

**INVESTIGATION OF THE IMPACTS OF CLIMATE CHANGE ON WATER  
RESOURCES: GLOBAL AND NIGERIAN ANALYSIS USING ARCGIS (ARCMAP)  
TO ANALYSE FOR EGOR LOCAL GOVERNMENT AREA IN NIGERIA**

**BY**

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## CERTIFICATION

This is to certify that this work was carried out by INEGBESE, VICTOR  
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**PLAGIARISM**

This work on the **INVESTIGATION OF THE IMPACTS OF CLIMATE CHANGE ON WATER-RESOURCES: GLOBAL AND NIGERIAN ANALYSIS USING ARCGIS (ARCMAP) TO ANALYSE FOR EGOR LOCAL GOVERNMENT AREA IN NIGERIA**

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## **DEDICATION**

I want to dedicate this work first to God Almighty who ensured that my path to achieving my academic dream was a very good success and has been my source and sustainer throughout these past five (5) years at the university of Benin. I also want to dedicate this work to the esteemed Lecturers and the Professors who have taken out time to impart immensely into my knowledge bank the fundamental principles of engineering that has allowed me soar this height thus far, I would like to also dedicate this work to my late father and loving mother (LATE MR. PAUL INEGBESE AND MRS. BOLA INEGBESE). And lastly, I am dedicating this work to the great university of Benin.

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## ABSTRACT

This paper documents an investigation of the impact of climate change on global and regional water resources in Nigeria using Egor local government area as case study. The aim of this study is to comprehensively examine the impacts of climate change on water demand in Nigeria, and to understand specific challenges that climatic changes cause to our water as well as recommending adaptive strategies for sustainable water resource management.

Primary climatic data (Rainfall and Temperature) for Nigeria were collected from the Nigeria Meteorological Station, Lagos between 1960 and 2002. Changes in Lake Chad waters were collected from the National Centre for Remote Sensing (NCRS), Jos. World temperature and water resources data were collected from different sources. The data were analysed using percentages and time series among others.

The result shows that the atmospheric concentration of most greenhouse gases (GHGs) is increasing and this has resulted to changing global climate with increasing temperature. The rise in global average temperatures since 1860 now exceeds 0.6°C. The effect of the Green House Gas concentration on global warming as at 2100 is estimated by three scenarios to be 1.5°C (Low), 2.5°C (Middle) and 4.5°C (High). In Nigeria, while rainfall has decreased by 92 mm, temperature increased by 0.8°C since 1960. This has led to increasing evapotranspiration and water stress resulting in the drying up of rivers and lakes. For example, Lake Chad has reduced in size from 22902 km<sup>2</sup> in 1963 to 16884 km<sup>2</sup> in 1972 and 304 km<sup>2</sup> in 2000. While climate change will make some countries to experience increase in water resources, majority will face serious water stress. Based on projection, by the 2080s, most countries in the Middle East, around the Mediterranean, part of Europe, North and South Africa will face acute water stress while Southern and Eastern Asia, U.S.A. and Alaska will experience reduction in water stress. Some recommendations were made to reverse this ugly situation.

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## CHAPTER ONE

### INTRODUCTION

#### 1.1 Background of Study

Climate change is already affecting water access for people around the world, causing more severe droughts and floods. Increasing global temperatures are one of the main contributors to this problem. The impacts of climate change (CC) have been experienced globally, especially in the tropics (Idowu et al., 2011; Williams et al., 2018). These have triggered a wide variety of physical and biological changes across the world with negative effects on agriculture, humans, and the environment (IPCC, 2014). It is important to note that while the vulnerability to CC impacts is higher in lower-middle- and low-income countries, particularly Africa, the readiness to improve resilience ranks very low in such countries (ND-GAIN, 2021). A recent report, for example, shows that Nigeria is one of the top **ten** of the most exposed countries to the effects of CC, with about 6% of its land area estimated to be exposed to extreme weather events (World Bank, 2019). A significant increase in rural-urban migration (Cattaneo and Massetti, 2019) and reduced streamflow (Akinwunmi et al., 2020), among other impacts of CC in Nigeria, have also been documented.

Climate change impacts the water cycle by influencing when, where, and how much precipitation falls. It also leads to more severe weather events over time. Increasing global temperatures cause water to evaporate in larger amounts, which will lead to higher levels of atmospheric water vapor and more frequent, heavy, and intense rains in the coming years.

