religious, events and festivals and financially, the climate hazards affected their income negatively because of low yield and destructive activities caused to vegetation and farm produce. [Akure (25.1%), Ologe (26.3%), Gambari (25.5%), and Okoiro (23.1%)]. However, the Pearson's Chi-square test for all the factors exposed to the hazards were statistically significant at $p < 0.05$. The indication of this is an evidence of the impacts of negative effect of climate on the livelihoods of the communities in the study area.

This is corroborated by literature that human health status in Nigeria is affected by climate change at a higher rate. Direct health impacts begin from extreme weather events such as high temperature²⁹. Indirect effects of climate change can be on the other way bring about malnutrition due to food shortages; the spread of infectious disease and food- and water-borne illness such as typhoid fever, malaria, cholera etc.; increased air pollution; and from higher temperatures correlated with increased cases of meningitis³⁰. It has also been confirmed that changes in weather conditions will continue to have a major impact on human life and ecosystems³¹

4.5.4 Farming Activities in and Around Forest Reserves

As shown in Table 4.47, it was gathered that farming takes the greatest share of the source of income in Southwest Nigeria. Farming activities were the major reasons for migrating to the forest reserves. Most of the respondents strongly agreed that their income emanated from farming, as Akure (51.9%), Ologe (53.1%), Gambari (43.5), and Okoiro (50.5%) responded. Only few of them were not farmers. It was confirmed that more than 75% of the population in the Nigeria engaged in agriculture as their primary occupation and means of livelihood³². Agricultural produce in Southwest Nigeria is mostly rain fed. Unpredictable rainfall variation makes it difficult for farmers to determine their farming calendar. Larger proportions of the population in

the Southwest rainforest zone live in rural areas and engage in agricultural activities for their livelihood³³. Crop production is the dominant agricultural enterprise that farmers in Southwest Nigeria engage in³⁴. Farmers have to contend with variations in climate and the risk of flooding³⁵.

Table 4.47 Sources of Income (financial asset) Generating Livelihood Activities in the Study Area.

Indicators	Forest Reserves and Household Respondents (%)			
	Akure (71)	Ologe (N=76)	Gambari (62)	Okoiro (66)
Farming	51.9	53.1	43.5	51.5
Livestock Rearing	46.7	42.7	45.6	65.1
Trading on Forest Products	46.1	60.4	65.7	27.8
Fishing Business	57.5	76.2	30.0	36.2
Hired Laborer	54	88.2	14.2	43.5
Hunting	51.5	59.1	54.5	34.9
Artisan	35.5	29.2	89.5	45.8
Gathering of NTFP	32.1	62.5	75.2	30.3
Transportation	80	96.9	13.3	20
Civil servant	37.5	62.5	0.0	0.0

Source: Author's Field Survey 2021

Table 4.47, when excogitating the major primary economic activity in the rural area of Southwest Nigeria, farming still stand out. It is the backbone where raw materials to other sectors emanate which include food supply to the entire population; supplying of inputs for industries and demand for industrial goods. Across the study locations, nearly all the respondents reside in their various locations because of farming activities. Buying and selling of agricultural products which include inputs supplier, agro-processors, traders etc., are the non-agricultural sub-sectors of the rural economy.

Regarding farming activities, Ologe (53.1%) had the largest responses while Gambari was the least (43.5%). However, the Pearson Chi-square statistical test exposed insignificant difference ($\chi^2=7.387$; $p=0.597$), which indicated that all the inhabitants in the study locations earned their income from farming as gathered from the field survey, however, the complaints on negative occurrences have eroded their hope concerning earning major income from farming. The sub-sectors aspect of the rural economy, such as livestock rearing, that is animal husbandry, Okoiro (65.1%) had the largest, while the least was Ologe (42.7%). Relating to trading on forest products Gambari (65.7%) and Ologe (60.4%) had the highest respondents, while, Okoiro (27.8%) had the least responses. All these were statistically significant with p value less than 0.05. With respect to fishing business and hired laborer, Ologe (76.2%) and Akure (57.5%) were into the business for survival, because of the Ologe Lagoon and river Ogun watershed that pass through the forest reserves. Many of the respondents claimed that they were fishermen especially in Ologe apart from farming occupation. Low responses were recorded for the other two locations as shown in Table 4.47. Furthermore, there were positive responses in hunting as well as gathering of non - timber forest product and artisan as sources of their income in some of the study locations.

In all the income generating indicators across the study locations, the Pearson's Chi-square test showed no significance different $p>0.005$ in trading, artisan and civil servant (this confirms little income from these variables) but in others, the result was statistically significant ($p<0.005$). This indicated that the activities generate income in the communities. For example, Akure and Ologe forest reserves where large rivers are very close to the villages, encouraged fishing more than Okoiro and Gambari forest reserves. The interest in women gathering natural resources is very high, they are

primarily responsible for gathering wood for cooking and heating, in charge of household water supply, and making available food for the family³⁶.

4.5.5 Vulnerability to Climate Change Effect

The communities were subjected to vagaries of weather in the following ways: Yield reduction, flooding, effect on food production, undefined season and pest and diseases. Climate change has led to food shortages. The erratic rainfall in many parts of southwest has led to flooding that swept away many agricultural lands causing poor yield or no yield. The decrease in food production is a threat to food security and this has facilitated the problem of poverty. Vulnerability is defined as.

*The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.*³⁷

As gathered from Baale in Araromi Village in Badagry, he said:

You are welcome to our village. They have told us that you people will be coming but I don't know it is today. The problem we are having is the rain that is not coming at the expected time. This has been giving us problem more than 30 years ago. Even at the time of dry season, the heat will be too much for us and the crops. Another problem is the cattle grazing and the herdsmen that destroy our farm and nobody can challenge them. We don't know when this will be over. Even, they destroy young plantation. Government is really trying concerning the planting of vegetation. They do give us seedlings to plant alongside our

crops. Another problem is the illegal deforestation. The forest guard are not enough to capture the people involved.

Table 4.48 presents the vulnerability of the communities to the effect of climate change. One of the vulnerabilities is the yield reduction, the hard-heated communities are Akure (60.2%) and Ologe (59.2%). It is not that other study location did not feel the effect as those that were mentioned. The manifestation of the climate change has deleterious effects on the livelihoods of the study locations as complained bitterly by the respondents. The unpredictable rainfall coupled with erratic nature caused flood and serious erosion in the in the study locations. The results of this are shown in the **table** with the highest respondents in Gambari (49.0%), followed by Akure (47.1%) and Ologe (42.1%) and the least was (40.3%). There were also positive responses concerning undefined season, Gambari (74.7%); pest and diseases, Akure (86.9%) and forest fire with Gambari (53.6%)





Plate 4.3: Livelihood support river in Akure Forest Reserve.

Table 4.48 Vulnerability to Climate Change Effect (Human Resources Problem)

Indicators	Forest Reserves and Household Respondents (%)			
	Akure (N=71)	Ologe (N=76)	Gambari (N=62)	Okoiro (N=66)
Reduction in Yield	60.2	59.2	42.0	38.6
Flooding	47.1	42.1	49.0	40.3
Food shortage	44.3	48.4	82.8	24.6
Undefined Season	40.6	36.7	74.7	38.2
Pests and diseases	86.9	37.3	50.6	25.2
Forest Fire	45.1	39.7	53.6	51.6

Source: Author's Field Survey 2021

The problem of vulnerability emanated from poor education status, low technology, lack of skill knowledge and negligence of government and other agencies in providing necessary tools and information to the communities.

As such, most of the respondent [Akure (60.2%), Ologe (59.2%) Gambari (42.0%) and Okoiro (38.6%)] opined that yield reduction was evident in their environment (Table 4.48). Due to unfavorable climate, the households interviewed express their concern about food shortage [Akure (44.3%), Ologe (48.4%) Gambari (82.8%) and Okoiro (24.6%)] that occurred at all seasons. As gathered by the researcher, the climatic variation adversely affected the communities in all the variables presented. The increase in temperature encourages influx of pests and diseases that attack crops. The inhabitants of the forested communities were vulnerable to flooding [Akure (47.1%), Ologe (42.1%) Gambari (49.0%) and Okoiro (40.3%)]. The same thing is the undefined season which brought about crop failure [Akure (40.6%), Ologe (36.7%) Gambari (74.7%) and Okoiro (38.2%)]. It was also gathered from the field that the communities were vulnerable to fire occurrence [Akure (45.1%), Ologe (39.7%) Gambari (53.6%) and Okoiro (51.6%)]. The Pearson's Chi-square test was statistically significant ($p < 0.05$) for flooding, undefined season and forest fire which

is a confirmation of the occurrences. The vulnerability to these environmental phenomena differs across the study locations may be due to different bio-geophysical nature.

This confirms some existing literature on climate change in Nigeria. Climate change is confirmed to be a threat to the security situation in Nigeria through conflict over resources. This is worsened by increasing water and food scarcity³⁸. Given the importance of the agricultural sector to livelihoods and the economy in Nigeria, problems with crop yields and productivity can have an adverse effect on gross domestic product, but taking part in non-farm economic activities provided farmers with adequate financial support to adopt a number of climate change adaptation strategies as gathered from the field³⁹. Small-scale farmers in Nigeria, through their inadequate capital are well known to be classified as resource poor due to the poor resources available to them. This causes low productivity as they produce purely for subsistence consumption and little marketable surplus⁴⁰. The respondent's complaint about bad road without adequate drainage that lead to their farmland. That any time rainy season is coming, it has always been sadness and joy to them. But the effect of flooding is not being felt the same way in across the study location. It was observed that human-induced was the major causes of forest fire. Communities opined that forest fire was mainly caused by cattle rustlers and game hunters for fresh pasture and to subdue the animals during hunting.

Observation from the field revealed Ologe forest reserve and some parts of Akure forest reserve also are prone to the effect of flood because of the topography of the area. This can be connected to the variability and the extremeness in rainfall pattern as a result of climate change. The challenges associated with climate change are so enormous in the Southwest Nigeria as there is high precipitation in the coastal land

and in the hinterland that led to destruction of farmland. This has led to flooding and erosion in the Southwest Nigeria⁴¹. Ocean surge and rising sea level in the coastal part of Lagos in Southern Nigeria has buried villages in Lagos State. Southwestern Nigeria is the largest urban agglomeration – and Lagos the most populous city - in Sub-Saharan Africa⁴².

These climatic threats are, extreme weather events, variability in the onset and cessation of rainfall and rainfall amounts, proliferation of pests and diseases and the effect of high temperature⁴³. The problem of uncertainty in the onset and cessation of rainfall affects crop yields in Southwest Nigeria. Unpredictable rainfall variation, heat stress and drought are factors that caused food shortages and low food production⁴⁴.

It was also confirmed in the research that between 1941 and 1970, late onsets of rains occurred in only a few areas of Nigeria. However, from 1971 to 2000, late onset and early cessation of rains had spread to most parts of the country, shortening the length of the rainy season⁴⁵. Excessive wind reduces the amount of forestry produce, such as wood which is the dominant product; lumber, paper, fodder for livestock and cane⁴⁶. Severe and sudden changes in rainfall patterns and rise in temperatures have caused unfavorable growing conditions into the cropping calendars thereby changing growing seasons which consequently affect the crop productivity. Results of these is rise in food prices, food insecurity, land use change^{47,48}. Because of the importance of the agricultural sector to livelihoods and the economy in Nigeria, gross domestic product is mostly affected negatively, because of the problems with crop yields and productivity^{48,49}.

4.5.6 Impact of Land Use on Vegetation Cover as Perceived by the Communities

The main drivers of forest degradation as perceived by the respondents were farming (expansion of crop cultivation), poor grazing management, fuel wood, illegal logging and illegal hunting.

Table 4.49 Perception of Impact of Land Use on Vegetation Cover

Indicators	Forest Reserves and Household Respondents (%)			
	Akure (N=71)	Ologe (N=76)	Gambari (N=62)	Okoiro (N=66)
Farming activities	46.5	53.3	51.9	48.4
Illegal Grazing	47.4	74.8	26.2	51.6
Fuel Wood	43.8	79.8	30.2	46.2
Illegal Logging	43.5	65.8	43.2	47.6
Hunting	64.1	64.4	38.1	31.4
Firewood Gathering	73.3	64.4	38.1	31.4

Source: Author's Field Survey 2021

As stated in table 4.49, the perception of the respondents was positive on Land use impact on vegetative cover concerning farming activities in Akure (46.5%), Ologe (53.3%), Gambari (51.9%), and Okoiro (48.4%); illegal grazing Akure (47.4%), Ologe (74.8%), Gambari (26.2%), and Okoiro (51.6%), and illegal logging Akure (43.5%), Ologe (65.8%), Gambari (43.2%), and Okoiro (47.6%); Hunting, Akure (64.1%), Ologe (64.4%), Gambari (38.1%), and Okoiro (31.4%); Akure (73.3%), Ologe (64.4%), Gambari (38.1%), and Okoiro (31.4%). However, a reasonable percentage of households agreed on this factor as confirmed by the Pearson's Chi-square test which indicated statistically significant in the community's perception regarding people expansion into the forest reserves believing in the richness of soil inside the forest. ($p < 0.05$). Expansion of crop cultivation by shifting cultivation

practice in and around the forest reserves is one of the key drivers of forest degradation in the study area. The inhabitant of the forested communities depends solely on fuel wood for their activities. This is because fuel wood is the primary source of domestic cooking energy for rural and urban household as well as industrial users in the developing countries such as Nigeria. Researcher found out from the households that the high cost of alternative cooking energy largely added to sporadic demand and cutting down of trees thereby leading to forest degradations (Plate 4.3).



Plate 4.4: Showing firewood gathered from deforestation in Ologe Forest Reserve



Plate 4.5: Lorry carrying log of wood



Plate 4.6: Lorry Carrying Wood from the Forest and the Farmland in Okoiro Forest Reserve

Source: Field Survey, 2021



Plate 4.7: Large Portion of Land Deforested

Source: Field Survey, 2021



Plate4.8: Farmland in Okoiro Forest Reserve

Source: Field Survey, 2021



Plate 4.9 Deforestation and wood gathering in preparation for Agriculture

Source: Field Survey, 2021

Results of this are shown in the satellite imageries of vegetation in all the study locations except in Ologe forest reserves where there is massive afforestation



Plate 4.10: Researcher inside 1000 seedlings planted with collaboration with NCF at Ologe Forest Reserve in Badagry
Source: Field Survey, 2021



Plate 4.11: Stage one of the afforestation in Badagry
Source: Field Survey, 2021



Plate 4.12 Stage two of the afforestation in Badagry
Source: Field Survey, 2021

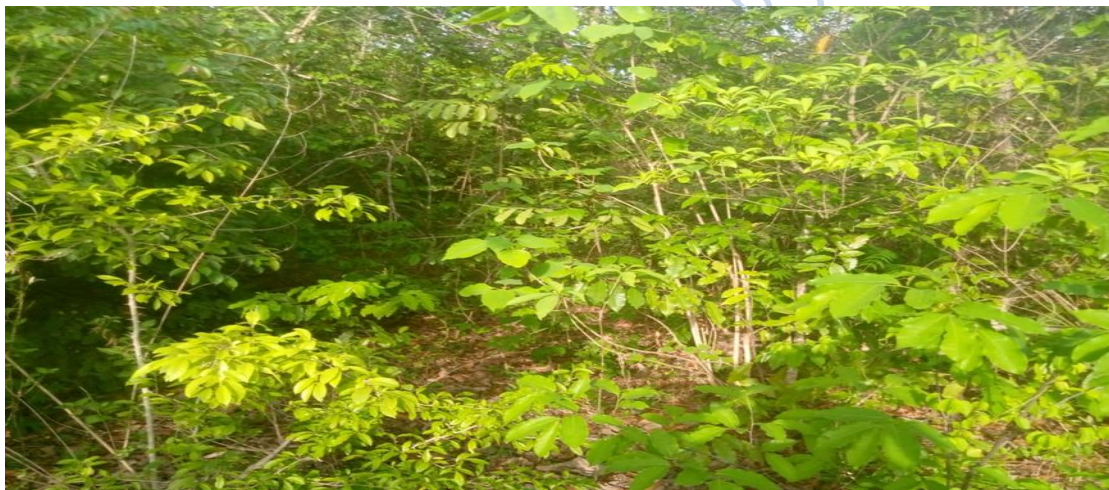


Plate 4.12 Stage 5 of the afforestation program in Badagry
Source: Field Survey, 2021

Forest Superintendent in Badagry has this to say:

Our major works in the forest are patrol and forest protection also, revenue is being generated for the government through selective logging. We give equipment to the farmers under our jurisdiction. Also, Lagos State Government collaborated with Nigeria Conservation Foundation (NCF) to plant 1000 indigenous seedlings last year, 2021, within the Forest Reserve as enrichment planting. Also, 10 years ago,

Federal Government raised 1,000,000 seedlings in Lagos State in which communities in the forest reserve were involved. Also, in the year 2022, 2000 indigenous seedlings were given to farmers to plant.

Part of the reserve is fenced to stop the encroachment of the tout and the traditional rulers from selling the forest land. This also reduced cattle grazing destroying the vegetation and farm crops. But in other areas including Agricultural settlement Iyaaḡin Badagry, part of the forest reserve, all the seedlings planted were eaten up by the cattle. Farmers within the settlements always have issues with the Fulani cattle herds.

Rainfall pattern have changed, this has given problem to the farmers in terms of planting dates. The onset and cessation of rain has changed greatly. We cannot even advise the farmers which month they should plant their crops There has been shortage in harvest and the farmers have switch to fishing as a means of livelihood. The temperature is also increasing even with the water bodies that surround the forest. I think this is real climate change effect.



Plate 4.14 Forest official assisting in giving information about the Forest Reserve during Researchers visit at Q-Brat Zoo inside the Araromi village in Ologe Forest Reserve

Source: Field Survey, 2021

Overall, the households interviewed were skeptical about the impact of illegal hunting as affecting vegetation cover, although it could have far reached impacts considering that most of these illegal practices involve cutting down and burning of forest to facilitate animal trap or built temporary settlements in the reserves.

Desert encroachment and steadily depleting vegetation and grazing resources in the North Sahelian zone caused mainly by climatic change and human activities, has prompted massive emigration and resettlement of people to areas less threatened by desertification such as Southwest Nigeria. This has exacerbated communal clashes among herdsmen and farmers and inter-ethnic clashes, some of which have resulted into kidnapping and killing⁵⁰.

The major concerned step to be taken by many ecological regions in Nigeria especially Southwest Nigeria, is the adoption of existing and new technologies for adapting to climate change and variability. This includes, the adoption of drought-tolerant and early maturing varieties of crops, crop diversification, and crop cover⁵¹. This will go to a large extent to ameliorate the effect of climate change.

4.5.7 Forest Products Used by the Community

The forest products used by the community examined here are: Timber, Tree Roots, Leaves, Firewood, Fruits, rubber, resins herbs and gum.

Table:4.50 Perception of the Respondents on the Forest Products Used

Indicators	Forest Reserves and Household Respondents (%)			
	Akure (N=71)	Ologe (N=76)	Gambari (N=62)	Okoiro (N=66)
Timber	18.3	17.4	29.4	24.8
Tree Roots	22.3	24.9	29.9	22.8

Leaves	23.1	22.1	33.7	21.2
Firewood	33.5	32.2	23.7	33.6
Fruits	18.8	0.0	6.2	75.0
Rubber	-	-	-	-
Resin	-	-	-	-
Herbs	22.5	19.8	33.2	24.6
Gum	-	-	-	-

Source: Author's Field Survey 2021

Table 4.50 enumerates the percentages of forest products used by the community. The responses on the firewood was: Akure (33.5%), Ologe (32.2%), Gambari (23.7%), and Okoiro (33.6%); Concerning timber, it was gathered that the household don't normally involve in timber harvesting but people from outside. The responses were: Akure (18.3%), Ologe (17.4%), Gambari (29.4%), and Okoiro (24.8%); Relating to tree root usage, the households interviewed perceived that harvesting medicinal plants was seen as one of the human-induced caused of forest resources degradation, and the result showed; Akure (22.3%), Ologe (24.9%), Gambari (29.9%), and Okoiro (22.8%). Majority of the household interviewed opined that illegal collection of firewood for subsistence and commercial purpose which most time involve deforestation was the major cause of land degradation. However, the Pearson's Chi-square test shows statistically significant among the communities ($p < 0.05$). Fruits had the least percentage of usage in the community. Uncontrolled extraction of tree roots and bark in forestlands often lead to the death of the affected tree thereby reducing the resource base as well as adversely impacting on the biodiversity, chemical composition quality of natural forest that drive away or inhibit diseases and ecosystem service provisioning of the forest³⁰. Other industrious usage was also shunned by the community example of these are Latex, rubber, resin and gum. It clearly shown that

there is no existence of rubber, latex, resins and gum in the study area. As such, firewood is the major forest product that support livelihood. As quoted in an international conference that "a woman collecting dead branches constitutes deforestation, the carver of black wood is accused of global warming, the local hunter is a poacher" as such, firewood gathering is classified as a menace to environmental development⁵².