Climate scientists predict that this shift will lead to more floods since more water will fall than vegetation and soil can absorb. The remaining water, or runoff, drains into nearby waterways, picking up contaminants like fertilizer on the way. Excess runoff eventually travels to larger

bodies of water like lakes, estuaries, and the ocean, polluting the water supply and limiting water access for humans and ecosystems.

When fertilizers from farming wash into lakes and the ocean, they promote the rapid growth of algae. These resulting algal blooms clog coasts and waterways with clouds of green, blue-green, red, or brown algae. The blooms block sunlight from reaching underwater life and diminish oxygen levels within the water. Toxins from the blooms can kill off fish and other aquatic animals, make people sick, and even kill humans. These toxins are especially dangerous because they can survive purification processes, making tap water unfit to consume once contaminated. Algal blooms also impact industries that rely on the water for business and often cause local waterfronts to shut down during blooms. As the climate warms, harmful algal blooms happen more often and become more severe.

As the ocean warms, freshwater glaciers around Earth begin to melt at an unsustainable rate, which results in rising sea levels. The freshwater from the melted glaciers eventually runs into the ocean. With the rise of sea levels, salt water can more easily contaminate underground freshwater-bearing rocks, called aquifers. A process called desalination removes salt from salt water, but it is a last-resort, energy-intensive, costly process for places where there are persistent droughts and freshwater is lacking. The Middle East, North Africa, and the Caribbean use desalination to produce freshwater out of necessity.

In the Northern Hemisphere where snow, a freshwater source, typically accumulates—warmer temperatures mean less snowfall, which leaves less water available in local reservoirs after winter. This negatively impacts farmers, who are left without enough water to irrigate their crops in the growing season.

There are many things that everyone can do to lessen the impact of climate change. Some measures include growing your own fruits and vegetables or buying locally grown produce,

since produce is often transported to grocery stores from far away by trucks, which add more carbon dioxide to the atmosphere. You could also walk or ride a bike instead of driving a car. On a larger scale, industries that are dependent on fossil fuels need to make the switch to renewable, cleaner energy sources to influence our planet for the better (National Geographic Society, 2023).

Climate change is a long-term shift, alternation or change in the type of climate prevailing over specific location, a region or the entire planet (Ayoade, 2004). Climate change could also be seen as a change in the variability of climate even if average weather conditions remain unchanged (Hengeveld et al., 2002). Variability is an inherent attribute of climate and climate (global or local) has never been static. What is crucial is the degree of variability that the change is subjected to as well as the duration and impact of such variability on man and the ecosystem.

A critical look into the palaeoclimatology of the world indicates clearly that the global climate has never been static, rather, it has gone through various changes (warming and cooling) in the geologic past. This has brought about many controversies concerning the current global warming. While some see it as a pointer of an impending danger when reflecting on the implications of similar condition between 5000 BC and 3000 BC (Odjugo, 2000c; Ayoade, 2003; NEST, 2003 and Pobeni, 2004), others view it as a normal climatic variation and nothing to make noise about or draw conclusion from (Clerk, 2002 and Mshelia, 2004).

Climate change has exacerbated these challenges, with more frequent and extreme flooding polluting fragile water sources and more prolonged droughts drying up springs. The changing climate has also impacted bodies of water such as rivers and lakes, as well as aquifers and other groundwater reserves.

This is how climate change affects the water resources in Nigeria.

In Nigeria, while rainfall has decreased by 92 mm, temperature increased by 0.8 degree Celsius since 1960. This has led to increasing evapotranspiration and water stress resulting in the drying up of rivers and lakes. For example, Lake Chad has reduced in size from 22902 km<sup>2</sup> in 1963 to 16884 km<sup>2</sup> in 1972 and 304 km<sup>2</sup> in 2000.

One of the reasons why understanding how climate change influences water demand is that it helps in effective resource planning. This involves developing strategies to manage water resources, ensuring a sustainable and resilient water supply for communities, agriculture, and industries.

Some of the problems of climate change in Nigeria is also reflected in drought, desertification, rising sea levels, erosion, floods, thunderstorms, bush fires, landslides, land degradation, more frequent, extreme weather conditions and loss of biodiversity. All of which continues to negatively affect human and animal life and also the ecosystems in Nigeria. Although, depending on the location, regions experience climate change with significant higher temperatures during the dry seasons while rainfalls during rainy seasons help keep the temperature at milder levels. The effects of climate change prompted the World Meteorological Organization, in its 40th Executive Council 1988, to establish a new international scientific assessment panel to be called the International Panel on Climate Change (IPCC).

Another reason is that climate change can lead to shifts in precipitation patterns, increased temperatures, and more frequent extreme weather events. Investigating these changes helps in assessing the risks associated with water scarcity, droughts, floods, and other climate-related impacts on water availability.

The problems and reasons listed above is what this research paper addresses.

## **1.2 STATEMENT OF THE PROBLEM**

Climate change is recognized as a global phenomenon with far-reaching consequences, and Nigeria is not exempt from its impacts. One critical aspect that demands urgent attention is the potential effects of climate change on water demand in Nigeria. As the climate undergoes alterations in temperature, precipitation patterns, and extreme weather events, the nation's water resources face considerable challenges. These changes can significantly disrupt the availability and distribution of water, thereby exerting pressure on existing water supply systems and amplifying the vulnerability of communities, industries, and agriculture to water scarcity.

Nigeria, being a country with diverse climatic regions and a rapidly growing population, is particularly susceptible to the adverse effects of climate change on its water resources. Erratic rainfall patterns, prolonged droughts, and more intense and unpredictable weather events are expected to impact both surface and groundwater availability, potentially leading to a misalignment between water supply and the escalating demand. This situation poses a threat to various sectors, including agriculture, energy, and public health, and may exacerbate existing water-related challenges such as inadequate sanitation and hygiene. Furthermore, the urbanization trend and population growth in Nigeria intensify the pressure on water resources, requiring effective strategies to adapt to and mitigate the impacts of climate change on water demand. Understanding the specific dynamics of how climate change influences water demand in different regions of Nigeria is crucial for formulating targeted and resilient water resource management policies. Without proactive measures, the potential consequences include increased competition for water resources, compromised water quality, and heightened social, economic, and environmental vulnerabilities.

Hence, there is an urgent need for research and action to comprehensively assess the impact of climate change on water demand in Nigeria, identifying specific vulnerabilities, and developing

adaptive strategies that integrate both climate resilience and sustainable water management principles. This research will contribute valuable insights to inform policy decisions, infrastructure development, and community engagement aimed at ensuring the nation's water security in the face of a changing climate.

### **1.3 AIMS AND OBJECTIVES**

The aim of this study is to comprehensively assess the impact of climate change on water demand in Nigeria, with the goal of understanding the specific challenges posed by changing climatic conditions and formulating adaptive strategies for sustainable water resource management.

The various objectives are listed below:

- a) To analyze historical climate data and project future climate scenarios for different regions in Nigeria by Investigating temperature variations, precipitation patterns, and the frequency of extreme weather events over the past decades.
- b) To evaluate the current water demand patterns in urban and rural areas of Nigeria by assessing water consumption trends in different sectors, including agriculture, industry, and domestic use. And identifying existing water stress points and areas susceptible to water scarcity.
- c) Examine sectoral water demand across the various sectors of the country like agriculture, industry etc..
- d) Identify challenges and propose solutions.

### **1.4 SCOPE OF THE RESEARCH STUDY**

The scope of this research work would span across various geographical location in Nigeria but especially Benin city with Egor local government area used as a particular case study.

These regions have been selected based on their vulnerability to climate change and importance in terms of water demand. The parameters to be monitored for the investigation of the impact of climate change in water demand are temperature and Rainfall (Precipitation).

ArcGIS is the selected software program for analyzing the unique parameters that the effect of climate change has made to cause many negative downturns to both environmental and community wellbeing like flooding, drought, and spikes in food prices which ultimately lead to food scarcity and poverty.

### **1.5 JUSTIFICATION OF STUDY**

Nigeria is already experiencing water scarcity challenges, and climate change is expected to exacerbate this issue. Understanding the specific impacts on water demand is crucial for developing effective strategies to address vulnerability and ensure water security.

Nigeria's rapidly growing population and increasing urbanization contribute to rising water demand. Climate change further amplifies this challenge, requiring a comprehensive understanding of how these factors intersect to inform sustainable water resource management. Agriculture, a key sector in Nigeria's economy, heavily depends on water resources. Climate-induced changes in water availability can significantly affect crop production and food security. Investigating these impacts is essential for ensuring agricultural sustainability.

The economy of Nigeria is closely linked to water-dependent sectors such as agriculture, industry, and energy production. Climate change can disrupt these sectors, impacting economic stability. This research provides insights into potential economic implications and adaptive measures.

Changes in water availability and quality have direct implications for public health and the environment. Investigating the potential consequences of climate change on water demand is crucial for safeguarding both human health and ecosystem integrity.