4.5.8 Climate Change Impact on Vegetation Growth in the Study Area

The section deals with perception on general climate.

Table 4.51 Perception of the Respondents on Climate Change Impact on Vegetation Growth.

Indicator	Forest Reserves and Household Respondents (%)			
	Akure	Ologe	Gambari	Okoiro
	(N=71)	(N=76)	(N=62)	(N=66)
General	48.2	55.9	50.8	45.2
Climate				

Source: Author's Field Survey 2021

Table 4.51 testified to the fact that climate change generally has negative impact on vegetation growth of the study location. All the respondents testified to variability in rainfall and temperature. They were aware of changes in the environment which is quite different from 30 years ago. The largest response came from Ologe (55.9%), followed Gambari (50.8%), and the least Okoiro, (45.2%). Nevertheless, the Pearson's Chi-square ($X^2 = 3.341$; $p = 0.756$) result showed no statistical significance. The implication of this according to respondents' perception depict that the impact of climate change differs from one another probably due to ecological differences and other likely factors.

4.5.9 Perception of the Respondents on the Causative Factors of Climate Change, Vegetation Dynamics and Livelihoods Practiced in the Selected Forested Communities.

4.5.10 Perception of the Respondents on the effect of changes in Climatic Parameters

This shows the feelings of the respondents across the study location on the situation of rainfall and temperature whether Increasing (I) or Decreasing (D)

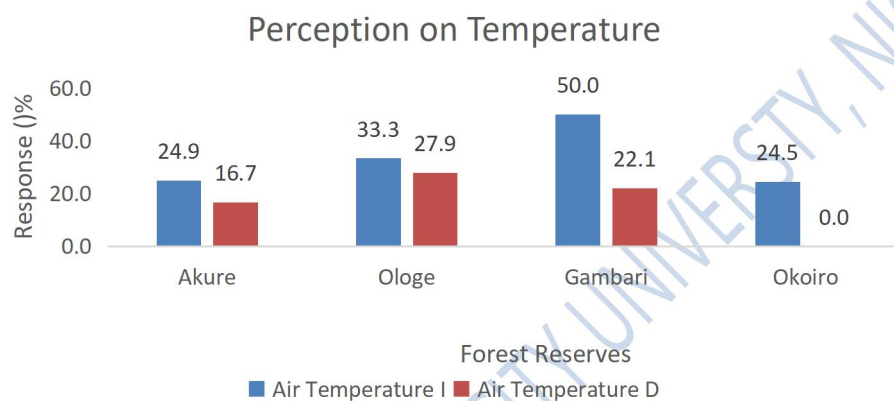


Figure 4.64: Frequency Distribution of the Respondents' Perception on Temperature

Source: Author's Field Survey 2021

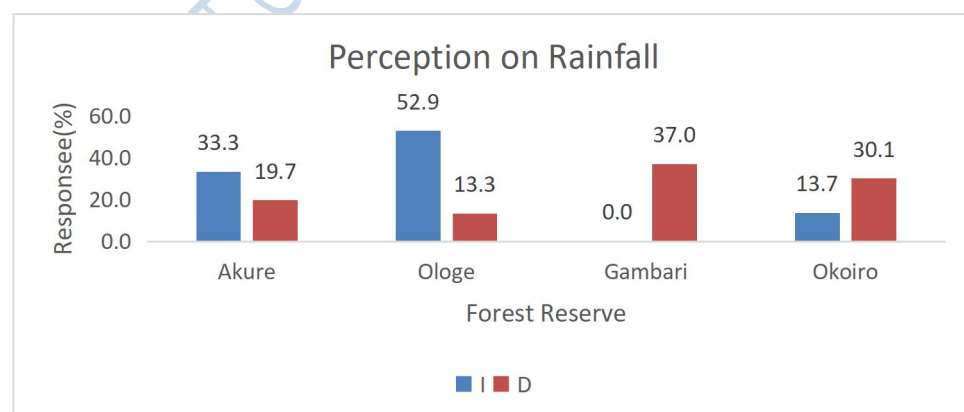


Figure 4.65: Frequency Distribution of the Respondents' Perception on rainfall

Source: Author's Field Survey 2021

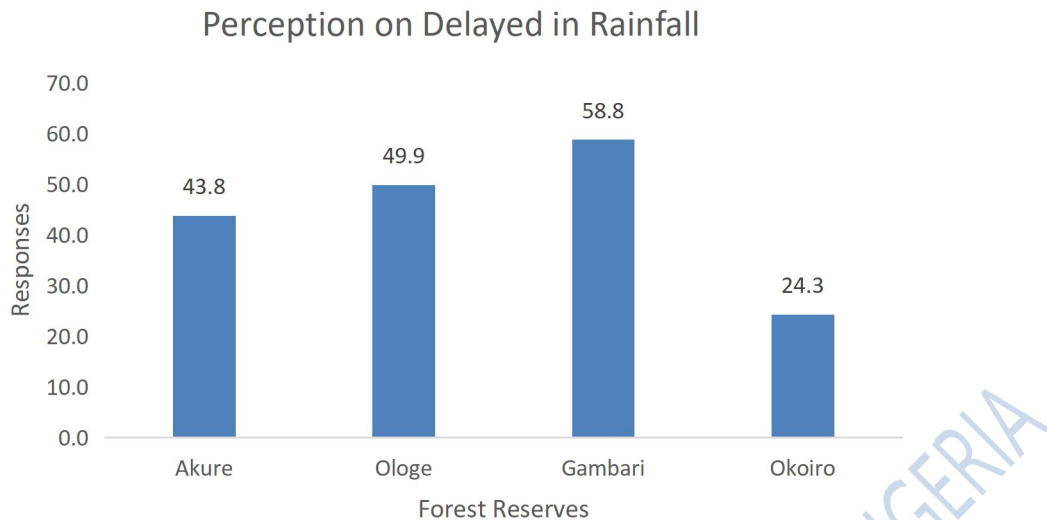


Figure 4.66 Perception on Delayed in Rainfall

Source: Author's Field Survey 2021

Figures 4.64, 4.65 and 4.66, present situation of impact of climate change on vegetation. Pertaining to temperature and rainfall, it was gathered from the study areas that temperature keeps on rising every year while the rainfall keeps on reducing. It is vividly clear from Figure 4.1 that temperature is rising in Akure (24.9%), Ologe (23.3%), Gambari (60.0%), and Okoiro (24.5%). The result is not statistically significant ($p=0.311$) among the study locations. However, the chart revealed the response to increase in temperature to be more than decrease in temperature. This is validated by the result from meteorological and satellite data on temperature increase. In the same vein, larger responses were recorded for increase in rainfall in Akure (33.3%) and Ologe (62.9%) forest reserves communities while decrease in rainfall were responded to in Gambari and Okoiro forest reserves communities. The reason for the increase could be as a result of its closeness to the coast and influence of Southwest monsoon wind that blows from the Atlantic Ocean. The results of meteorological data revealed increase in rainfall in all the study locations when compared with rainfall normal. The general result showed a statistically significant

($p=0.000$). There were positive responses from all the study locations that the rainfall is even been delayed or vary for planting season but at different time maybe because of different ecological zones (Figure 4.3), as we have the results in Akure (43.8%), Ologe (49.9%), Gambari (58.8%) and Okoiro (24.3%). The chi-square result shows significant relationship among the study area with $p= 0.002$. The reason for this occurrence cannot be detached from land use change, deforestation and other human activities going on in the study area. Crop yields are affected by extreme temperatures, lower or excessive rainfall, droughts, and desertification which has negative impact on farmlands. This leads to adverse effect on agricultural productivity, production stability and household income in Southwest that already have high levels of food insecurity as gathered from the field. Unfavorable rainfall intensity in the coastal region, sea level rise, flooding and erosion of farmland will also jeopardize agricultural production. This is supported by the research that temperatures have risen significantly above normal since the 1980s, with relatively higher figures in 1973, 1987 and 1998⁵³. Temperature increases of approximately 0.2 to 0.3°C per decade have been observed in the various ecological zones of the country⁵⁴. Minimum temperature in the country has increased slightly faster than the maximum temperature, resulting in smaller temperature range. This shows the effect of greenhouse with carbon concentration. This warming of the environment is most significant between June and November each year⁵⁵



Plate 4.15: Respondent in Gambari Forest Reserve responding to Rainfall, Temperature Changes and variation in planting date.
Source: Field Survey, 2021

4.5.11 Perception of the Respondents on Climatic Variables as a Components of Climate Change

The following perceptions of the respondents on the effect of variation of climatic parameters as a source of environmental problems. These variables include: rise in rainfall versus increase yield; rainfall fluctuation versus forest production; high relative humidity versus diseases on forest; changes in rainfall and temperature pattern versus diseases; land degradation versus cultivation of forest products; high humidity versus forest product; increase in rainfall and temperature versus forest products; unpredictable sun intensity versus forest products and; weather condition 10 to 20 years ago differs from nowadays.

Table 4.52: Respondents Perception on Climatic Variables as a Component of Climate Change.

Indicators	Forest Reserves and Household Respondents (%) on Climate Change
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	Akure (N=71)	Ologe (N=76)	Gambari (N=62)	Okoiro (N=66)
Rise in annual Rainfall not increase yield	42.7	46.4	45.4	65.5
Rainfall fluctuation don't favor forest production	55.4	51.7	45.7	47.3
High relative humidity cause diseases on forest	45.6	46.7	48.7	24.9
Changes in rainfall and temperature pattern encouraged diseases	59.8	51.0	40.3	49.0
Land degradation can be stopped by cultivation of forest products.	58.9	58.0	48.0	35.1
High humidity not in favor of forest product	49.1	69.7	41.8	39.3
Increase in rainfall and temperature threatens forest products	51.7	66.4	37.9	44
Unpredictable sun intensity doesn't favor forest products	48.8	56.0	32.8	62.4
The weather condition 10 to 20 years ago differs from nowadays	44.3	57.0	61.6	46.2

Source: Author's Field Survey 2021

As presented in Table 4.52, respondents from Akure (42.7%), Ologe (46.4%), Gambari (45.4%), Okoiro (65.5%) strongly agreed that much rainfall is not a determinant of food surplus. With respect to whether the increase in annual rainfall cause crop yield, the result of $\chi^2=15.89$; p-value 0.069 which is not significant. The researcher also gathered from the field that even though rainfall increased, it does not signify increase in yield because the onset and cessation of rainfall are unpredictable, Akure (55.4%), Ologe (51.7%), Gambari (45.7%), Okoiro (47.3%) ($\chi^2 =19.79$; p= 0.922), which is not in favor of forest products. The forest products are also lost to disease infestation on the field due to high relative humidity which is the product of precipitation and temperature, the responses were, Akure (45.6%), Ologe (46.7%), Gambari (48.7%), Okoiro (24.9%). The Chi-square is statistically significance ($\chi^2 =$

16.466; $p = 0.011$). When the relative humidity is too high or too low, it always attracts pest infestation on the forest and farm products. So also, change in rainfall and temperature pattern cause high incident of pest. The responses were Akure (59.8%), Ologe (51.0%), Gambari (40.3%), Okoiro (49.0%). The Chi-square is statistically significant among the study locations. They are being affected differently ($\chi^2 = 11.873$; $p = 0.011$).

Result on perception on whether cultivation of forest product reduce the effect of land degradation or not, it was found out that it will reduce land degradation according to respondents' responses in all the study locations, with the overall result which is statistically significant ($\chi^2 = 32.027$; $p = 0.000$). The responses of the households were, Akure (58.9%), Ologe (58.0%), Gambari (48.0%), Okoiro (35.1%).

From the overall result of whether high humidity cause increase in yield or not, it was gathered that it does not with responses, Akure (59.8%), Ologe (51.0%), Gambari (40.3%), Okoiro (49.0%). this showed different experience among the communities in the study locations ($\chi^2 = 30.159$; $p = 0.000$). To get the understanding of this question for the respondents required explanation. As such, the respondents in all the study location testified that when trees are planted, it reduces the effect of erosion.

Perception on whether unpredictable solar intensity favor forest product or not, all the respondent agreed that it doesn't favor forest products [Akure (48.8%), Ologe (56.0%), Gambari (32.8%), Okoiro (62.4%)]. The Chi-square test showed that it is not statistically significant ($\chi^2 = 5.695$; $p = 0.127$). The general result on whether the increase in rainfall and temperature threatens the forest product or not, majority confessed it that forest products are not lover of too much heat as the result revealed, Akure (51.7%), Ologe (66.4%), Gambari (37.9%), Okoiro (44.0%) ($\chi^2 = 30.784$; $p = 0.000$). The belief of the respondents was that heat causes deleterious damage to any

farm product. Research revealed that temperature increase reduces global yield of major crops in four independent estimates⁵⁶.

Concerning the perception on historical experience of 10 to 20 years ago compare to nowadays, all the respondents agreed that the weather are no more the same. The records from each location revealed (Gambari, 61.6%; Ologe, 48%; Okoiro, 46.2% and Akure, 44.3%). The chi-square test of significance of households' perceptions in the different communities showed no significant difference, implying that the occurrence was just by chance (P value = 0.094). It was a great lamentation when the respondents were expressing their views on the climate change. The responses of the respondent were given just by guess because the influences of these parameters were not measured. The evidence of climate change is real. Globally the consequences are being felt by the rural households in developing Countries and more importantly they are the burden bearer^{57,58}.

In order to integrate climate change adaptation into every aspect of national life, grass root awareness and knowledge and access to useful knowledge is highly important. Level of perception about climate change is determined by the aforementioned factors for Nigerian and how it is impacting them and how they can adapt cannot be underated⁵⁹. They also need to be equipped with relevant skills to enable individuals, communities, regions and the country to address climate change risks and implement adaptation. Most vulnerable communities must have access to important information and knowledge sharing. The level of public awareness on issues related to climate change in Nigeria is considered to be low. There is a convincing opinion that the Nigerian media has not given sufficient attention to climate change issues⁶⁰. The degree of information exposed to is the prerequisite to the level of awareness on climate change issues⁶¹. Exposure to specific weather information, early warning and

forecast technologies can also help farmers to develop and readjust coping or adaptation strategies⁶²

4.5.12 Adaptation Strategies to Climate Change Effects

The following adaptation strategies are perceived to be what the communities adopt in the study area as presented in table 4.10. These include, planting of timber forest product with non-timber forest product; adoption of different planting date; shifting cultivation; soil conservation; irrigation practices; use of organic fertilizer; water conservation and soil protection.

Table 4.53 Adaptation Strategies to Climate Change in the Study Location.

Indicators	Forest Reserves and Household Respondents (%)			
	Akure (N=71)	Ologe (N=76)	Gambari (N=62)	Okoiro (N=66)
Planting of TFP and NTFP	58.4	43.1	51.7	46.8
Changing Planting Dates	55.7	45.3	54.3	44.6
Shifting Cultivation	54.1	45.3	51.8	48.9
Irrigation	16.7	16.7	33.3	33.3
Use of Organic fertilizer.	17.9	34.9	33.3	72.7
Water Conservation	47.2	70.2	48.2	41.8
Soil Conservation	55.2	75.5	43.2	35.0
Soil Protection	47.8	82.0	53.0	26.3

Source: Author's Field Survey 2021

On Adaptation strategies to climate change effects, most of the respondents opined that Planting of different varieties of NTFP's and TFP's is a good form of adaptation with response from the households interviewed in Akure (58.4%), which has the largest response, followed by Gambari (51.7%) then Okoiro (46.8%) and the least was Ologe (43.1%), the farmers were given seedlings to plant alongside their crops. The

Chi-square result showed no statistically significant among the communities in different locations ($X^2=16.201$; $p=0.063$). The indication of this portends similar experience. The result of maintaining different planting dates shows Akure (55.7%), Ologe (45.3%), Gambari (54.3%), Okoiro (44.6%). The Chi-square result revealed statistically significant across the study location as $X^2=28.753$; $p= 0.001$. This portends evidence of climate change and adoption of changing planting dates. Even though, there were larger responses, the respondent's complaint was that, as they are trying to change planting date, it didn't work as expected. Also, practicing shifting cultivation is another adaptation strategy adopted to improve crop yield in the communities which revealed the responses in Akure (54.1%), Ologe (45.3%), Gambari (51.8%), Okoiro (48.9%), the farmers, after cultivating a portion of land for some years would go to another uncultivated land for good harvesting. Another way of reducing social vulnerability is the adoption of water Conservation. The responses were Akure (47.2%), Ologe (63.0%), Gambari (48.2%), Okoiro (41.8%). The households interviewed expressed their involvement in planting tree to limit water run-off. They also said that they avoid bare land against wind erosion (soil conservation). This borne the idea of mixed cropping to protect the soil and to adapt to rainfall variability. It also ensures harvest throughout the year to stabilize households' income or food production as gathered from the field. There is the hope of if one of the crops fail, the other one will substitute the failure and farmers will not be in total loss. The results showed the most response from Ologe (70.2%), followed by Gambari (48.2%), while Akure (47.2%) and Okoiro (41.8%) were the least. Relating to soil protection, majority of the households interviewed testified to the adoption of soil conservation as Akure (55.3%), Ologe (66.5%), Gambari (43.2%) and Okoiro (35.0%) responded; Soil protection have the following response: Akure

(55.2%), Ologe (75.5%), Gambari (43.2%), and Okoiro (35.0%). The Pearson's Chi-square for all the variable were statistically significant ($p < 0.05$). These are the positive adaptation strategies to climate change adopted in the study area. Results on this were presented in Table 4.53. In the same vein, there is low response in increased irrigation practice, use of organic fertilizers, are not better adaptation strategies to climate change effects in the study area. The forested communities don't belief in using fertilizer because the soil is believed to be fertile but due to climate change, infertility of soil set in. Strategy of water conservation involved farmers to rotate the types of crops they plant by season or years, thus providing enough varieties for the soil and plant to thrive. Water and nutrients required by crops differ and when farmers rotate this constantly, even though it takes much efforts, it increases yield and save precious natural resources. By focusing on better soil quality, good soil can hold more moisture and oxygen for plant. Good soil management practice includes reducing tillage and mulching method of water conservation adopted in the study location. Soil conservation adopted in forested communities are afforestation and changing agricultural practices. In other words, soil conservation includes all those measures which help in preventing soil from erosion and exhaustion.

The degree at which individuals, communities, region or nation adjust to climate change, moderate potential changes, take advantage of opportunities or to cope with the consequences, exhibit their adaptive capacity. Steps taken to reduces the effect of sensitivity of phenomenon to climate change in different ecological zones in Nigeria differ. Demographic factors such as sufficient education, assets, information and income are precondition for adaptive capacity⁶³. Nigeria has also experienced climate extremes in recent years. There have been persistent issues of floods destroying properties in Southwest Nigeria. The durations and intensities of rainfall have

increased in the last three decades, producing large runoffs and flooding in many places⁶⁴. The tendentiousness for coastal inundation to increase problems with flooding and intrusion of sea water into fresh-water sources and ecosystems, endanger people's safety, destroying infrastructure, heightening the social conflict already prevalent in this area is on the high side⁶⁵. Household socio-demographic characteristic and other institutional factors influence the adoption and intensity of climate change adaptation strategies in Southwest Nigeria. The adaptation strategies are location specific⁶⁶.

4.5.13 Benefits of Land Use Cover Change

The benefit of land use perceived in this context include: Increased food production, increased Pastureland, economic empowerment, income and livelihood diversification, increased land for settlement, increased basic services, improved infrastructure, increased collaboration with Institutions, more land for farming, access to fuel wood and access to medicinal plants.

Table 4.54 Perceptions of the Respondents on the Benefit of Land Use Cover Change for Boosting Financial Assets (DFID's Capital).

Indicators	Forest Reserves and Household Respondents (%)			
	Akure (N=71)	Ologe (N=76)	Gambari (N=62)	Okoiro (N=66)
Increase Food Production	51.1	52.0	48.8	48.1
Increase Pasture	56.3	90.3	21.8	50.6
Economic Empowerment	46.6	47.7	51.3	54.5
Livelihoods Diversification	50.6	49.6	48.6	50.9
Land for Settlement	50.6	48.8	47.2	53.4
Basic Services	49.1	58.9	50.8	50.2
Infrastructure	51.7	60.2	38.2	49.8
Collaboration with Institution	52.7	64.3	41.9	39.1
Increase Farmland	67.3	63.4	29.5	39.7
Access to Fuelwood	60.9	45.1	26.1	77.9

Medicinal Plant	78.0	63.1	24.7	34.2
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Source: Author's Field Survey 2021

Table 4.54 present the benefits of land use land cover change. Nearly all the benefits were in favor of land use cover change such as increased food production, economic empowerment, income and livelihood diversification, increased land for settlement, increased basic service, improved infrastructure, increased collaboration with institutions and more land for farming. Concerning increased food production, there was almost equal responses from all the respondents in the study locations. The forest land was cleared fell for agricultural purposes to increase yield. As such, the results are, Akure (51.1%), Ologe (52.0%), Gambari (48.8%), Okoiro (48.1%). Regarding increased Pastureland, there was disturbance by the cattle rearing in the farmland which hampered farming activities. There was a bitter complaint from Ologe (90.3%), Akure (56.3%), Okoiro (50.6%) and Gambari (21.8%). Regarding economic empowerment, the respondents agreed that it was beneficial to them in that it increased their financial status, hence the reactions were: Akure (46.6%), Ologe (47.7%), Gambari (51.3%), and Okoiro (54.5%); responses on livelihoods diversification was also positive from the households heads, income from the farm produce were easily being diverted to other activities that can fetch them more income, the result revealed the following: Akure (50.6%), Ologe (49.6%), Gambari (48.6%), and Okoiro (50.9%); More Land for Settlement was seen as an advantage for land cover change, the settlement observed from the various study locations showcase the increase in population. The respondents testified that more people are coming to settle in the forest reserves because of the forest resources that are beneficial to them, hence the responses are as follows: Akure (50.6%), Ologe (48.8%), Gambari (47.2%), and Okoiro (53.4%). Because of the increase in population in the forest reserves, there were basic services such as schools, health centers provided. But the basic services

provided do not correspond to the level of developments going on. The household heads complaint of scarcity of drugs in the clinic and no enough chairs and table for the pupils. The response structure from the respondents were, Akure (49.1%), Ologe (58.9%), Gambari (50.8%), and Okoiro (50.2%). Also, because of the developments in the communities, infrastructure facilities were improved but not as expected. The respondents' complaints were the poor roads that made it difficult to convey their harvest during the rainy season. They want government to help them to tar their roads for easy transportation, as such, the result revealed the following: Akure (51.7%), Ologe (60.2%), Gambari (38.2%), Okoiro (49.8%); There was a good collaboration between the forest residents and the Institutions in some of the forest reserves. Seedlings were provided for the farmers to plant alongside their crops (tungya farming). The collaboration was much felt in Akure (52.7%) and Ologe (64.3%) than Gambari (38.2%) and Okoiro (39.1%), there was also positive response concerning increased farmland, Akure (63.7%), Ologe (63.4%), Gambari (29.5%) and Okoiro (39.7%); access to fuelwood, Akure (60.9%), Ologe (45.1%), Gambari (26.1%), Okoiro (77.9%); and finally, access to medicinal plant, Akure (60.9%), Ologe (45.1%), Gambari (26.1%) and Okoiro (77.9%). It was revealed from the Pearson Chi-square statistical test that food increment was the only benefit that was not significant ($p>0.005$), but others were **statistically significant ($P<0.005$)** in all the study locations. This portends that the household heads consent to the fact that they benefited from the land use land cover change.

In view of this, it is more beneficial to change land status than to leave it untouched. But afforestation, plantation, forest enrichment, and other necessary action should be taken into consideration so that forest resources will not be jeopardized for other land uses. This will guide the land from being opened to erosion. Erosion and excessive

wind reduce the amount of forestry produce. Forests are under significant pressure not only from climate change but also from human pressure which include, increasing populations and greater demand for forest resources⁶⁷. It therefore goes without saying that Land-use Land-Cover (LULC) change is a reflection of natural resources and planning choices, with their implications on rural livelihoods opportunities, the ecosystems biodiversity and health of the environment.

4.5.14 Different types of Land use Adopted in the Study Area.

The current land use land cover examined are rain farming, Private grassland, communal grassland, forest land, wetland and bare land. The aim of this section is to find out if these are increasing or not.

Table 4.55 Perception of Respondent on the Current Status on LULC (DFID'S Physical Assets)

Indicators	Forest Reserves and Household Respondents (%)			
	Akure (N=71)	Ologe (N=76)	Gambari (N=62)	Okoiro (N=66)
Rain farming	95.7	34.7	44.0	25.6
Private grassland	36.5	49.6	42.7	71.3
Communal grassland	34.3	48.4	53.7	63.7
Forestland	38.6	35.8	37.8	87.8
Wetland	87.9	63.7	25.4	25.1
Bare land	53.6	52.3	47.4	46.8

Source: Author's Field Survey, 2021

The Interview Conducted with some of the Youths in Akure and Okoiro Forest Reserves was as this:

In fact, the cattle rustler is affecting our farmland. We are looking for way to leave this community. Even, Government is adding to our problem. We are being threatened to quit the farm. Apart from the

unfavorable whether affecting us as farmers, we are afraid of the problem of cattle Fulani. There is no rest of mind even some have left the farmland for greener pasture in the city.



Plate 4.16: Youth in Okoiro Forest Reserves
Source: Field Survey, 2021



Plate 4.17: Young farmers in Akure
Source: Field Survey, 2021



Plate 4.18 Researcher on the Road dividing the forest Reserve in Gambari Forest Reserve
Source: Field Survey, 2021

From the Table 4.55, it is revealed that the forested communities, with an agrarian population depends so much on small-holder rainfed agriculture whose livelihood is substantially tied to the terrestrial ecosystem and rainfall which determines the rhythm of life. As such the forested communities don't rely on irrigation for farming activities. The evidence of this is shown in the response of the respondents that the totality of the population depends on rainfall for livelihood for sustainability, Akure (95.7%), Ologe (34.7%), Gambari (44.0%) and Okoiro (25.6%); Private grassland, Akure (36.5%), Ologe (49.6%), Gambari (47.7%), and Okoiro (71.3%); communal grassland, Akure (34.3%), Ologe (48.4%), Gambari (53.7%), Okoiro (63.8%); forestland, Akure (38.6%), Ologe (35.8%), Gambari (37.8%), Okoiro (87.8%); wetland, Akure (87.9%), Ologe (63.7%), Gambari (25.4%), Okoiro (25.1%); and bare land, Akure (53.6%), Ologe (52.3%), Gambari (47.4%), Okoiro (46.8%). However, rain farming, private forest land, communal forestland, forestland and wet land were all **statistically**

significant at $p < 0.005$ except bare land that was not statistically significant at $p = 0.402$. It was observed that the private and communal grassland is on the lower side because most of the land belong to government, only on allocation are the communities reside. Opposite the forest reserve are forest land that belong to private people including the farmers residing within the forest reserve. Okoiro has the largest forestland while Akure and Ologe forest reserves have the larger portion of wetland due to the rivers that ran through the forest (Ogun River watershed and Ologe lagoon). The bare land, as shown in the table is also increasing due to ecological devastation.



Plate 4.19 The researcher and forest guard conducting interview with a traditional ruler in Onigambari'
Source: Field Survey, 2021

4.5.15 Perception of the Respondent on the Use of Income Generated in the Study Area.

Under this are trading and education

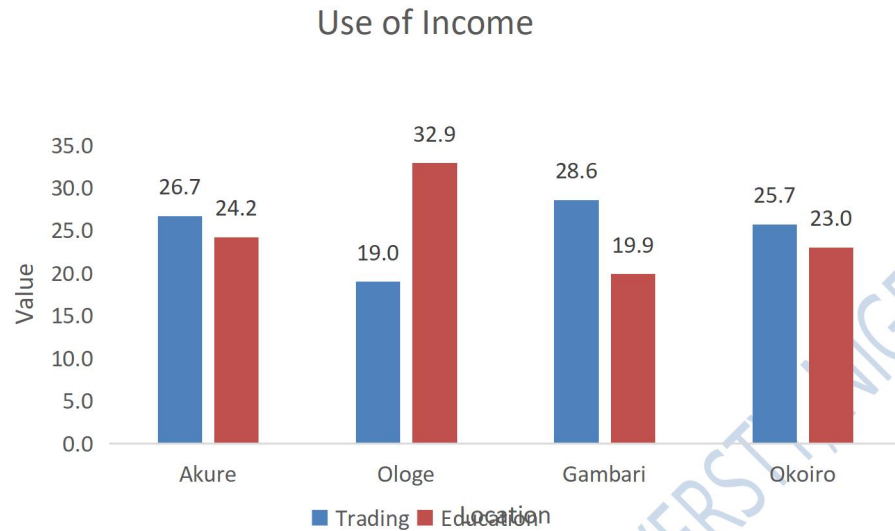


Figure 4.67: Respondent's Opinion of the Distribution of Income from the Forest
Source: Author's Field Survey, 2022.



Plate 4.20:
Source: Field Survey, 2021



Plate 4.21 Secondary school students in Gambari Forest Reserve which is one of the facilities provided for the community.
Source: Field Survey, 2021

From, Figure 4.67, Akure (26.7%), Gambari, (28.6%) and Okoiro (25.7%) household heads used their income generated from farm produce and forest resources for trading in other ventures apart from farm produce. Only the majority of the respondents in Ologe (32.9%) use their income on their children education. However, the Pearson Chi-square statistical test showed insignificant difference among the two variables ($p=0.210$). From Figure 4.68, it is observed that the communities in the study locations switch to either rearing of animals like goats, sheep, dogs etc. and poultry. Most of the respondents in Akure (24.9%), Ologe (33.1%), and Okoiro (24.3%) are into poultry business to support crop failure and inadequate yield. While majority in Gambari (34.0%) engaged in animal rearing to support livelihoods. The Pearson's Chi-square is not significant among the study locations ($p>0.005$).

Livelihood adjustment during the time of seasonal shortages and crop failure.

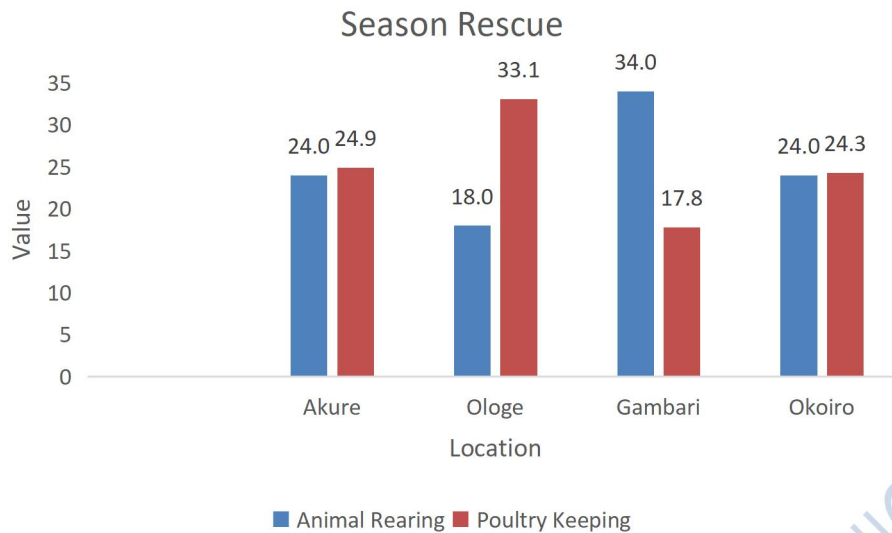


Figure 4.68: Respondents Strategies for Survival

Source: Author's Field Survey, 2021

4.5.16 Diversification from Forest Resources to Maintain Livelihood

Under this caption, Agriculture for subsistence productivity, Agriculture for production for the market, Self-employment activities, Agriculture for production for the market, Participation in labor market and Laboring in the home are the activities sustaining livelihoods in various study locations.



Plate 4.22: Researcher and his Assistant Conducting Interview in Kolawole Village in Akure Forest Reserve.

Source: Field Survey, 2021

Table 4.55 revealed the diversification strategies in the study area. Under the practice of agriculture for subsistence, majority of the respondent consented to practicing it as the statistics exposed it. Akure (25.2%), Ologe (27.0%), Gambari, (23.7%) and Okoiro (24.1%), Agriculture for production for the market, Akure (24.4%), Ologe (24.4%), Gambari, (25.6%) and Okoiro (25.5%), Self-employment activities, Akure (23.6%), Ologe (28.0%), Gambari, (23.2%) and Okoiro (25.2%), Participation in labor market and home service have the same statistical response Akure (23.1%), Ologe (23.1%), Gambari, (20.5%) and Okoiro (33.3%). However, the Pearson's Chi-square revealed statistically significant ($p < 0.05$) in laboring, self-employment and subsistence farming as alternative sources of income to forest resources, while marketing and participation in labor market were significant across the study locations. Information gathered by the researcher from the field was that majority of the farmers engaged in subsistence agriculture which with the occurrence of climatic hazard added to cattle grazing scenario has resulted to poverty and starvation in most parts of the communities. The Ologe community don't rely so much on agriculture but what the nature made available to them which is the Ologe lagoon where they carry out fishing activities.

Interview with Baale of Itemu Village in Okoiro Forest Reserve, Ogbomoso goes like this (Plates 4.16 and 4.17):

I thank God that he brought you here today because of the trending issue that we are facing. This issue is about the cattle Fulani. They are seriously destroying our farmland, killing our people, raping our women and kidnapping our people and demanding for money. We are not safe at all. Many of us have started to run away from the village.

(Plate 4.16)

The weather now is not favoring us because rainfall has not been falling at the expected time and it is affecting us.

Government should help us because there is no money with our people.



Plate 4.23 Researcher with his assistant in the house of Baale of Itemu village in Okoiro forest reserve, Ogbomosho.

Source: Field Survey, 2021

Interview conducted with Assistant Forest Superintendents in Gambari Forest Reserve revealed some information about the happenings in the reserve (Plate 4.17):

*Forest is very essential to forest reserve as it is very necessary to boost the growth of *Tectona grandis* above the age of three years of planting.*

*When this is in place, it doesn't allow the growth of *Gmelina aborea* and even kill other plants at their tender age. We also have issue on wildfire that destroy vegetation, dry fuel wood and micro-organism in the soil.*

We also have different types of fire occurrence, including top fire, ground fire and wild fire. We also operate on fire tracing.

The top fire destroys the crown leaves and branches which might also lead to ground fire. All these fire types are what we monitor in the forest so as not to spread to vital area. We have seen cases of fire destroying the whole plantation at the hour of the night, even invading tree crops and farms. This can get out of hand especially during the dry season.

The rainfall and temperature in the past 20 years has changed from what is happening now. There is decrease in rainfall and increase in temperature. There is reduction in number of rainy days, the onset of rainy season is unstable, cessation of rainfall is undeterminable.

*The invasion of cattle into farmland and reserve should be totally discouraged and adequate punishment should be accorded to anyone found wanting of such. We have the problem of vandalization of *Gmelina spp* and over grazing that led to hard pan of the soil. Also feeding on leaves, seeds seedlings and stem.*

The community need to give information of any illegal activities detected in the forest to the forest guard immediately. There is always clash with the herds. The state of ecosystem and forest management in the area is not good enough as the management do not provide adequate tools to work and give the forest necessary silviculture practice. Illegal activities and cattle rustlings bring about extinction of tree species and even food crops shortage and loss of vegetation. Some trees harvested are replanted but might not meet the rate of deforestation carried out. The rainfall is decreasing and not even come at the expected time while there has been records of increase in

temperature which cause health problem and loss of seedlings and crops.



Plate 4.24: Showing the researcher interrogating the forest guards and the office of the forest superintendents in Gambari Forest Reserve.
Source: Field Survey, 2021

Table 4.56: Respondents' Perception on the Strategies for Diversification

Indicators	Forest Reserves and Household Respondents (%)			
	Akure (N=71)	Ologe (N=76)	Gambari (N=62)	Okoiro (N=66)
Agriculture subsistence productivity	25.2	27.0	23.7	24.1
Agriculture production for the market	24.4	24.4	25.6	25.5
Self-employment activities	23.6	28.0	23.2	25.2
Participation in labor market	23.1	23.1	20.5	33.3
Laboring in the home	23.1	23.1	20.5	33.3

Source: Author's Field Survey, 2021

In addition, agricultural extension services are essential to improving agricultural productivity by providing farmers with useful farming and weather-related information and skills training that can enhance their productivity⁶⁸. The current

irregularity of extension services in Nigeria is a constraint to agricultural adaptation⁶⁹. Non-farm jobs can be of great relief in the aspect of a farming households diversification strategy, as it provides opportunities to reduce the risk of climate change and create resilience which will improve land productivity and also acts as a shock absorber during off-season periods. The non-farm employment could be reinvested into the agricultural operations and other climate change mitigation strategies (Table 4.56 and Plate 4.18).



Plate 4.20: Palm Kernel production as a means of livelihood diversification
Source: Field Survey, 2021



Plate 4.21: Palm Kernel Business under cocoa trees in Akure Forest Reserve as a livelihood diversification.
Source: Field Survey, 2021



Plate 4.27 Cocoa stands in Akure Forest Reserve as Non-Timber Forest Product
Source: Field Survey, 2021

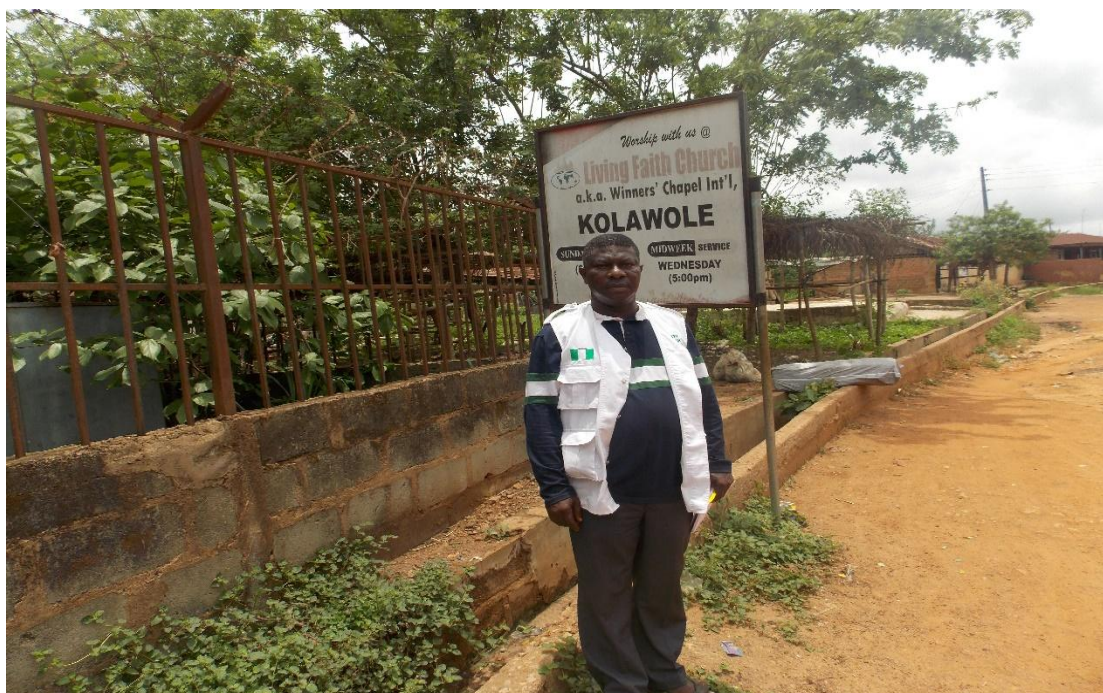


Plate 4.28: Researcher in one of the villages in Akure Forest Reserve
Source: Field Survey, 2021

4.5.17 Forest Product generating income for the livelihood

The following are the forest product generating income for the livelihoods: Timber, tree root, fruit, leaves, rubber, resin herbs and gum. In all, fire wood is the major source of income among the communities in the study area in relevant to Department for International Development's (DFID) financial capital.

Table 4.57 Forest Product generating income for the livelihood (Financial Capital)

Indicators	Forest Reserves and Household Respondents (%)			
	Akure (N=71)	Ologe (N=76)	Gambari (N=62)	Okoiro (N=66)
Timber	18.3	17.4	29.4	24.8
Tree roots	22.3	24.9	29.9	22.8
Leaves	23.1	22.1	33.7	21.2

Fruit	18.8	0.0	6.2	75.0
Rubber	0.0	0.0	0.0	0.0
Resin	0.0	0.0	0.0	0.0
Herbs	22.5	19.8	33.2	24.6
Gum	0.0	0.0	0.0	0.0
Firewood	24.5	28.8	24.9	24.0

Source: Author's Field Survey, 2021

Table 4.57 showcase the impact of the forest products on income generation in the study locations. Timber, tree roots, leaves, fruits and fire woods are the forests products available in the study area as they contribute in small measure in generating income. Concerning the timber, it is not the forest dwellers that embarked in the business, rather the people that got allocation from government and the illegal fellers. Forest products such as Resin, Gum, and rubber are not available in the study locations.



Plate 4.29: The researcher conducting interview with the wife of Baale in Onipe village

Source: Field Survey, 2021



Plate 4.30: Researcher conducting interview with a woman in a village in Gambari Forest Reserve.
Source: Field Survey, 2021

Table 4.58: General Distribution of Forest Products Income Generation by ranking for the Livelihood

Which of the forest products generate income for the livelihood	No	Yes	Rank
Fire wood	8.3	91.7	1 st
Timber	78.6	21.4	2 nd
Leaves	91.7	8.3	3 rd
tree roots	93.2	6.8	4 th
Fruits	95.1	4.9	5 th

Source: Author's Field Survey, 2021



Plate 4.31 Researcher in the portion of the land deforested in Gambari Forest reserve.

Source: Field Survey, 2021



Plate 4.32 Researcher in the portion of the land deforested in Ologe Forest reserve.

Source: Field Survey, 2021



Plate 4.33 Massive deforestation going on in Okoiro Forest Reserve, Ogbomosho
Source: Field Survey, 2021

From Table 4.58, the activities available in the study area for livelihood sustainability are ranked in order of income generation. It can be inferred from observation that firewood is mostly available in the communities for livelihood sustainability (94%). The gathering of firewood is counted as a menace to environmental development. This acts against carbon sequestration, and as such lead to increase in temperature and global warming⁷⁰.

Reason for the first rank of fire wood is that forest is seen as alternative to rising gas, kerosene and electricity prices. In the early 90s, there was a critical fuel crisis. There is a forest reserve in Ibadan called Igbo Agala. It is on a hill, and runs through Oke Aremo-Yemetu axis. It was a forest reserve to protect that landscape because of the sloping nature to prevent floods from runoff. When there was problem of fuel crisis, people started to go to the forest, cutting the trees. Now one cannot get any reasonable standing tree again. As if that is not enough, people started to uprooting the stumps. So, Igbo Agala was degraded. The people could not afford kerosene and gas which the rich people could afford. As such, energy crisis affects forests. Compared to 30 years ago, gas and kerosene has become very scarce because they are from the same

product. Non availability of these, leads to increase in prices. The next thing would be to result to firewood and charcoal, especially for people in rural areas.



Plate 4.34: The chairman and the executives of the fire wood association, Gambari.

Source: Field Survey, 2021



Plate 4.35 Researcher, the assistant and Association of wood Gatherer in Onigambari Forest Reserve

Source: Author's Field Survey, 2021

Association of Wood Sellers in Gambari Forest Reserve was interviewed and said:

I am the president of this association for fifteen years. We the association of wood sellers are cooperating with Government by

paying into account every month. The problem we are facing is Kidnapping. The cattle rustlers always come suddenly to disturb our activities. This has created fear in the whole community. Some of us are also farmers in this community, we have problem of irregular rainfall. Even the temperature is always very tense during the dry season that most of the crops planted get dried up in the soil. What sustains most of us is this offcut of timber and the branches of trees that we sell. It provides income generating to us and even the communities. The reason why Government allowed the association is that during the dry season when there used to be fire outbreak, the wood that we are parking does not allow the fire extending to unwanted places. Parking the fuelwood enhances better forest fire management and ensure effective forest fire control and prevention. Government should find solution to the vices of kidnapping in the forest so that farmers can have rest of mind to do their farming and protect the forest.

Interview with Baale in Araromi Village in Badagry exposed some information:

You are welcome to our village. They have told us that you people will be coming but I don't know it is today. The problem we are having is the rain that is not coming at the expected time. This has been giving us problem more than 30 years ago. Even at the time of dry season, the heat will be too much for us and the crops. Another problem is the cattle grazing and the herdsmen that destroy our farm and nobody can challenge them. We don't know when this will be over. Even, they destroy young plantation. Government is really trying concerning the

planting of vegetation. They give us tree to plant alongside our crops.

Another problem is the illegal deforestation. The forest guard are not enough to capture the people involved.



Plate 4.36: Researchers visit at Q-Brat Zoo inside the Araromi village in Ologe Forest Reserve
Source: Author's Field Survey, 2021



Plate 4.37: The forest being tampered with for agricultural purpose. Shrubs replaces the trees in Ologe Forest Reserve, Badagry.

Source: Author's Field Survey, 2021

Traditional Ruler in Gambari Forest Reserve was interrogated concerning problem confronted them in the communities:

The problem confronting us is the cattle rustlers. These people disturb farming activities by using their animals to destroy crops and dropping excreter on the farmland. They rape our women and kill our people. Even, many of us have run away from the community. We cannot boldly hold meeting because if they find out they will come in the night to kill us. This action affect harvest and eventually lead to loss of income. There is fear all over the community because of kidnapping. They destroy arable crops such as maize, cassava etc., also seedlings and coppicing. Another problem is that Government finds it difficult to curb them.



Plate 4.38: Researcher Conducting Interview for a Household Head in Odonbon in Okoiro Forest Reserve.
Source: Author's Field Survey, 2021



Plate 4.39: Encroachments of buildings inside the forest in Ologe Forest Reserve
Source: Author's Field Survey, 2021

Interview with the Farmers on Herdsmen and their Animals in Akure Forest Reserve exposed the activities of cattle Fulani:

Ha, this is a great problem for us. We cannot go to farm again. We cannot hold meeting as usual because if they get to know, they will come and kill us or kidnap us. They have their informant all over the

communities. Our lives are in danger. Even many of us have ran to the town for safety. There is no gain for us again, we are feeling hungry.



Plate 4.40 Researcher with the forest officials at their office in Ogbomoso
Source: Author's Field Survey, 2021



Plate 4.41 Researcher conducting interview with the forest officials in their office at Ogbomoso before going to the reserve in Ogbomoso
Source: Author's Field Survey, 2021



Plate 4.42 Researcher in Okoiro Forest Reserve in Ogbomosho conducting interview



Plate 4.43 Researcher and the assistant interviewing one of the household head
Source: Author's Field Survey, 2021



Plate 4.44 Researcher, the assistant and the forest officer with bale Itemu and his wife
Source: Author's Field Survey, 2021



Plate 4.45 Researcher and his assistant with the association of farmers in Okoiro Forest Reserve
Source: Author's Field Survey, 2021



Plate 4.46 Researcher in Olodonbon palace in odonbon village in okoiro forest reserve
Source: Author's Field Survey, 2021

4.6 Evaluate the relationship between demographic characteristics of the residents of forested communities and the adaptation strategies employed in the

forest communities for the improvement of livelihood and effective sustainability of forestry resources Using Pearson Chi-Square coefficient SPSS Statistics

Climate change adaptation is a two-stage process. First, there must be perception that climate is changing and the area that they are being affected is being noticed, secondly, the households should respond to such changes through appropriate adaptation strategies. This is assumed that the farmers use the adaptation strategies when they perceived that the benefit surpasses the loss⁷¹. Forested communities adopted different strategies to cope with climate variability depending on their economic capacity. The adaptation methods adopted in the study location were profit-driven rather than climate variability by shifting to livestock or otherwise which has lower reliance on crop production that is more susceptible to climate variability. But concentration was on climate change/farmers' methods of mitigation. The variables used in this study were demographic data and important adaptation strategies relevant to the ecological zones under consideration.

In rural livelihoods, there are security variables that should be in place if sustainability is to be maintained. There are distinctions between income level, income stability (or regularity) and degrees of risk. Income level is obviously important to people, but to poor people income stability and risk avoidance may be as important. The farming households have been employing actions before the negative impact, even though on informal way, (ex-ante response) in response to risks and shocks of climate change, and these actions are considered as usual⁷². The income referred to is not limited to monetary but also in kind such as food generated for home consumption. The factor that can affect income stability can be seasonality. The seasonality is a reflection of climatic factors in agriculture which are often dramatic and can profoundly affect

livelihoods security. As such, efforts should be made to reduce seasonal income fluctuations and associated vulnerability.

A sample correlation matrix considered include, the variables including: age, education level, monthly income, length of stay in the area, and profession. These variables will give knowledge about their association with adaptation methods such as, shift in planting dates, shifting cultivation, irrigation practice use of organic manure, water conservation, soil conservation and soil protection. The benefits of these will manifest on livelihoods, climate change effect, vulnerability to climate change effect, impact on vegetation cover dynamics, adaptation strategies to climate change effects, benefits of land use cover change and improved/increased factors for mitigating climate change^{73,74,75}.

Each table consists of cross-tabulation of the demographic characteristics and adaptation methods perceived in the four study locations.

Table 4.59 Relationship between respondents' age with changing of planting dates as a coping strategy

Forest Reserves			Value	def.	Asym. Sig. (2-sided)	Status
Akure	Pearson Square	Chi-	8.423 ^a	4	0.077	NS
Ologe	Pearson Square	Chi-	1.615 ^b	6	0.951	NS
Gambari	Pearson Square	Chi-	1.541 ^c	2	0.463	NS
Okoiro	Pearson Square	Chi-	2.011	6	0.919	NS
Total	Pearson Square	Chi-	1.190	6	0.977	NS

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

S=Significant NS=Not significant

Implication of this is that there is no relationship between age and planting date. The p -value (0.077) shows statistically insignificant. This implies that age cannot determine the planting date in all the study area.

Table 4.60 Relationship between respondents' age with water conservation as a coping strategy

Forest Reserves			Value	Def.	Asym. Sig. (2-sided)	Status
Akure	Pearson Square	Chi-	10.617 ^d	6	0.101	NS
Ologe	Pearson Square	Chi-	4.801 ^b	6	0.570	NS
Gambari	Pearson Square	Chi-	4.916 ^c	4	0.296	NS
Okoiro	Pearson Square	Chi-	16.986	6	0.009	S
Total	Pearson Square	Chi-	13.230	6	0.040	S

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

S=Significant NS=Not Significant

Considering the association of age and water conservation, there is no relationship between age and water conservation in all the study area except Okoiro Forest Reserve with p -value (.009). the overall association shows weak relationship (p -value 0.040).

Table 4.61 Relationship between respondents' residence with changing of planting dates as a coping strategy.

Forest Reserves			Value	Def.	Asym. Sig. (2-sided)	Status
Akure	Pearson Square	Chi-	76.955	4	0.000	S
Ologe	Pearson Square	Chi-	45.623 ^b	6	0.467	NS
Gambari	Pearson Square	Chi-	0.632 ^c	1	0.427	NS
Okoiro	Pearson Square	Chi-	13.036	6	0.042	S
Total	Pearson Square	Chi-	18.796	6	0.005	S

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

S=Significant NS=Not significant

Table 4.61 shows relationship between residence and planting date in the study locations. There is a strong association between residence and planting date together with overall total (p -value .00). Okoiro shows a weak association with p -value 0.042. Others are not significant ($p < 0.05$).

Table 4.62 Relationship between respondents' residence with water conservation as a coping strategy.

Forest Reserves			Value	Df	Asym. Sig. (2-sided)	Status
Akure	Pearson Square	Chi-	41.956 ^d	6	0.000	S
Ologe	Pearson Square	Chi-	9.567 ^b	6	0.144	NS
Gambari	Pearson Square	Chi-	6.773 ^c	2	0.034	S
Okoiro	Pearson Square	Chi-	5.940	6	0.430	NS
Total	Pearson Square	Chi-	61.110	6	0.000	S

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

S=Significant NS=Not significant

The Chi-square coefficient for age and planting date (Table 4.61 and Table 4.62) across the study location is not significant, which signifies that difference in age group has nothing to do with knowledge of changes in planting. All the age groups are vulnerable to changes in climate. As such, it will affect vegetation and crop yield. Under the same age groups and water conservation, there is no significant relationship. There is no strong evidence that water utilization exists due to age in all the study locations (**p -value is more than 5% significant level**). However, Okoiro Forest reserve seems to be practicing water conservation because of the statistical level closer to 5% than other forest reserves ($P=0.009$), significant level. The reason why Okoiro conserves water in a little way may be due to its ecological location. They are hard heated by drought in the Savanna area than the rain forest⁶⁶.

Tables (Table 4.63 and Table 4.64) shows the influence of residence on planting date. It can be inferred that the relationship is significant in Akure and Okoiro forest reserves, and overall reserves, with **p-values < 0.05**. Locational factor strongly determines planting date in Akure and Okoiro Forest Reserves than other forest reserves because the overall level is very significant. Also, there is significant relationship between residence and water conservation in Akure and Gambari forest reserves and the traces of relationship showcased in overall (**p-value <0.05**). The reason for the overall statistical significance cannot be unconnected with the years of experience in their areas. The respondents in the location confessed their bad experience in the past 30 year.

Table 4.63 Relationship between respondents' education with changing of planting dates as a coping strategy

Forest Reserves			Value	Df	Asym. Sig. (2-sided)	Status
Akure	Pearson Square	Chi-	10.928 ^d	6	0.091	NS
Ologe	Pearson Square	Chi-	11.673 ^b	6	0.070	NS
Gambari	Pearson Square	Chi-	0.136 ^c	2	0.934	NS
Okoiro	Pearson Square	Chi-	9.281 ^a	6	0.158	NS
Total	Pearson Square	Chi-	17.178 ^a	9	0.046	S

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

S=Significant NS=Not significant

Table 4.64 Relationship between respondents' education with water conservation as a coping strategy

Forest Reserves			Value	Def.	Asym. Sig. (2-sided)	Status
Akure	Pearson Square	Chi-	9.509 ^d	9	0.392	NS
Ologe	Pearson Square	Chi-	6.531 ^b	6	0.365	NS
Gambari	Pearson Square	Chi-	4.845 ^c	4	0.304	NS
Okoiro	Pearson Square	Chi-	26.796 ^a	6	0.000	S
Total	Pearson Square	Chi-	21.567 ^a	6	0.010	S

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

S=Significant NS=Not significant

Table 4.65 and Table 4.66 showed the association between education level with planting date and water conservation. The influence of education attainment with the planting dates is significant overall (**p value <0.05**) while education and water conservation are significant in Okoiro and overall (**p value <0.05**). This shows the significant impact education has on both planting dates and water conservation. But there is a strong relationship of education and water conservation in Okoiro Forest reserve (**p-value of 0.000**). There a strong relationship in the statistical analysis⁷⁷. The residence of the forest reserves utilized the water around them to augment the shortage or inadequate rainfall.

Table 4.65 Relationship between respondents' profession with changing of planting dates as a coping strategy

Forest Reserves			Value	Def.	Asym. Sig. (2-sided)	Status
Akure	Pearson Square	Chi-	10.305 ^d	6	0.112	NS
Ologe	Pearson Square	Chi-	7.381 ^b	12	0.831	NS
Gambari	Pearson Square	Chi-	6.803 ^c	2	0.033	S
Okoiro	Pearson Square	Chi-	11.096 ^a	9	0.259	NS
Total	Pearson Square	Chi-	9.272 ^a	12	0.680	NS

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

S=Significant NS=Not significant

Table 4.66 Relationship between respondents' profession with water conservation as a coping strategy.

Forest Reserves		Value	df	Asym. Sig. (2-sided)	Status
Akure	Pearson Chi-Square	17.651 ^d	9	0.039	S
Ologe	Pearson Chi-Square	13.458 ^b	12	0.336	NS
Gambari	Pearson Chi-Square	8.268 ^c	4	0.082	NS

Okoiro	Pearson Chi-Square	9.331 ^a	6	0.407	NS
Total	Pearson Chi-Square	10.644 ^a	12	0.560	NS

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

S=Significant NS=Not significant

From the tables 4.67 and 4.68, it revealed the type of influence profession has over planting date and water conservation. There is no association between the two variables as *p*-value is greater than **5% significant level** in overall but only significant in Gambari forest reserve. Profession relationship with water conservation, it is only significant in Akure.

Tables 4.69 and Table 4.70 revealed monthly income of the respondents in each study location and planting date together with water conservation. There is significant relationship between monthly income and planting date in Gambari and overall forest reserves with ***p*-values of 0.001 and 0.000**. This portends that, if the forest communities are assisted financially, there will be improvement in food production which will indirectly increase vegetation cover through the practice of agroforestry. In addition, there is statistical significance between monthly income and changing planting dates in Gambari forest reserve and overall ($p < 0.05$), while relationship between monthly income and water conservation is strong significant relationship in Akure and Okoiro forest reserve and in the overall forest reserves at ***p*-value of 0.000**.

The results are indication that low income or income inequality is the factor that contribute to farm size and household size is the factor that contribute to low level of income in the study location. It was gathered from the field that majority of the inhabitants in the study area earn income of between 5000-10,000 naira⁷⁸. This finding, however portends that, production technology should be improved, access to credit and land should be made easier. The large family size should be discouraged

and infrastructural facilities should be provided to facilitate a more equitable distribution of income and increase agricultural production

Table 4.67 Relationship between respondents' monthly income with changing of planting dates as a coping strategy.

Forest Reserves			Value	Def.	Asym. Sig. (2-sided)	Status
Akure	Pearson Square	Chi-	3.873 ^d	6	0.424	NS
Ologe	Pearson Square	Chi-	12.151 ^b	6	0.059	NS
Gambari	Pearson Square	Chi-	15.433 ^c	3	0.001	S
Okoiro	Pearson Square	Chi-	8.734 ^a	9	0.462	NS
Total	Pearson Square	Chi-	46.380 ^a	9	0.000	S

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

S=Significant NS=Not significant

Table 4.68 Relationship between respondents' monthly income with Water conservation as a coping strategy.

Forest Reserves			Value	Def.	Asym. Sig. (2-sided)	Status
Akure	Pearson Square	Chi-	12.978 ^d	6	0.043	S
Ologe	Pearson Square	Chi-	8.162 ^b	6	0.226	NS
Gambari	Pearson Square	Chi-	3.322 ^c	6	0.767	NS
Okoiro	Pearson Square	Chi-	20.270 ^a	9	0.016	S
Total	Pearson Square	Chi-	35.088 ^a	9	0.000	S

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

S=Significant NS=Not significant

Finally, length of stay does not have any relationship with planting date and water conservation (Tables 4.71 and 4.72). It is revealed that there is no relationship except in Okoiro with statistical *p*-value of 0.049.

Table 4.69 Relationship between respondents' length of stay with changing of planting dates as a coping strategy.

Forest Reserves			Value	Df	Asym. Sig. (2-sided)	Status
Akure	Pearson Square	Chi-	3.536 ^d	6	0.739	NS
Ologe	Pearson Square	Chi-	12.104 ^b	6	0.060	NS
Gambari	Pearson Square	Chi-	5.688 ^c	3	0.128	NS
Okoiro	Pearson Square	Chi-	10.489 ^a	9	0.312	NS
Total	Pearson Square	Chi-	9.353 ^a	9	0.405	NS

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

S=Significant NS=Not significant

Table 4.70 Relationship between respondents' length of stay with water conservation as a coping strategy.

Forest Reserves			Value	Df	Asym. Sig. (2-sided)	Status
Akure	Pearson Square	Chi-	2.483 ^d	9	0.981	NS
Ologe	Pearson Square	Chi-	5.665 ^b	6	0.462	NS
Gambari	Pearson Square	Chi-	4.987 ^c	6	0.545	NS
Okoiro	Pearson Square	Chi-	16.972 ^a	9	0.049	S
Total	Pearson Square	Chi-	10.412 ^a	9	0.318	NS

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

S=Significant NS=Not significant

Summarily, in all the variables that the overall show statistical significance that shows *p*-value less than 5% level of significance are very important to take note of and to reconsider those that are not significant to boost the adaptation and reduce or eradicate the vulnerability to climate change effect of the forested communities in Southwest Nigeria⁷⁹.

The overall number of respondents in the sample answering both items were 275. P-value for this Chi-Square coefficient is 0.000. It's not technically zero. SPSS does not give p -values to more than three decimal places. Since most of the overall relationship between demographic characteristics and adaptation strategies adopted are statistically significant, it calls for answer for the hypothesis. The statistical hypothesis test for this p -value is: H_0 : There is no significant relationship between adaptation methods and demographic characteristic. H_a : There is a statistically significant relationship between adaptation methods and demographic characteristics. Because $p < .05$, **reject the null** of no relationship and conclude that the relationship is statistically significant. For as long as there are some variables that revealed relationship such as income, education and residence with planting date and water conservation, there is a reason for the rejection.

4.6 Re-Statement of Research Questions and hypotheses

4.6.1 Research Question and Hypothesis 1

What are the trends in annual and monthly variations of Rainfall and temperature?

There is no significant trend in the rainfall and temperature among the study locations. From all indications, standardized anomalies revealed the coefficient of variation higher (between 11% and 29.5%) than the ideal CV of between 1 and 5%. which is an indication of variability and unreliability of rainfall. Also, from the study, it was revealed that there was an irregular pattern in the data series (rainfall and temperature) across the study area. The data has a trend variation as shown in Figures 4.13-4.24. In addition, the temperature anomaly displays mostly warmer characteristics in all the study locations above the Long-Term Average (LTA), 1982 2010⁸⁰. This portends

that the **null hypothesis** needs to be **rejected** since the p -value (0.01) for the series are less than 5% level of significance.

4.6.1.1 Discussion of Findings

Further exercise was carried out on the data series because of its attainment of seasonality. Diagnostic plot of the residuals generated from the time series model comprises the residual plots, autocorrelation function plot and histogram to show the normality of the residuals. It was revealed that in all the residuals, the error generated was normal for the time series analyses. These results are pointers that give way for prediction through the time series models. Autocorrelation Function Plot (ACF) and histogram showed the normality of the residual generated from the time series analysis of the rainfall and temperature for all the study area. In water resources engineering and management, intensity-duration- frequency (IDF) parameters are most important and the most commonly adopted tools for planning, design and operation of a wide range water resources related projects. Institution of this is commonly based on value analysis of observed timeseries, extracted using monthly/annual maxima series (AMS) method or the peak over threshold. Usually, historical data are used under the assumption that the same underlying processes will govern future rainfall patterns. As such, the non-stationarity assumption of rainfall extreme, due to climate change projection, is expected to affect hydrological cycle. Researcher's finding revealed an increase in future rainfall intensity (September and June), which can result in increased flood risk and increase risk for agriculture. In view of this, adaptation and constant consideration of IDF must be incorporated in the design procedure to reduce vulnerability of the rural populace and infrastructural projects.

4.6.1.2 Summary Table of Findings

Table 4.18, shows the Augmented Dickey Fuller Test for the series. It revealed that all the parameters (rainfall, maximum temperature and minimum temperature) for the study area. The table showed that there is seasonality in the series for all the regions with order 1 except for the minimum temperature series for Badagry that does not attain stationarity which is likely due to existence of waterbodies, industrialization in Agbara, among other unexplainable factors.

4.6.2 Research Question and Hypothesis 2

What are the perceived changes and impact of climate change on vegetation cover dynamics and livelihoods of the forest communities of Southwest Nigeria?

Ho: There is no changes and impacts of climate change on vegetation cover and livelihood activities in the study area.

Researcher found out from the satellite map through remote sensing that there were changes in vegetation due to climate change within the period of study. Land area of Akure Forest Reserve in 1990 was 99% and in the year 2020 it reduced to 88%; Land area of Gambari Forest Reserve in 1990 was 87.3% and reduced to 71% in the year 2020; land area of Okoiro Forest Reserve in 1990 was 91% and reduced to 62% in the year 2020. But in Ologe Forest Reserve the land area increased from 4.2% in 1990 to 33.9% in the year 2020. Also, the Pearson's Chi-square statistical test of the responses from the households on whether the climate change affect the vegetation cover, showed statistically significant across the study area ($X^2=65.336$; $p=0.000$). This portends that all the respondents in the study locations testified to the effect of climate change on the growth of vegetation⁸¹. Evidence from the satellite imageries signified decadal changes in vegetation cover which can be attached to land use land cover changes and deforestation⁸². As such, **the null hypothesis is rejected.**

4.6.2.1 Discussion of the Findings

Findings from the study revealed that largest parts of the forest reserves experienced changes as the climatic parameters, especially temperature increases. Tables 4.57-58 showed the changes in vegetation during the period of study. In Gambari Forest Reserve the percentages changes experienced in 1990,2000,2010 and 2020 were 87.30%, 84.69%, 60%, and 71%; Okoiro Forest Reserve experienced 90%, 84%, 69%, and 62%; Akure Forest Reserve experience 99%, 92%, 74%, and 88%; and Ologe Forest Reserve were 4%, 14%, 25%, and 33% respectively. The first decade in all the forest reserves were the area occupied by the forests as at the period of study in relative to other land use⁸¹. It could be observed that Ologe Forest Reserve was growing in forest coverage. The reasons for this among other factors was firstly, the afforestation program embarked upon by Lagos State Government, secondly, the area is waterlogged as such water needed for the expansion was not lacking. Researchers observed from the field the encroachments that was going on into the reserve but it was been substituted by the afforestation program. In others, forest reserves were seriously affected by human activities such as deforestation, firewood gathering, agriculture, etc⁸³.

4.6.2.2 Summary Table of Findings

Tables 4.53-56 showed the summary findings of the vegetation dynamics while Table 4.57 showed the vegetation dynamics alongside temperature changes, while Table 4.58 exhibited the percentage increase in temperature along the decades. This indicates climate change that affected the variation of forest resources alongside the livelihood activities⁸⁴.

4.6.3 Research Question and Hypothesis 3

What are the prevailing livelihoods practiced in selected communities in Southwest Nigeria?

H₀: There is no prevailing type of livelihoods practice existing in the study area.

From the study, researcher discovered that the majority living in the study area sustain their livelihood from farming. The Pearson's Chi-square statistical test revealed the statistical significance across the study locations with $X^2 = 19.572$ and $p = 0.003$. Meanwhile, the other types of livelihoods practiced were also significant at $p < 0.005$ but this are not their major occupations. As such, we **reject the null hypothesis** as there are evidences of livelihood practiced in the study area.

4.6.3.1 Discussion of the Findings

Findings from the field as shown in table 4.55 revealed that 78.2% of the respondents accepted that farming is their major occupation. Other source of livelihoods such as fire wood (94%), tree roots usage (73.8%), and medicinal (73.3%) are secondary. All these are the forest products used by the communities as shown in Figure 4.64. The study locations showcased the multi-faceted nature of agricultural livelihoods being located on different agricultural zones. In view of this, the dynamism of contexts, temporality and element of human agency responding to and operating on accessible capital assets make it difficult to generalize which livelihood strategies generate the best outcomes for human well-being⁸⁵. Yet, the need to establish which livelihood strategies lead to the best food security outcomes within the specific context remain important. In the study locations, there are some peculiarity attached to each which direct the way of food security to the forested dwellers. This, the government should prioritize by expanding this for the improvement of the community livelihoods. The research found out from the field in Akure, cash crops such as Cocoa, palm oil,

plantain; Ologe forest reserve is well known for fishing, sugarcane etc.; Gambari forest dwellers are known for garri making etc. there should be shift from subsistence oriented to commercial oriented production of crops or other venture.

4.6.3.2 Summary Table of Findings

Table 4.12 showed the different occupations that sustained the livelihoods of the study area.

4.6.4 Research Question and Hypothesis 4

What are the adaptation and mitigation strategies that are already in use in the forest communities to ameliorate the impact of climate change in the study area and how such strategies can be modified for the effectiveness and sustainability of the forests?

Ho: There is no association between adaptation strategies and demographic characteristics in the study area.

The Pearson's Chi-square statistical test showed significant relationship between demographic characteristics and adaptation strategies adopted in the study locations as most of the p - values are less than 5% ($p < .005$), **as such, the null hypothesis of no relationship is rejected.** There is strong relationship between income, education, profession and residence with the independent variables (planting date and water conservation). However, the relationship across the study locations differs.

4.6.4.1 Discussion of Findings

The relationship between adaptation strategies and demographic structure is very statistically significant at $p < 0.005$ as shown in Tables 4.59 - 4.72. For survey scale type data, this is pretty large. The overall number of respondents in the sample answering both items was 275. Pearson's Chi-Square coefficient is $p=0.000$. It's not technically zero. The implication of this is that the inhabitants of different ecological zones had different approach at reaching the same goal⁸⁵. The major occupation of the

forested community in the study location is farming. The researcher discovered that there are lots of threat to the achievement of food security at the face of adaptation strategies put in place. While trying to justify the demographic characteristic workability against the adaptations, the flooding of the farms, herdsmen attacks, government arbitrary conducts, violence and gang activities stand as unfortunate situation. It is very disheartening to discover that Nigeria has come to accept the category nomadic as a permanent description of a vital segment of our populace. As gathered by researcher, the consequence has been frequent blood shed between nomads and the farmers in nearly every part of Southwest Nigeria. It was reported that farmland was destroyed by the cattle and the rarer, while women, young girls and children are raped, herdsmen stage high way robbery attacks. The results due to livelihood threats in study locations were insecurity, loss of lives, violence and kidnapping, hunger and food losses, displacement and loss of shelter, a climate of fear and panic, forced migration, diseases and suicidal attempts etc. The vulnerable groups are farmers, women, youth and virtually all the inhabitants in the communities. Wealth and assets in terms of skills were affected with the resultant effect on inaccessibility of natural resources, reduced savings and credits, dying formal and informal relationship, shortage water supply and the likes.

4.6.4.2 Summary table of findings

The summary table of findings is in tables 4.59 - 4.72

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Chapter Five

This chapter has five sections. Section 5.1 gives the summary of the whole research work which entails, the nature of dataset used, the aim of the research, method used for modelling and some of the major/significant findings from the result obtained. Section 5.2 gives the conclusion from the study while section 5.3 presents some recommendation based on the result of the analysis, section 5.4 presented contribution to knowledge and finally section 5.5 showed area of further research.

5.1 Summary

The Study examines the impact of climate change and variability on vegetation cover dynamics and livelihoods sustainability of the forested communities of Southwest Nigeria over the last 30 years and how such changes have influenced feedback on climate. Changes were measured through different methods: firstly, through local perceptions and description of change were addressed through household interviews and field observation; secondly, in the same vein, effectiveness of adaptation methods adopted to changes in climate and variability were measured through the structure of demography in the study locations; the trend of climate parameters was examined through standardize anomaly and time series analysis; while vegetation cover dynamics were measured through progressive changes over four decades by the employment of remote sensing method.

The results from the research revealed the vulnerability of the forested communities due to poverty, population growth, lack of technology, and paucity of information about climate change. The forested communities were opened to several hazard such as natural hazard (rainfall and temperature), physical hazard (health, heat waves, malaria, jaundice, flood and drought); social (events, religious, festival, cultural and

custom); and financial food shortage and security, low income, low yield and climate extreme with p value of 0.05 level of significant. This is corroborated by literature that human health status is affected by climate change at higher rate. The local communities expressed their perception on the changes in rainfall and temperature over three decades ago, that growing seasons cannot be predetermines while any mistake to plant with usual knowledge always result to big loss of crops. The key interview revealed that there has been migration of people to the urban because of the unattractive environment in the communities and to add to their problem is the menace caused by cattle grazing. This is supported by literature that temperature have risen significantly above normal since 1980s, with relatively higher figure in 2018. Temperature increase of approximately 0.2 °C to 0.3 °C per decade observed in various ecological zones of the Country.

Perception on the adaptation measure to reduce the effect of climate change were discovered. Age, gender, education, income, and length of stay, were tested against the effect of climate change which include planting date, shifting cultivation, water conservation, soil conservation, planting of TFP and NTFP. Most of these methods were embarked upon but they are ex-ante approach. The efforts are not yielding optimum result because of low technology and illiteracy level (p value of less than 5% level significant). This is supported by literature that demographic factors such as sufficient education, assets, information and income are precondition for adaptive capacity.

The climatic characteristics revealed a great change and variability. Computation of 30 years observe rainfall and temperature against standardize normal revealed departure from normal, while the forecast years revealed great disparity from standardize normal in Akure (-6 to 3.0); Ologe (-2.3 to 1.8); Gambari (-1.4 to 2.6);

and Okoiro (-1.2 to 2.6) . The time series revealed irregular pattern, the data series are stationarity and trends in climate vary. In all the study locations extreme rainfall was predicted to be highest every September, except Ologe forest reserve (June) and temperature to be highest in all the months every February.

Further results revealed shrinking vegetation cover while other land uses especially, agriculture was increasing in all the study locations except in Ologe forest reserve where there was massive afforestation. As there was negative progressive change in vegetation cover, there was positive progressive change in temperature. Literature supported the findings that positive correlation of rainfall with vegetation cover dynamic is connected to the decrease evaporation rate in the rainy season which has no impact on normal function of plants photosynthesis. Human activities such as burning of fossil fuels, deforestation, industrialization and urbanization affected decadal mean temperature. This is also corroborated by the literature that climate change is expected to change and relocate plant species distribution; ant community composition and diversity; vegetation structure and ecosystem processing of carbon, nutrients water.

5.2 Conclusion

Based on the results of the literature review and the survey of researcher, the research reached a number of conclusions regarding the state of climate change and variability alongside with its impact through field survey and meteorological data on the vegetation and livelihoods. The research primary conclusions are discussed as below:

There is an enormous amount of information pertinent to discover the status of forested communities through a lot of materials from variety of sources. The livelihood practiced in the selected forest reserves was majorly subsistence agriculture. Other livelihoods practice is firewood gathering, fishery, livestock rearing, and

trading in forest products. Women are primarily responsible for gathering wood for cooking and heating, while Ologe and Okoiro forest reserves used the opportunity of Ologe lagoon and Ogun catchment river to engage in fishing business. If the farmers are encouraged by the government, their livelihood activities will shift from subsistence to commercially oriented thereby improve their livelihood status. However, forest reserves act as a saving grace for sustainability for the communities. The limitation encountered by the forested communities in facing the challenges of climate change were justified by poverty and low technology. Although the information concerning the happenings in the environment may not be understood by the poor rural populace but there should be experts in the field who will put them through the practical operation.

Additionally, the adaptation strategies practiced in the forest reserves are agroforestry (planting of TFP and NTFP), changing planting dates, shifting cultivation, water conservation, soil protection and conservation. Most rural inhabitant in the study locations possess years of experiences due to their knowledge of their environment and with these experiences comes a wealth of practical knowledge. In many respects, they have their ways of adapting to shocks and stress. However, the adaptation methods are fire brigade approach because of the informal way of application. Hence, the results do not justify the means. Farmers need to be exposed to information and technical know-how to improve methods of circumventing the risk and shocks from climate change. There is room for improvement if proper adaptation strategies are considered and all involving stake holders are put to responsibility concerning conservation of forest reserves and prevention of land degradation. In addition, the welfare of the forested communities must be guaranteed

Furthermore, climate has been changing and its impact has been negatively affecting the vegetation and livelihoods. Also, the feedback of human activities is telling on hydrological regime. There is variation in rainfall and temperature trend and irregular patterns discovered in the data series. Observing the standardize anomalies and the observed climatic parameters, a great positive disparity was revealed. Rainfall and temperature prediction revealed extreme rise in annual rainfall and temperature above climate standardize normal. Specifically, extreme rainfall is expected in every September in all the locations except Ologe forest reserve (June). Government needs to prepare ahead against flood and drought.

Finally, it was ascertained that vegetation area were reducing while other land uses were increasing in all the study locations except Ologe forest reserve due to afforestation program. The reforestation in other location were very low with high deforestation. As such, this accounted for the decadal fluctuation of vegetation coverage. Increase in temperature was discovered with decrease in vegetation coverage. Government should employ more forest guard with sophisticated materials to work with, encourage farmers with hybrid seeds to practices agro forestry and also practice selective tree harvesting so as to bring back the services rendered by the forest.

The research on this theme gives information and innovative practices for other forest reserves, particularly forest reserves that are located in the same general geographic area and have similar operational characteristics. However, the researcher can learn a great deal from larger coverage, who may face certain problems, issues, or situation more frequently and thus gain knowledge more quickly regarding what techniques that will work or not.

The activities in the reserve will not be completed if the impact of cattle grazing on vegetation and livelihoods are not mentioned. There has been farm destruction, terrorism, kidnapping, climate change and other social vices. However, security gadget put up by the state government have reduced the crime rates to some extent. What should be a major concern should be locally-oriented safety and security.

In general, forest reserves dwellers are important and doing excellent job in preventing and providing timely report about poachers in the forest reserves. However, the survey respondents may not be representative of the whole Southwest in this regard. Also, since human activities can change frequently as well as climatic phenomenon occurrences. This is an important research that requires adequate discussion in further research. In addition, the findings should reference the forthcoming land use and livelihood planning under a separate project.

5.3 Recommendation

Based on the findings and conclusion presented, the following recommendation are suggested.

- There must be awareness programs which will educate people on recent changes in rainfall and temperature in order to enhance people's adaptive capacities that will both improve health and reduce vulnerability. This can be carried out through advocacy campaigns and multimedia products addressing both policy-makers and the general public on climate prediction and its effect on human and the environment.
- These forested communities should have access to information regarding historical climate, projections of future climate change, potential impacts, causes of vulnerability, technologies and measures for managing climate risks, and the know-how for implementing these technologies. Nigeria

Meteorological Agency (NiMETS) is in position to make data available to policy makers. Government policies concerning agriculture, forestry, water resources development and other related sectors should take into consideration ways of tackling the recent increase in temperature and rainfall amount in recent years and make it available to capacity builders who will reach the grass root.

Indigenous people should be integrated within climate change-oriented organizations to create sense of belonging to local fishermen and farmers. A bottom-up approach where local problems are treated in achieving sustainable development should be adopted. Government should provide amenities in the communities to improve their status and discourage rural migration to the urban cities

- Socio-economics qualities of the forested communities must be improved. Cooperatives and other limited trades organizational opportunities can be introduced to contribute to supporting productive farming livelihoods as income (loan) is positively and significantly related with institutional adaptation.
- Farmers also need to have access to adaptive technology and innovations, through extension services and information systems. This to be done through climate-smart strategies such as, changes in cultivation practices, insurance, soil fertility improvement measure, mulching, use of improved varieties of crops, and change in planting/harvesting dates. In case of bad harvest through climate vagaries, farmers can engage in diversification, use of cover crops and increase in farm size especially in the wetland such as Ologe communities.

- Farmers need to be thought about and understand the implications of some of their farming practices such as mono cropping, bush burning, indiscriminate use of synthetic agrochemicals and felling of trees, that can encourage ecological problems. Government should implement accessible and sustainable irrigation scheme among farmers especially in Akure and Ologe forest reserves where they are accessible to rivers. This has not been adopted in the study area due to lack of skills and funds. Also, there should be supply of improved agricultural inputs.
- Farmers should avoid area that are prone to flood such as low land and valley, to avoid farm crops destruction and plant on hilly or sloppy area such as the occurrence in Akure forest reserve communities.
- Many farmers complained of climate variations that influenced the distribution of many vectors such as Anopheles mosquitoes. This has resulted into accumulated stresses and vulnerabilities such as immune status. This has affected productions which promote poverty and bad health. Government should take adequate actions health facilities for sustainable production and consumption, thus abating poverty and enhance health.
- Infrastructural facilities should be improved in the communities to facilitate easy conveyance of farm products to the market or points of sale during the wet season. Government intervention is highly necessary by improving and strengthening human capital, extension services and infrastructures in the communities.
- Soil degradation through water and wind erosion should be rehabilitated. Agricultural Extension profession should assist farmers in soil testing to enable them to know what nutrients are lacking (Nitrogen, Potassium and

Calcium) and the right fertilizer to apply for improve farm yield. There should be soil management in terms of no-till practices, terracing, erosion control. Tilling of soil encourages wind and water erosion.

- Deforested area should be filled with indigenous plant/trees to resuscitate the ecological services provided to humans and animals. Government should restore the forest landscape which can help reverse some of the ill-effects of deforestation such as the on-going project in Lagos State that involved collaboration with Nigerian Conservation Foundation (NCF), erosion control agroforestry and forest regeneration by natural means. Government should employ adequate number of forest guard who will distribute and monitor seedlings and curb illegal activities in the forest reserves.
- The amount of in-coming solar energy into the earth's surface must be controlled to reduce the solar heating. Agricultural Extension Professional should encourage farmers to plant reflective crops, as plants reflect light intensity. Religious values and practices can also serve as mitigation strategy to climate change. This traditional religion is very close to nature, with structures, practices and sanctions that can effectively protect the environment.
- Atmospheric pollution must be reduced to reduce the effect of extreme temperature on vegetation and humans. Carbon sequestration or actions that encourage sink capacity of bio-geophysical systems that will reduce greenhouse gases emission in the atmosphere. Fuel switching in the energy sector, and the direct reduction of their concentrations must be embarked upon by Government Agency and Non-Government Agency (NGO).
- Conflict between farmers and cattle herders must be resolve to stop crops and vegetation destruction. Government (federal, State and Local), should provide

cattle ranch. This will cut down carbon footprint and lower the negative effects on the environment.

- Firewood used as fuel should be discouraged and should be replaced with low carbon generation technology, since carbon dioxide is the greatest contributor to the radiative forcing, which is the source of climate change. Petroleum products prices should be made low, stable and affordable. If the gas and kerosene are largely available and affordable, it will reduce the number of people using firewood and charcoal in the forest communities.
- An aspect of forestry that plants special fast-growing trees with high calorific value should be encouraged to facilitate the establishment of forest plantation. Bio-tech department in Forestry Research Institute of Nigeria (FRIN) should be funded to carry out research in this direction.
- Finally, record has it that Nigeria, like many African countries, has not received significantly benefit from international climate financing arrangements such as Green Climate Fund (GCF), REDD+, Adaptation Fund and other special climate funds to finance a paradigm shift towards a green economy and low carbon development pathway through the Nationally Determined Contribution (NDC) targets. As such, Nigeria should work towards these facilities and spread it towards the different ecological zones to ameliorate the effect of climate change.

5.4 Contribution to Knowledge

The primary aim of the researcher in this study is to relook at the issue of climate, climate change, vegetation cover dynamics and livelihoods of the forested communities in part of Southwestern Nigeria, from a new perspective.

- So far, most studies on these phenomena have been on one or combination of any two variables at a time in the same region or town or different region or town from the study area. In this study, the researcher has tried to shift the focus to the issues rather than the individual glorification and this has led to further development of an integrated of many phenomena in a region.
- The method used in administering the questionnaire differ from some researchers. The criteria were based on the area that are greening in nature which attracted human settlements for their livelihood's sustainability. More importantly, researcher based the selection of the study area on different ecological zones for comparison.

The methodology employed were:

- The climatic data used covered 31 years (1990-2020) with the same period for satellite data. Sustainable Livelihood Approach (SLA) of United Kingdom Department for International Development (DFID's livelihood Approach) was applied for the capitals and asset available in the study area.
- Use of climate normal to justify decadal changes in rainfall and temperature.
- Use of standardize anomaly analysis to establish the extent of disparity of climatic parameters from normal.
- Use of time series analysis to established the trend, seasonality and stationarity of trend was adopted.
- Use of ARMA model to establish 5 years rainfall and temperature prediction
- Use of regression analysis for the vegetation cover dynamics
- Employment of NDVI and NDBI to establish changes in land use land cover changes overtime was explored.

The data collection methods were:

- 10% of the population sample size
- Combination of focus group, key interview, household heads survey
- 30 years Climatic data covering 1991-2020.
- 31 years remote sensing data on vegetation and temperature

Researcher worked on the research title because the literature recorded it that climate is one of the causative factors of ecological change whose present and future impact on biodiversity remain uncertain. The uncertainty status has caused impediments to effective planning and decision making for conservation and natural resources management. As such, ecological responses to climate change vary. Climate change has caused a range shift that has potentials to reshape ecological communities, alter ecosystem function and provision of ecosystem services, and impact human well-being. Species shift can also have feedback effect on the climate change. This uncertainty of the effect of climate change on ecosystem called for continuing research on the subject matter.

Problems identified during the period of study were: the forested inhabitant were majorly illiterate which accounted for their poverty level; negligence on the side of government to provide necessary facilities such as good roads and infrastructure, government failure in adequate community participation, lack of grassroots planning and inability of government to optimize local resources. Research on this created a template of solving similar problem in other regions or town as the case may be. That is, where forest and its resources has become sole provider of income and where many forest species have entered danger list or extinction.

5.5 Area of Further Research

- ✓ Further research can investigate the number of people in the households, the area of their farmland and the income coming for each household heads to

justify the poverty level. This will help government and its agency, such as National Agency for Rural Development (NARD), District Rural Development Agency (DRDA) who is responsible to manage and oversee the implementation of different anti-poverty programs of the ministry of rural development and Federal Ministry of Agriculture and Rural Development (FMARD). This will assist to improve the livelihoods of the rural communities.

- ✓ As the distance to the forest land determines the level of impact on the forest reserve, the range of distance to the forest can be in stepwise like impact of the people living within 500 meters to the forest reserve and between 500 meters and one kilometer to the forest reserve. Comparison of the two different distances can be assessed to reveal the level of impact distance can have on vegetation changes.
- ✓ The period of climate parameters can be extended to more than 31 years like 1981- 2021 (40 years). This can further reveal the trend of climate and climate extreme. Knowledge of this will enable the kind of assistance to render to the rural people in the area of adaptation and mitigation.
- ✓ Health effect from extreme temperature and flood can be examined to justify the productivity and income status of the rural communities in various regions of Nigeria.
- ✓ Since Normalize Difference Vegetation Index (NDVI) method adopted generally differentiates the vegetation from nonvegetative areas. Further study can examine the percentage impact of each Land Use (LU) on the changes in vegetation across the region
- ✓ In the area of forecast, it can be extended to forty years. As such, there will be preparation ahead by the stakeholders to avert the danger.

- ✓ Further, the whole region can be considered, may be there can be events occurrence that were not revealed in selecting just few forest reserves.

The methodology applied in this research can be adopted in the same study location or any other region with the same biogeographical characteristics. As such, it will reduce the impact of vagaries of weather and forest resources quality will be maintained. Knowledge of this variables will help government and its agencies to plan for the achievement of 17 Sustainable Development Goal (SDG) which include no poverty, sustainable Cities/ Communities, climate action etc.

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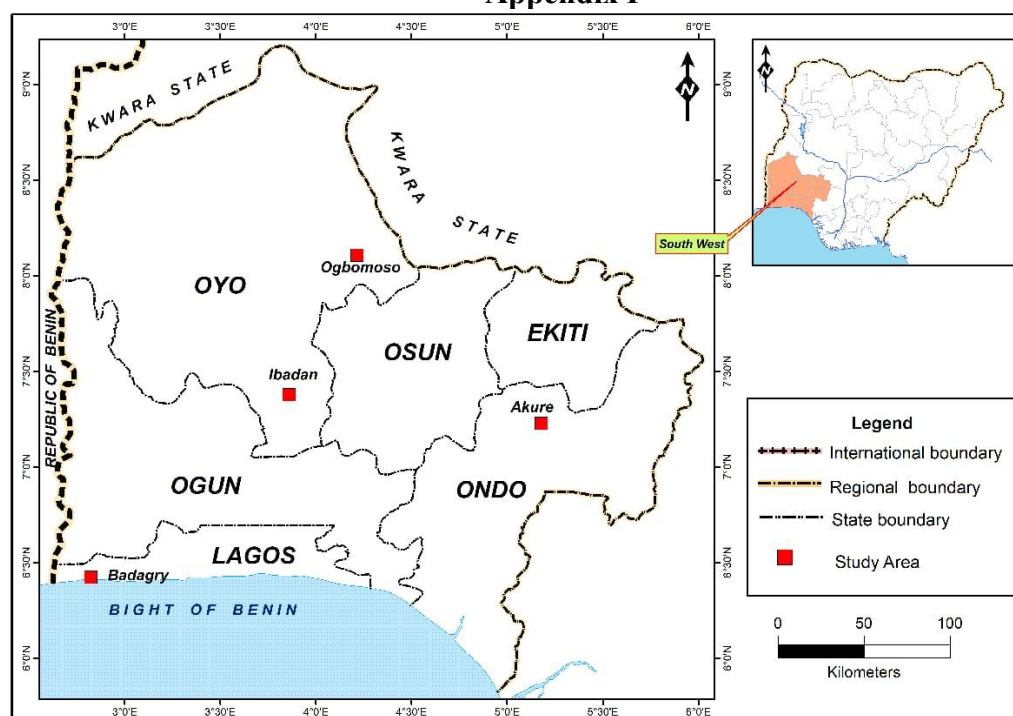
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Appendices

Appendix I



The study area in the context of South West Region, Nigeria

Source:⁷¹

Appendix II

Population of the Study Area

Population Characteristics of the Study Locations

Study Area	Population (Estimated for 2019)	Population Density/Sq Km	Land Area (Sq. Km)
Ibadan	3, 464, 000	464.71	3,080
Lagos	13, 904,000	6,871	1,171.28
Ogbomoso	527, 000	253	207,978
Akure	420, 000	225	1,866

Appendix III

Research Activities Log Frame

Study Objectives	Sub-themes	Data Needed	Data Sources	Data Analysis
Assesses the rainfall and Temperature trends in Southwest Nigeria in the past 31 years (1990-2020)	Climate change; climate variability; climate change adaptation; Decadal variability of rainfall and temperature.	31 years data on rainfall and temperature	Nigeria Meteorological Society, world Meteorological Organisation (Standardize normal data)	Decadal analysis. Time series analysis (trends analysis and seasonality index), descriptive analysis (table, graph, etc.) ARMA Model used for the prediction

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Determine the trends and magnitudes of climate changes and variability that have occurred between 1990 and 2020 through Landsat imageries (the extent of vegetation cover dynamics and climate parameters) in the study area	Vegetation theories; climax concepts and theories;	Landsat satellite imageries of the study areas for 1990, 2000, 2010, and 2020 for vegetation and temperature.	United State Geology Survey (USGS)	Sub-pixel analysis and land surface temperature retrieval. NDVI, NDBI and temperature retrieval from satellite data was adopted, covering the period of the study. Landsat TM, ETM+ and OLI images which are the three-medium resolution Landsat Imageries in assessing land use land cover pattern of the study area was employed. <i>Idrisi taiga</i> 17 version, regression analysis (development of the land classes) and ArcGIS 10.5 (display, process and enhance image
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3.Examine the perception of the respondents on the causative factors of climate change, vegetation dynamics, and livelihoods practiced in selected forested (forest-based) communities	Socio-economic characteristics (Part A); land use land cover change; climate trends and its impact on livelihood; sources of income; vulnerability to climate change effect; etc. (Part B	Primary data through structured Questionnaire	Field survey include: In-dept interview (IDI), Household interview, photographing, Focus Group Interview (FGI), Key Informant Interview and field observation	Pearson's Chi square correlation, descriptive analysis (table, graph
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4. Evaluate the relationship between demographic characteristics of residents of forested communities and the available adaptation strategies in the forest communities for the improvement of livelihood and effective sustainability of forestry resources	Information about the socio-demographic characteristics of the respondents and adaptation strategies to climate change effects utilized (planting dates, planting of different varieties of NTFP and TFP).	Demographic characteristics (age, income, education etc.) and adaptation strategies adopted (soil conservation, planting dates, water conservation, etc.) in different study location	Field Survey and questionnaire administration (Both formal and informal). Sampling technique. 1. Purposive selection of four forest reserves in different ecological zones, 2. less than 2km away from the reserves 3. 10% of the households. 4. systemic sampling method key informant interview;	Pearson's chi-Square analysis.
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Appendix IV

Questionnaire for the field work

Department of Environmental Management

Faculty of Environmental Design & Management

Lead City University, Ibadan, Oyo State

Doctor of Philosophy in Environmental

Management

Survey Questionnaire on Climate Change and Variability as a Determinant of Vegetation Cover Dynamics and Livelihoods of the Forested Community of Southwest Nigeria

Dear respondent,

The Purpose of this questionnaire below is for research work and an academic exercise at the Lead City University, Ibadan. All the information provided will be used for the betterment of the communities and will be treated confidentially. As such, your cooperation is needed as regard sincerity of given information.

Mark appropriately the following options (✓)

Part A

Information About the Socio-Demographic Characteristics of Survey

Respondent

1. Age: A. 30- 40 years, () B. 41-60years, () C. 61 and above()
2. Gender: A. Male, () B. Female ()
3. Area of residence: A. Sub-Urban () B. Rural () C. Rural-rural ()
4. Level of Education: A. None, () B. Primary,() C. Secondary,() D. Tertiary ()
5. Marital status: A. Married () B. Single () C. Separated () D. Divorced ()
6. Professional level: A. Semi-professional, () B. lesser professional,() C. Skilled,() D. Non Skilled ()
7. What is your main occupation?
A. Hunter () B. Gatherer () C. Subsistence farming () D. Trader () E. Forest product processor () F. Employee in local forest industries ()
8. Monthly income: A. less than 5000 (), B. 5000-10000, () C. 11000- 20000, () D. 21000- above ().
9. Length of stay in the area. A. <5 Years, () B. 5-10 Years, () C.10-20Years,() D. >20Years ()
10. What language(s) do you speak? A Yoruba () B.English () C.Hausa () D. Igbo () E. Pigin () F. Other specify

Part B

Information About the Knowledge of Land use/Land Cover Change in The Study Area.

11. The following factors are responsible for land use change in this area.

s/n	Item/Statement	A	SA	D	SD
1	Cropland				
2	Pastureland/grazing				
3	Forestland				
4	Population				
5	Urbanization				

A= Agree, SA= Strongly Agree, D= Disagree, SD = Strongly Disagree

12. What has been from your experience, about the effect of climate hazard brought about by deforestation in this area?

Climate hazards and impact of changes on local livelihoods

i. Natural (rainfall and temperature)

ii. Physical (Health)

iii. Social (Business)

iv Financial (poverty level)

13. The Following Are the Sources of Income Generating Livelihood Activities In This Area.

Source of Income	A	SA	D	SD
Farming				
Livestock rearing				
Trading on forest products				
Fishing				
Hired laborer				
Hunting				
Artisan				
Gathering of NTFPs*				
Transport business				
Civil servant				

*Non- Timber Forest Products

14. Vulnerability to Climate Change Effect:

Vulnerability	A	SA	D	SD
Reduction in yield				
Flooding				
Shortage of food				
Undefined season				
Pests and diseases				
Forest fire				

15. The crop failure can be as a result of climate change A. () SA () D () .SD ()

16. Perception of Impact of Land Use on Vegetation Cover

Do the land use activities have impact on vegetation cover dynamics?

Vegetation Change	A	SA	D	SD
Farming activities				
Illegal grazing				
Fuel wood				
Illegal logging activities				
Illegal hunting				

17. What are the forest products used by the community? A, Fire wood () B. timber () C. tree roots () E. leaves () F. fruits.() G. Rubber () H. Latex () I. Resins () J. Medicinal herbs () K. Gum ().

18. Climate change has impact on vegetation growth of your area

A. A () SA () D () SD ().

19. Choose from the option whether increase or decrease (I) = Increase: (D) = Decrease

How do you perceive climate change to be?

A Air temperature change I D

- B Rainfall I D
 20. The onset of rainfall is delayed A () SA () D () SD ().
 21. The Following Are the Effect of Climate Change

Perception	A	SA	D	SD
The rise in annual rainfall had not led to increase yield of forest products				
Fluctuation of rainfall is never in favour of forest production				
Forest products are lost to disease infection on the field due to high relative humidity				
There is high incidence of pests due to change in temperature and rainfall pattern.				
Cultivation of forest product may decrease the problem of land degradation				
High humidity does not increase yield of forest products.				
Increase in temperature threatens forest products.				
Unpredictable nature of sun intensity negatively affects forest products.				
The weather condition 10 to 20 years ago differs from nowadays				

22. Adaptation Strategies to Climate Change Effects Utilized.

Do you agree that the following adaptation strategies are useful to mitigate the effect of climate change?

Adaptation Strategy	A	SA	D	SD
Planting of different varieties of NTFPs* and TFPs. *				
Different planting dates				
Practicing shifting cultivation.				
Increase irrigation practice				
Use of organic fertilizer.				
Increase water conservation.				
Soil conservation.				
Soil protection through tree planting.				

*Timber Forest Product (TFPs).

23. Benefits of Land Use Cover Change

Benefits of Land Use Cover Change	A	SA	D	SD
Increased Food Production				
Increased Pastureland				
Economic Empowerment				
Income and Livelihood Diversification				
Increased Land for Settlement				
Increased Basic Services e.g. Schools, Health				
Improved Infrastructure e.g. Road, Transport				
Increased Collaboration with Institutions				
More Land for Farming				
Access to Fuel Wood				
Access to Medicinal Plants				

24. From your experience, do you agree that the following is increasing? Pick an option.

Factors	A	SA	D	SD
Rain-farming				
Private grassland				
Communal grassland				
Forestland				
Wetland				
bare land				

Note: Private grassland (pasturing); Communal grassland (grassland that belongs to the community); Forestland (community); Wetland (waterlogged area); Bare land (individual land for erecting building)

25. In relation to livelihood security, which activity do you diversify to from forest reliance?

- A. Agriculture for subsistence productivity
- B. Agriculture for production for the market
- C. Participation in labour market
- D. Laboring in the home
- E. Self-employment activities

26. Which of the forest products generate income for the livelihood?

- A. Fire wood () B. timber () C. tree roots () E. leaves () F. fruits () G. Rubber () H. Latex () I. Resins () J. Medicinal herbs () K. Gum ()

27. What do you use the income from the forest to do?

- A. Trading () B. Educate children () saving in Cooperative Society.

28. During the time of seasonal shortages and crop failure, what do you do for livelihood?

- Rearing of animal () B. Poultry keeping () C. Wild game () E. Mention Others ()

Key Informants' Questionnaire

Name of Local Government :

Department.....

State.....

Interviewer Mr. Ayeni Olatunji

David.....

Respondent Status.....

What is the approximate population of this LGA.....?

What is the major responsibility of your department?.....

What are the other secondary responsibilities?.....

What services do you render to the community members under your jurisdiction?.....

.....

What is your view in the state of ecosystem and forest management in your jurisdiction?.....

.....

From the under listed, which are the most prominent challenges in your jurisdiction?

	Regularly	Occasionally	Never
Drought			
Flood			
Water shortage			
Pest infestation			
Food shortage			
Clash with the herds			
Heat waves/ extreme temperature			
Forest fire			

How do you assist or respond to the challenges?.....

.....

How will you describe the relationship between climate change and forest management in your jurisdiction?

.....

What is the staff strength for overseeing forest activities in your area?

What support do you want from the community?

.....

What is your view about the invasion of cattle into farmland and reserved areas?

.....

How many reported cases have you recorded and from which communities?.....

.....

What are the causes of cattle invasion into farms?.....

.....

.....

What types of crops do the cattle
destroy?.....
How can the problems be solved
amicably?.....

.....
On what conditions do you think they can both co-exist and do their work without
loss of farm products, death of farmers and
casualties.....

.....

In your view, how best can the following contribute to resolving the challenges
considering fact that they co-exist, marry and support each other.

- ° Fulani herd men
- ° Communities
- ° Farmers.....
- ° NGOs
- ° Government

What in your own opinion are the likely future threats to the sustainability of the
forests in this community?

Are some trees harvested replanted?

If not why?

How would you describe the weather in recent time?
compare to 10 years ago with regards to the followings?

Issue	Experience
Annual rainfall	
Temperature	
Number of rainy days	
Hot days	
Cold days	
Onset of rainy season	
Cessation of the rains	
Onset of growing season (planting season)	

22. what percentage of your household income do you spend on?

Activity	Percentage	Activity	Percentage
Food		Clothing	
Water		Energy	
Education		Savings	
Health		Recreation	

Appendix V

Forecast value for Climatic Parameters in the Study Locations

Forecast Value for Climatic Parameters in Akure

Date	Maximum Temperature			Minimum Temperature			Rainfall		
	Forecast	Lo 95	Hi 95	Forecast	Lo 95	Hi 95	Forecast	Lo 95	Hi 95
Jan-21	33.55	32.22	34.88	21.56	20.27	22.84	2.53	-179.82	184.88
Feb-21	34.42	32.98	35.86	23.69	22.36	25.02	8.34	-175.01	191.68
Mar-21	33.93	32.49	35.37	24.08	22.70	25.46	128.85	-54.49	312.20
Apr-21	32.81	31.36	34.25	23.89	22.48	25.29	119.51	-63.84	302.85
May-21	31.70	30.26	33.14	23.20	21.78	24.63	197.08	13.74	380.42
Jun-21	30.25	28.81	31.69	22.93	21.49	24.36	354.77	171.43	538.12
Jul-21	28.72	27.28	30.16	22.56	21.12	24.01	235.38	52.03	418.72
Aug-21	28.23	26.79	29.67	22.17	20.72	23.63	150.56	-32.79	333.90
Sep-21	29.05	27.61	30.49	22.47	21.02	23.93	383.45	200.10	566.79
Oct-21	30.55	29.11	31.99	22.56	21.11	24.02	189.74	6.40	373.09
Nov-21	32.19	30.75	33.63	23.90	22.45	25.36	35.68	-147.66	219.03
Dec-21	33.09	31.65	34.53	22.82	21.36	24.28	11.38	-171.96	194.72
Jan-22	33.71	32.26	35.15	23.44	21.93	24.95	1.37	-206.90	209.65
Feb-22	34.70	33.25	36.14	24.62	23.11	26.14	4.52	-204.02	213.05
Mar-22	33.98	32.54	35.43	24.93	23.41	26.45	161.17	-47.36	369.70
Apr-22	32.72	31.28	34.17	24.73	23.20	26.25	127.57	-80.97	336.10
May-22	31.69	30.25	33.14	24.21	22.69	25.74	155.40	-53.13	363.94
Jun-22	30.26	28.81	31.70	23.89	22.37	25.42	339.35	130.81	547.88
Jul-22	28.85	27.41	30.29	23.39	21.86	24.92	164.38	-44.15	372.91
Aug-22	28.18	26.73	29.62	23.17	21.64	24.69	83.46	-125.07	292.00
Sep-22	29.04	27.59	30.48	23.17	21.65	24.70	419.75	211.22	628.29
Oct-22	30.52	29.08	31.97	23.42	21.89	24.95	147.62	-60.91	356.16
Nov-22	32.34	30.90	33.78	24.24	22.71	25.77	23.83	-184.71	232.36
Dec-22	33.18	31.73	34.62	24.08	22.55	25.61	15.79	-192.75	224.32
Jan-23	33.59	32.12	35.05	21.93	20.35	23.50	1.90	-247.65	251.46
Feb-23	34.56	33.09	36.03	23.69	22.11	25.27	6.27	-243.70	256.23
Mar-23	33.98	32.51	35.45	24.48	22.89	26.06	146.37	-103.60	396.33
Apr-23	32.75	31.29	34.22	24.02	22.43	25.60	123.88	-126.09	373.84
May-23	31.68	30.21	33.15	23.68	22.09	25.27	174.49	-75.47	424.46
Jun-23	30.25	28.78	31.72	23.33	21.74	24.92	346.41	96.45	596.38
Jul-23	28.80	27.33	30.27	23.01	21.42	24.60	196.90	-53.06	446.87
Aug-23	28.18	26.71	29.65	22.19	20.60	23.78	114.20	-135.77	364.17
Sep-23	29.05	27.58	30.52	22.47	20.88	24.06	403.12	153.15	653.09
Oct-23	30.54	29.07	32.01	22.71	21.12	24.30	166.92	-83.05	416.88

Nov-23	32.27	30.80	33.74	23.84	22.25	25.43	29.26	-220.71	279.22
Dec-23	33.13	31.66	34.60	23.62	22.03	25.21	13.77	-236.20	263.73
Jan-24	33.60	32.13	35.08	22.11	20.31	23.92	1.66	-275.42	278.75
Feb-24	34.58	33.11	36.06	23.95	22.12	25.77	5.47	-271.90	282.83
Mar-24	33.98	32.51	35.46	24.42	22.58	26.26	153.15	-124.22	430.51
Apr-24	32.75	31.27	34.23	24.16	22.31	26.00	125.57	-151.80	402.93
May-24	31.68	30.20	33.16	23.60	21.75	25.46	165.75	-111.62	443.11
Jun-24	30.25	28.77	31.73	23.30	21.44	25.15	343.18	65.81	620.54
Jul-24	28.81	27.33	30.29	22.91	21.05	24.78	182.01	-95.36	459.37
Aug-24	28.18	26.70	29.65	22.45	20.58	24.31	100.12	-177.25	377.49
Sep-24	29.05	27.57	30.52	22.68	20.81	24.54	410.74	133.37	688.11
Oct-24	30.54	29.06	32.02	22.84	20.98	24.71	158.08	-119.29	435.45
Nov-24	32.29	30.81	33.76	24.01	22.15	25.88	26.77	-250.60	304.14
Dec-24	33.14	31.66	34.62	23.36	21.49	25.22	14.69	-262.67	292.06
Jan-25	33.60	32.11	35.09	22.82	20.89	24.76	1.77	-303.53	307.07
Feb-25	34.57	33.08	36.06	24.30	22.36	26.24	5.83	-299.76	311.43
Mar-25	33.98	32.49	35.47	24.75	22.81	26.70	150.04	-155.55	455.63
Apr-25	32.75	31.26	34.24	24.48	22.53	26.43	124.79	-180.80	430.39
May-25	31.68	30.19	33.17	23.99	22.04	25.94	169.75	-135.84	475.35
Jun-25	30.25	28.76	31.74	23.67	21.72	25.62	344.66	39.06	650.25
Jul-25	28.81	27.31	30.30	23.24	21.29	25.19	188.83	-116.76	494.43
Aug-25	28.18	26.68	29.67	22.82	20.87	24.78	106.57	-199.02	412.16
Sep-25	29.05	27.56	30.54	22.95	20.99	24.90	407.25	101.66	712.84
Oct-25	30.54	29.05	32.03	23.17	21.21	25.13	162.13	-143.47	467.72
Nov-25	32.28	30.79	33.77	24.15	22.19	26.11	27.91	-277.68	333.50
Dec-25	33.14	31.65	34.63	23.84	21.89	25.80	14.27	-291.33	319.86

Source: Processed Meteorological Data

Appendix VI
Forecast Value for Climatic Parameters in Badagry

Date	Maximum Temperature			Minimum Temperature			Rainfall		
	Forecast	Lo 95	Hi 95	Forecast	Lo 95	Hi 95	Forecast	Lo 95	Hi 95
Jan-21	33.98	32.91	35.06	23.83	22.20	25.46	71.62	-	1 254.40
Feb-21	34.49	33.36	35.63	24.44	22.55	26.34	91.54	-91.24	5 274.32
Mar-21	33.98	32.83	35.14	24.70	22.71	26.68	48.60	-	6 231.38
Apr-21	33.51	32.32	34.69	24.23	22.20	26.25	144.25	134.17	2 327.03
May-21	32.30	31.11	33.50	24.16	22.12	26.19	182.75	-38.52	3 365.52
Jun-21	30.36	29.16	31.56	23.48	21.44	25.52	373.13	-0.03	3 555.91
Jul-21	29.12	27.91	30.32	23.29	21.25	25.34	163.19	190.36	9 345.97
Aug-21	29.06	27.85	30.27	23.20	21.15	25.24	52.50	-19.59	5 235.27
Sep-21	29.64	28.43	30.85	23.43	21.38	25.48	228.08	130.28	2 410.86
Oct-21	30.98	29.77	32.19	23.47	21.42	25.51	243.43	45.31	1 426.21
Nov-21	32.69	31.48	33.90	23.42	21.37	25.47	87.69	60.65	3 270.46
Dec-21	33.60	32.39	34.81	23.18	21.13	25.23	60.61	-95.09	2 243.39
Jan-22	33.88	32.66	35.11	23.59	21.43	25.76	43.41	-	1 248.62
Feb-22	34.30	33.07	35.52	23.84	21.63	26.05	53.48	161.80	1 258.69
Mar-22	33.97	32.74	35.20	23.94	21.72	26.17	51.00	-	9 256.21
Apr-22	33.54	32.32	34.77	23.75	21.52	25.98	138.60	154.21	4 343.80
May-22	32.28	31.06	33.51	23.72	21.49	25.96	147.13	-66.61	0 352.34
Jun-22	30.35	29.12	31.58	23.45	21.21	25.69	392.31	-58.08	4 597.52
Jul-22	29.13	27.90	30.36	23.38	21.13	25.62	169.90	187.10	7 375.11
Aug-22	28.99	27.77	30.22	23.34	21.09	25.58	50.15	-35.31	8 255.36
Sep-22	29.69	28.46	30.92	23.43	21.19	25.68	220.85	155.06	0 426.05
Oct-22	30.94	29.72	32.17	23.45	21.20	25.69	162.64	15.63	2 367.85
Nov-22	32.64	31.41	33.87	23.43	21.18	25.67	95.48	-42.57	4 300.69
Dec-22	33.60	32.37	34.83	23.33	21.08	25.58	58.60	109.73	6 263.81
Jan-23	33.93	32.70	35.16	23.50	21.23	25.77	57.22	-	9 304.02
Feb-23	34.38	33.14	35.61	23.59	21.31	25.87	72.12	189.58	9 318.91
Mar-23	33.99	32.76	35.23	23.64	21.35	25.92	49.83	174.68	4 296.62
Apr-23	33.56	32.33	34.79	23.56	21.27	25.85	141.37	-	1 388.16
May-23	32.32	31.08	33.55	23.55	21.26	25.84	164.57	105.43	4 411.36
Jun-23	30.36	29.12	31.59	23.44	21.15	25.73	382.92	-82.23	5 629.72
Jul-23	29.14	27.91	30.38	23.41	21.12	25.70	166.62	136.12	6 413.4

								-	
Aug-23	29.05	27.81	30.28	23.39	21.10	25.69	51.30	195.50	1 298.09
Sep-23	29.69	28.45	30.92	23.43	21.14	25.73	224.39	-22.41	0 471.18
Oct-23	30.96	29.73	32.20	23.44	21.14	25.73	202.19	-44.61	2 448.99
								-	
Nov-23	32.66	31.43	33.89	23.43	21.13	25.73	91.67	155.13	6 338.46
								-	
Dec-23	33.59	32.35	34.82	23.39	21.09	25.69	59.58	187.21	8 306.38
								-	
Jan-24	33.94	32.69	35.18	23.46	21.15	25.76	50.46	222.09	4 323.01
								-	
Feb-24	34.39	33.15	35.63	23.50	21.19	25.80	62.99	209.56	2 335.54
								-	
Mar-24	33.99	32.75	35.24	23.51	21.20	25.82	50.40	222.15	6 322.95
								-	
Apr-24	33.56	32.31	34.80	23.48	21.17	25.79	140.01	132.54	2 412.56
								-	
May-24	32.32	31.07	33.56	23.48	21.16	25.79	156.03	116.52	7 428.58
Jun-24	30.36	29.11	31.60	23.43	21.12	25.75	387.52	114.96	2 660.07
								-	
Jul-24	29.14	27.90	30.39	23.42	21.11	25.74	168.23	104.33	1 440.78
								-	
Aug-24	29.05	27.81	30.30	23.42	21.10	25.73	50.74	221.82	7 323.29
Sep-24	29.68	28.44	30.93	23.43	21.11	25.75	222.66	-49.90	6 495.21
Oct-24	30.96	29.72	32.21	23.43	21.11	25.75	182.83	-89.73	0 455.38
								-	
Nov-24	32.66	31.42	33.91	23.43	21.11	25.75	93.53	179.02	2 366.08
								-	
Dec-24	33.59	32.34	34.83	23.41	21.09	25.74	59.10	213.45	4 331.65
								-	
Jan-25	33.93	32.68	35.19	23.44	21.12	25.77	53.77	246.56	5 354.10
								-	
Feb-25	34.39	33.13	35.64	23.46	21.13	25.78	67.46	232.88	0 367.79
								-	
Mar-25	33.99	32.74	35.25	23.46	21.14	25.79	50.12	250.21	0 350.45
								-	
Apr-25	33.56	32.30	34.81	23.45	21.12	25.78	140.67	159.66	0 441.01
								-	
May-25	32.32	31.06	33.57	23.45	21.12	25.78	160.21	140.12	9 460.55
Jun-25	30.36	29.10	31.61	23.43	21.10	25.76	385.27	84.93	4 685.60
								-	
Jul-25	29.14	27.88	30.40	23.43	21.10	25.76	167.44	132.90	3 467.77
								-	
Aug-25	29.05	27.79	30.31	23.43	21.09	25.76	51.01	249.32	8 351.34
Sep-25	29.68	28.43	30.94	23.43	21.10	25.76	223.50	-76.83	0 523.84
								-	
Oct-25	30.96	29.70	32.22	23.43	21.10	25.77	192.31	108.03	0 492.64
								-	
Nov-25	32.66	31.40	33.92	23.43	21.10	25.77	92.62	207.72	6 392.95
Dec-25	33.59	32.33	34.85	23.42	21.09	25.76	59.34	-	6 359.67

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Appendix VII

Forecast Value for Climatic Parameters in Ibadan

Date	Maximum Temperature			Minimum Temperature			Rainfall		
	Forecast	Lo 95	Hi 95	Forecast	Lo 95	Hi 95	Forecast	Lo 95	Hi 95
Jan-21	34.52	33.29	35.76	22.51	21.25	23.77	3.83	-139.66	147.32
Feb-21	35.66	34.31	37.01	24.41	23.09	25.72	9.47	-134.06	152.99
Mar-21	35.05	33.68	36.42	24.17	22.83	25.50	185.48	41.96	329.00
Apr-21	33.70	32.32	35.08	24.05	22.70	25.41	134.57	-8.95	278.09
May-21	32.34	30.95	33.72	23.59	22.23	24.95	260.36	116.84	403.89
Jun-21	30.62	29.23	32.00	23.06	21.70	24.42	357.04	213.52	500.56
Jul-21	29.04	27.66	30.43	22.46	21.10	23.83	246.26	102.73	389.78
Aug-21	28.61	27.22	30.00	21.89	20.53	23.26	89.58	-53.94	233.11
Sep-21	29.59	28.20	30.98	22.37	21.01	23.74	398.75	255.22	542.27
Oct-21	31.03	29.64	32.41	22.70	21.34	24.07	275.49	131.97	419.02
Nov-21	33.21	31.82	34.59	24.00	22.63	25.37	34.88	-108.64	178.41
Dec-21	34.15	32.76	35.53	24.36	22.99	25.73	31.61	-111.91	175.13
Jan-22	34.56	33.17	35.94	23.10	21.63	24.57	5.17	-162.10	172.44
Feb-22	35.75	34.36	37.14	24.52	23.04	26.00	9.50	-157.77	176.78
Mar-22	34.94	33.55	36.33	24.19	22.71	25.68	213.56	46.28	380.84
Apr-22	33.64	32.25	35.03	24.26	22.77	25.74	141.43	-25.85	308.71
May-22	32.31	30.92	33.70	23.76	22.28	25.25	255.71	88.43	422.99
Jun-22	30.62	29.23	32.01	23.15	21.66	24.63	392.80	225.52	560.08
Jul-22	29.04	27.65	30.43	22.62	21.13	24.10	252.44	85.16	419.72
Aug-22	28.59	27.20	29.99	22.10	20.61	23.59	62.69	-104.59	229.97
Sep-22	29.61	28.22	31.00	22.42	20.93	23.91	421.06	253.79	588.34
Oct-22	31.15	29.76	32.54	22.52	21.03	24.01	277.33	110.05	444.60
Nov-22	33.27	31.88	34.66	23.88	22.39	25.37	30.50	-136.78	197.78
Dec-22	34.11	32.72	35.50	23.87	22.38	25.36	41.06	-126.22	208.34
Jan-23	34.57	33.16	35.98	22.65	21.11	24.20	7.50	-192.16	207.17
Feb-23	35.67	34.26	37.08	24.36	22.81	25.91	12.36	-187.32	212.04
Mar-23	35.05	33.64	36.46	24.27	22.72	25.82	205.17	5.49	404.85
Apr-23	33.72	32.31	35.13	24.11	22.55	25.66	141.55	-58.13	341.23
May-23	32.36	30.95	33.77	23.83	22.28	25.38	260.45	60.77	460.13
Jun-23	30.65	29.24	32.06	23.23	21.68	24.79	381.32	181.64	581.00
Jul-23	29.08	27.67	30.49	22.49	20.94	24.05	252.83	53.15	452.51
Aug-23	28.64	27.23	30.05	21.89	20.33	23.44	76.35	-123.32	276.03
Sep-23	29.63	28.22	31.04	22.31	20.75	23.86	414.98	215.30	614.66
Oct-23	31.08	29.67	32.49	22.66	21.10	24.21	279.46	79.78	479.14
Nov-23	33.25	31.84	34.66	24.15	22.60	25.71	35.13	-164.55	234.81
Dec-23	34.18	32.77	35.59	23.99	22.43	25.55	40.14	-159.54	239.82
Jan-24	34.59	33.18	36.01	22.69	20.94	24.44	9.44	-213.77	232.64
Feb-24	35.77	34.35	37.19	24.44	22.67	26.20	14.09	-209.13	237.30
Mar-24	34.99	33.58	36.41	24.25	22.47	26.02	211.41	-11.81	434.62
Apr-24	33.68	32.27	35.10	24.14	22.36	25.91	144.38	-78.84	367.59
May-24	32.35	30.94	33.77	23.75	21.97	25.53	261.42	38.21	484.63
Jun-24	30.66	29.24	32.08	23.18	21.40	24.96	388.80	165.59	612.02
Jul-24	29.08	27.67	30.50	22.53	20.75	24.31	255.55	32.33	478.76
Aug-24	28.64	27.22	30.05	21.96	20.17	23.74	73.74	-149.47	296.96
Sep-24	29.65	28.23	31.06	22.39	20.61	24.17	420.30	197.08	643.51
Oct-24	31.17	29.76	32.59	22.69	20.91	24.47	281.48	58.26	504.69
Nov-24	33.30	31.88	34.72	24.08	22.30	25.86	36.15	-187.07	259.36
Dec-24	34.16	32.74	35.57	24.17	22.38	25.95	43.38	-179.83	266.60
Jan-25	34.61	33.18	36.04	22.89	21.01	24.78	11.54	-234.49	257.56
Feb-25	35.72	34.29	37.15	24.49	22.60	26.39	16.27	-229.77	262.31
Mar-25	35.08	33.64	36.51	24.26	22.36	26.16	211.78	-34.26	457.82
Apr-25	33.75	32.31	35.18	24.22	22.31	26.12	146.11	-99.92	392.15

May-25	32.40	30.96	33.83	23.80	21.90	25.71	263.90	17.87	509.94
Jun-25	30.69	29.25	32.12	23.21	21.30	25.11	388.67	142.64	634.71
Jul-25	29.11	27.68	30.55	22.60	20.69	24.50	257.33	11.29	503.37
Aug-25	28.68	27.24	30.11	22.04	20.13	23.95	77.66	-168.37	323.70
Sep-25	29.66	28.23	31.10	22.42	20.52	24.33	421.04	175.00	667.07
Oct-25	31.13	29.70	32.56	22.65	20.74	24.55	283.54	37.51	529.58
Nov-25	33.30	31.86	34.73	24.04	22.13	25.94	38.61	-207.43	284.65
Dec-25	34.21	32.78	35.64	24.04	22.14	25.95	44.96	-201.08	290.99

Source: Processed Meteorological Data

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Appendix VIII Forest Value for Climatic Parameters in Ogbomosho

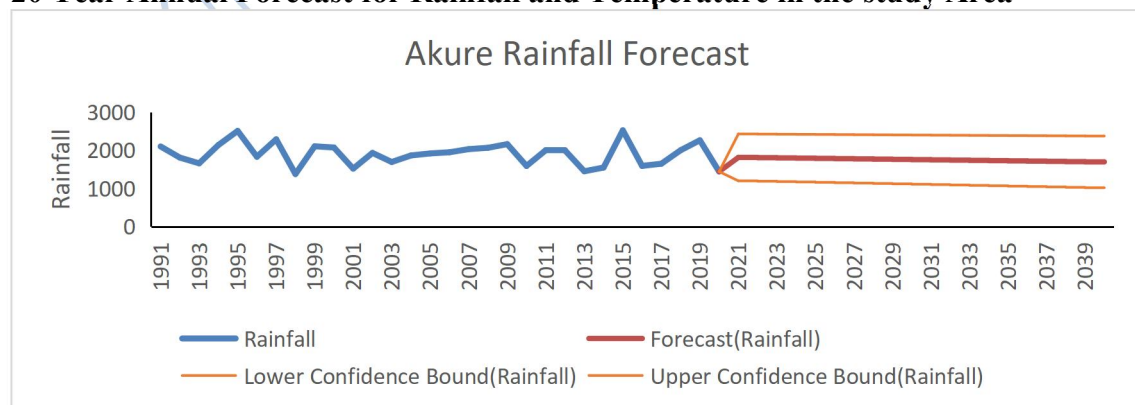
	Maximum Temperature			Minimum Temperature			Rainfall		
Date	Forecast	Lo 95	Hi 95	Forecast	Lo 95	Hi 95	Forecast	Lo 95	Hi 95
Jan-21	34.92	33.05	36.80	20.56	18.15	22.97	25.35	-116.82	167.53
Feb-21	36.42	34.35	38.49	21.99	19.54	24.44	35.50	-107.37	178.36
Mar-21	36.01	33.90	38.12	23.97	21.52	26.41	69.84	-73.52	213.19
Apr-21	34.50	32.39	36.62	23.71	21.27	26.16	134.46	-9.25	278.16
May-21	32.60	30.48	34.72	22.86	20.42	25.31	281.54	137.58	425.50
Jun-21	30.15	28.03	32.27	22.21	19.76	24.65	263.01	118.87	407.15
Jul-21	28.80	26.68	30.92	21.47	19.03	23.92	219.27	75.00	363.54
Aug-21	28.38	26.26	30.51	21.07	18.62	23.51	209.62	65.25	353.98
Sep-21	29.10	26.98	31.22	21.36	18.92	23.81	426.13	281.70	570.56
Oct-21	30.43	28.31	32.55	21.46	19.02	23.91	266.49	122.01	410.97
Nov-21	33.83	31.71	35.95	22.02	19.58	24.47	37.43	-107.08	181.94
Dec-21	34.79	32.67	36.91	20.93	18.49	23.38	19.73	-124.81	164.26
Jan-22	34.40	32.02	36.79	19.38	16.63	22.13	23.90	-122.91	170.72
Feb-22	36.36	33.93	38.80	21.32	18.57	24.08	34.64	-112.24	181.52
Mar-22	36.25	33.80	38.70	24.18	21.42	26.93	69.48	-77.44	216.41
Apr-22	34.87	32.42	37.32	23.85	21.09	26.61	134.53	-12.43	281.48
May-22	32.93	30.48	35.38	22.98	20.22	25.73	281.97	134.99	428.95
Jun-22	30.50	28.05	32.95	22.30	19.54	25.06	263.75	116.75	410.74
Jul-22	28.96	26.51	31.41	21.73	18.97	24.48	220.26	73.26	367.27
Aug-22	28.51	26.06	30.96	21.28	18.52	24.03	210.83	63.82	357.85
Sep-22	29.26	26.81	31.71	21.53	18.77	24.28	427.53	280.51	574.55
Oct-22	30.87	28.42	33.32	21.58	18.82	24.33	268.05	121.02	415.07
Nov-22	34.27	31.82	36.72	21.72	18.97	24.48	39.12	-107.90	186.15
Dec-22	35.04	32.58	37.49	21.30	18.54	24.06	21.53	-125.50	168.56
Jan-23	34.66	31.82	37.49	19.95	16.65	23.24	25.81	-123.20	174.81
Feb-23	36.42	33.51	39.33	21.64	18.33	24.95	36.63	-112.41	185.66
Mar-23	36.19	33.26	39.11	24.08	20.76	27.39	71.53	-77.52	220.59
Apr-23	34.75	31.82	37.68	23.78	20.47	27.10	136.64	-12.43	285.71
May-23	32.83	29.90	35.76	22.92	19.61	26.23	284.13	135.05	433.21
Jun-23	30.38	27.45	33.32	22.26	18.94	25.57	265.95	116.86	415.04
Jul-23	28.93	26.00	31.86	21.60	18.29	24.92	222.50	73.41	371.59
Aug-23	28.49	25.56	31.42	21.18	17.86	24.49	213.10	64.00	362.20
Sep-23	29.23	26.30	32.16	21.45	18.14	24.76	429.82	280.72	578.92
Oct-23	30.72	27.79	33.65	21.52	18.21	24.83	270.36	121.26	419.46
Nov-23	34.12	31.19	37.05	21.87	18.56	25.18	41.45	-107.65	190.56
Dec-23	34.97	32.04	37.90	21.12	17.81	24.44	23.88	-125.23	172.98
Jan-24	34.58	31.39	37.78	19.68	16.02	23.33	28.17	-122.86	179.19
Feb-24	36.43	33.18	39.69	21.49	17.83	25.15	39.00	-112.05	190.04
Mar-24	36.25	32.98	39.51	24.12	20.46	27.79	73.92	-77.15	224.98

24									
Apr-24	34.84	31.57	38.10	23.82	20.15	27.48	139.03	-12.05	290.10
May-24	32.90	29.63	36.17	22.95	19.28	26.61	286.53	135.44	437.61
Jun-24	30.47	27.20	33.73	22.28	18.61	25.94	268.35	117.25	419.44
Jul-24	28.98	25.71	32.25	21.66	18.00	25.33	224.91	73.81	376.00
Aug-24	28.53	25.26	31.80	21.22	17.56	24.89	215.51	64.41	366.61
Sep-24	29.27	26.01	32.54	21.49	17.82	25.15	432.23	281.13	583.34
Oct-24	30.82	27.55	34.08	21.55	17.88	25.21	272.78	121.67	423.88
Nov-24	34.22	30.95	37.48	21.80	18.14	25.46	43.87	-107.23	194.98
Dec-24	35.03	31.76	38.30	21.21	17.55	24.87	26.30	-124.81	177.41
Jan-25	34.65	31.12	38.18	19.81	15.78	23.83	30.59	-122.41	183.58
Feb-25	36.46	32.87	40.05	21.56	17.53	25.60	41.42	-111.60	194.44
Mar-25	36.25	32.66	39.85	24.10	20.06	28.14	76.34	-76.69	229.37
Apr-25	34.83	31.23	38.44	23.80	19.76	27.84	141.45	-11.59	294.50
May-25	32.90	29.30	36.51	22.93	18.90	26.97	288.95	135.90	442.01
Jun-25	30.47	26.86	34.07	22.27	18.23	26.30	270.78	117.71	423.84
Jul-25	28.99	25.39	32.59	21.63	17.60	25.67	227.33	74.27	380.40
Aug-25	28.55	24.95	32.15	21.20	17.16	25.24	217.94	64.87	371.01
Sep-25	29.29	25.69	32.89	21.47	17.43	25.50	434.66	281.59	587.74
Oct-25	30.81	27.21	34.41	21.53	17.50	25.57	275.21	122.13	428.28
Nov-25	34.21	30.61	37.81	21.83	17.80	25.87	46.30	-106.77	199.38
Dec-25	35.04	31.44	38.64	21.17	17.13	25.20	28.73	-124.35	181.80

Source: Processed Meteorological Data

Appendix IX

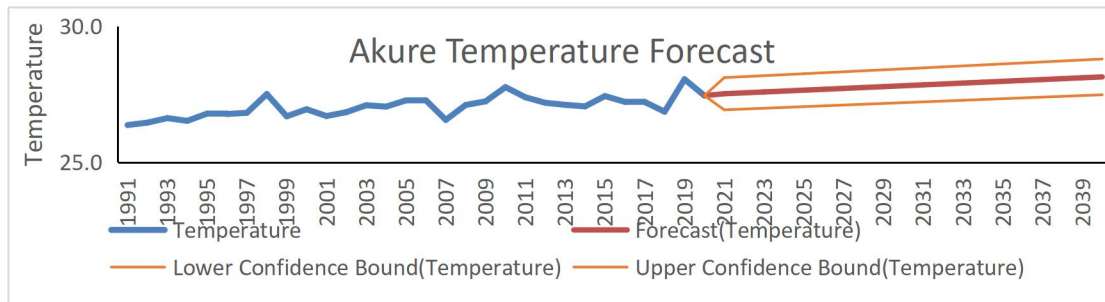
20 Year Annual Forecast for Rainfall and Temperature in the study Area



20 years forecast plot for Annual Rainfall in Akure

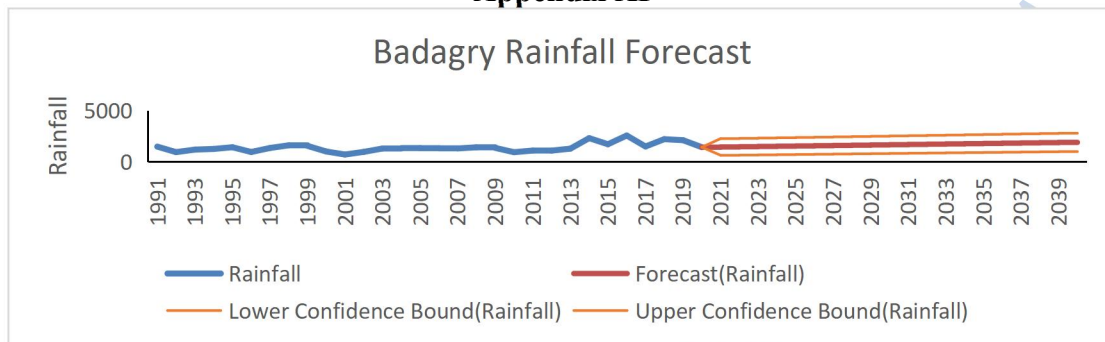
Source: Author's Analysis, 2022

Appendix X



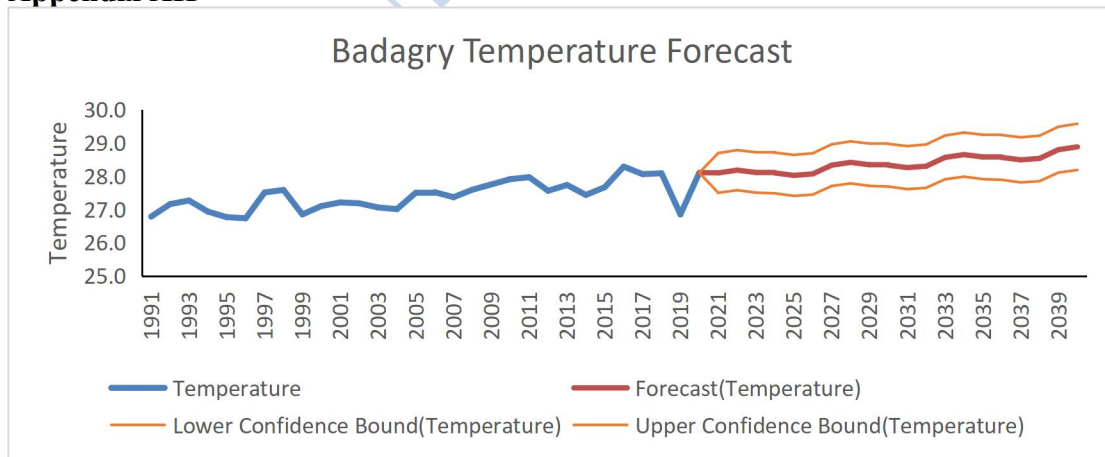
20 years forecast plot for Average temperature in Akure
Source: Author's Analysis, 2022

Appendix XI



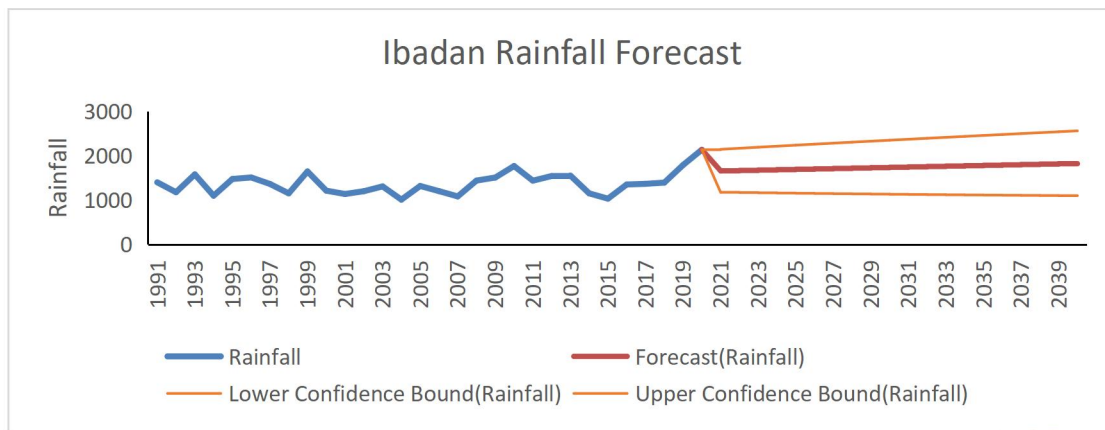
20 years forecast plot for Annual Rainfall in Badagry
Source: Author's Analysis, 2022

Appendix XII



20 years forecast plot for Average Temperature(°C) in Badagry
Source: Author's Analysis, 2022

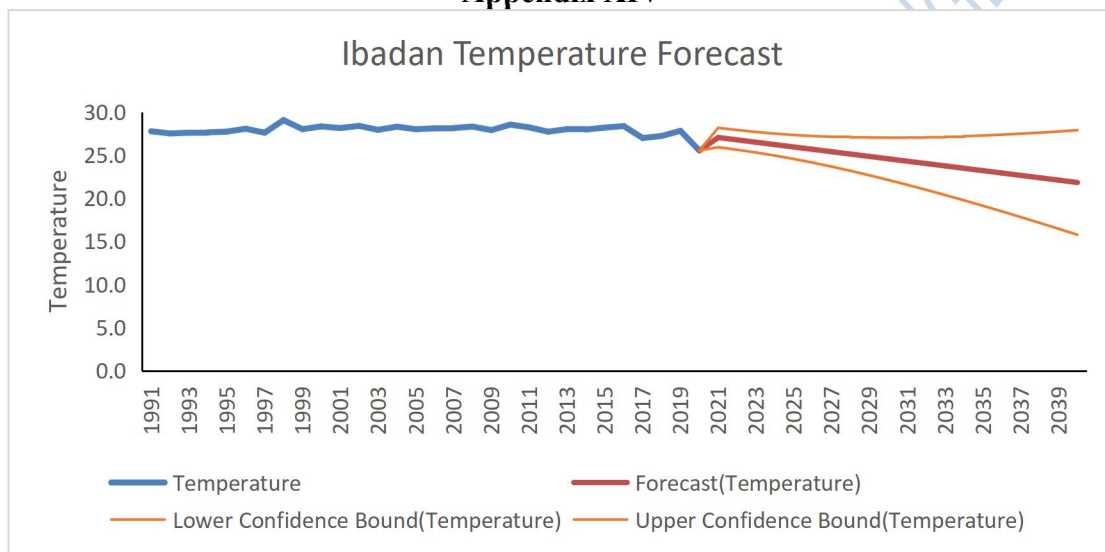
Appendix XIII



20 years forecast plot for Annual Rainfall in Ibadan

Source: Author's Analysis, 2022

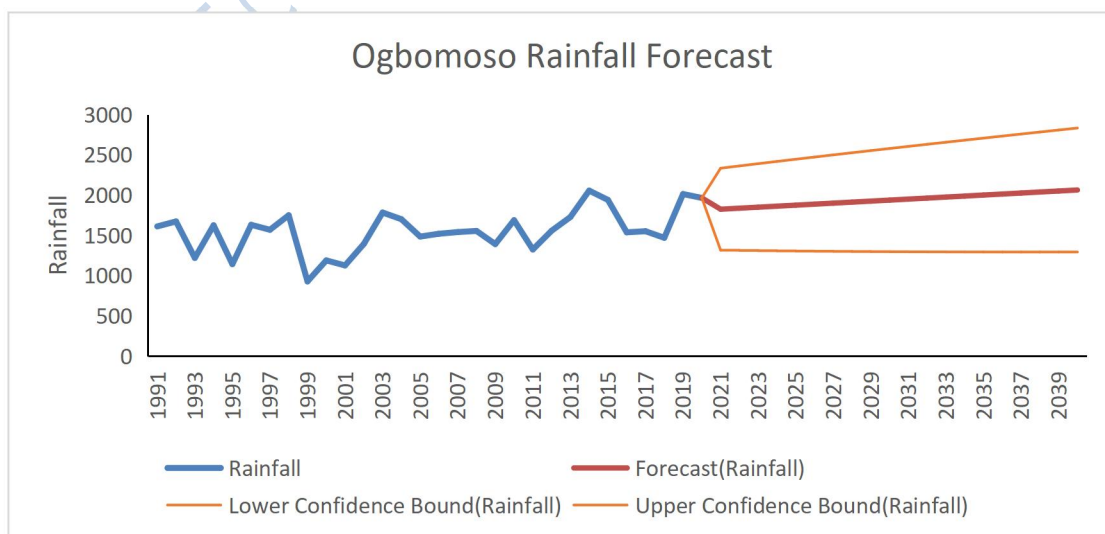
Appendix XIV



20 years forecast plot for Annual Average Temperature in Ibadan for 2021-2040

Source: Author's Analysis, 2022

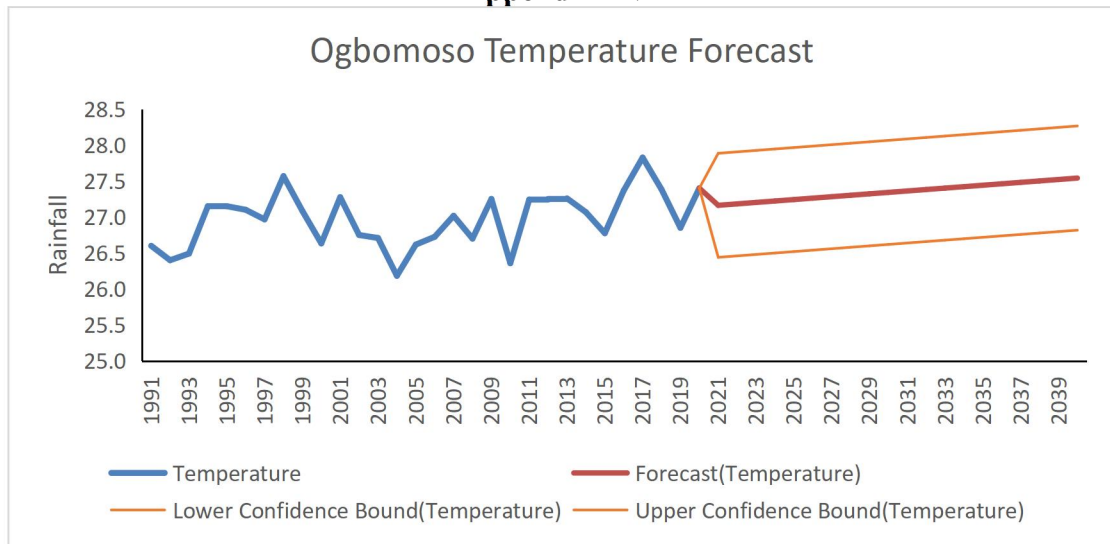
Appendix XV



20 years forecast plot for Annual Rainfall for Ogbomosho

Source: Author's Analysis, 2022

Appendix XVI



20 years forecast plot for Annual Average Temperature in Ogbomosho
Source: Author's Analysis, 2022

Bio Data

Name: Ayeni, Olatunji David

E-mail: ayeniolatunji62@yahoo.com

Mobile Number: 08036673441

Contact Address: No. 17, Favour Avenue, Ajinde 2 Estate Odoona Elewe Orita

Challenge, Ibadan

Personal Data

Date of Birth: 18th May, 1961

Nationality: Nigerian

State of Origin/Local Government Area: Osun/Oriade

Home Town: Ijebu-ijesa

Sex: Male

Marital Status: Married

Place of Work: Forestry Research Institute of Nigeria, Ibadan.

Educational Institution and Qualification Obtained

Lead City University, Ibadan	PhD	In-view	2018
Delta State University, Abraka	M.B.A.	Business Administration	2000
University of Ibadan	M.Sc	Geography	2010
University of Ibadan	BSc	Geography	1986
Ijaye High School, Ijaye Orile Ibadan	WASC	-	1979

Work Experiences

Forestry Research Institute of Nigeria

2017 till date

Head of Section

Responsibilities

Forecasting of weather and climate for climate change amelioration.

1. Computation of equilibrium moisture content for wood seasoning
2. Overall supervision of sectional staff.
3. Observation and measuring of daily weather data.
4. Monitoring and regulation of climate/weather instrument at the station.
5. Compilation and computation of daily weather data for FRIN HQ and outside station in the country.
6. Analysis and interpretation of daily climatic/weather data.
7. Use of climate data to predict weather /climate.
8. Releasing of information on weather data to local, state and federal government for sustainable management of the ecosystem, biodiversity, conservation and global warming mitigation.
9. Collaboration and synergizing with other sections/department in the area of research activities.
10. Liaising with stakeholders in the area of issuing advice to encourage improvement in Research/ Business activities and also to forestall likely environmental danger. Such stakeholders are: farmers, boosting their harvest; foresters in the area of fire danger warning; wood work in the area of equilibrium moisture content for lasting wood work; road construction works; Releasing information to Nigeria Port Authority (NPA); and other parastatals.
11. Training of Industrial Training Students from various institutions in the country.

12. Create public awareness and provide environmental education on prevailing weather situation through bulletin and any other contact that may be necessary to reach the public.
13. Writing of climatic/weather report for FRIN consumption as at when due.
14. Organizing seminar on weather activities within FRIN to sensitize them on prevailing weather situation.
15. Employing mathematical formulae to get fire danger index for researchers, farmers and communities in the environment
16. Reading and analyzing the sensitized card to get the sunrise, sunset and duration of sunshine.
17. Employing of Mathematical formulae to work out Relative Humidity, Dew point and Vapour pressure.

Federal College of Forestry, Ibadan

2007-2017

Lecturer

Responsibilities

1. Lecturing Ordinary National Diploma and Higher National Diploma Students
2. Supervision of Students Projects
3. Engaging Students on Field Trip.
4. Head of Meteorological Station
5. Observing/measuring/maintenance of meteorological instrument

Commercial Officer

Responsibilities

Head of Commercial

1. Supervision of Staff in organizing and distribution of water bills
2. Attending to problem of water connection
3. Synergizing with works manager to solve customers' water connection problems
4. Prepare weekly, monthly, and quarterly report to the headquarters.

Signature

Date

University Compliance Certificate

This is to certify that this thesis by Olatunji David AYENI with Matric Number LCU/PG/000256 in the Department of Environmental Management, Faculty of Environmental Design and Management, Lead City University, Ibadan, Oyo State is in full compliance with the approved University's format and style.

.....

Signature

.....

Date

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