## **CHAPTER TWO**

### **LITERATURE REVIEW**

#### **2.1 Climate Change**

Climate change is a broad term used to refer to changes in the Earth's climates, at local, regional, or global scales, and can also refer to the effects of these changes. In recent decades, the term 'climate change' is most often used to describe changes in the Earth's climate driven primarily by human activity since the pre-Industrial period (c. 1850 onwards), particularly the burning of fossil fuels and removal of forests, resulting in a relatively rapid increase in carbon dioxide concentration in the Earth's atmosphere. (Pachaur et al., 2014)

#### **2.2 Global Warming**

Global warming is a term often used interchangeably with climate change, as it is one of the most important measures of global changes. Global warming refers to the rise in average global temperatures, which is linked to significant impacts on humans, wildlife, and ecosystems around the world. Because there are more factors and impacts than only rising surface temperatures, the term climate change is used to include these additional impacts. There is strong consensus among scientists, representing 97% of actively publishing climate scientists, that human influence has been the dominant cause of observed warming trends since the 20th century. (M. R., Barros et al, 2014).

The concentration of carbon dioxide in the atmosphere has risen from hovering around 280 parts per million (ppm) in pre-Industrial time, to 413 ppm as of early 2020. (Yale Environment 360, 2017).

This concentration of carbon dioxide is unprecedented in recorded history. Scientists have reported that we need to return to a 'safe' concentration of 350 ppm by 2100 in order to stabilize global warming (Hansen et al, 2017).

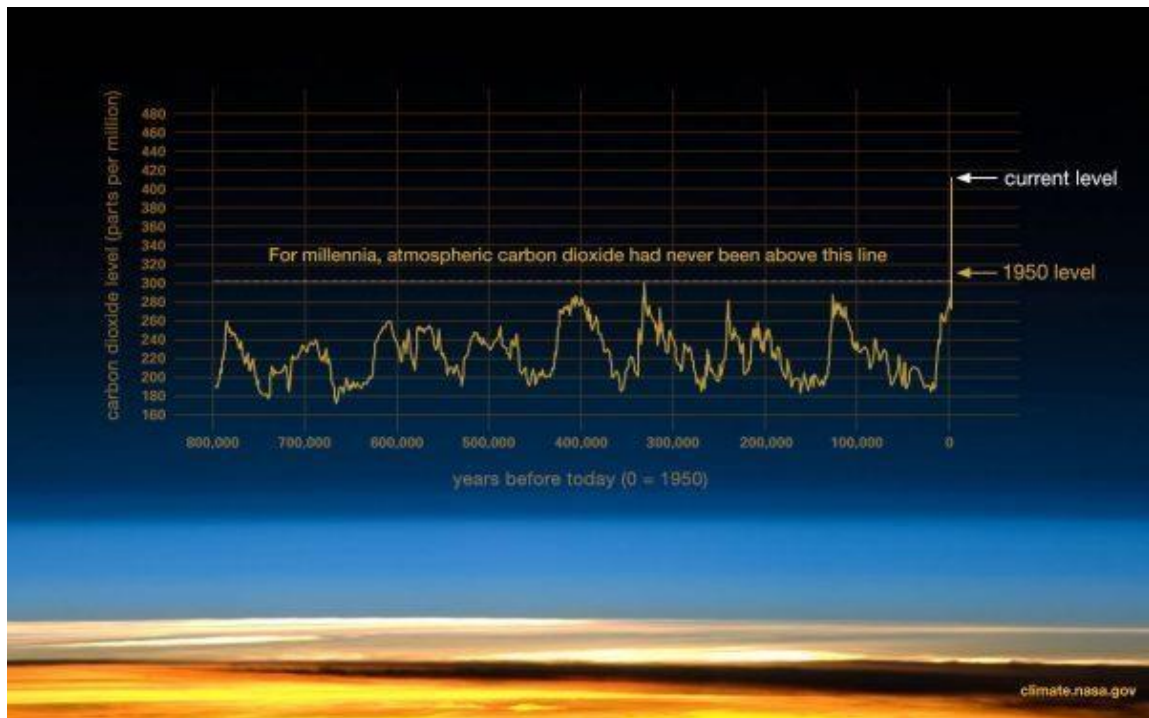


Figure 2.1: Graph of carbon dioxide level in parts per million (climate.nasa.gov, 2014).

The largest anthropogenic (human caused) source of carbon dioxide emissions is the global energy system, which means transforming the global energy system is one of the most significant ways to reduce greenhouse gas emissions and mitigate climate change.

As of 2019, approximately 81% of the world's primary energy supply still comes from fossil fuels, (specifically, coal, oil, and natural gas), which result in carbon emissions both upstream (in the extraction and production of the energy) and downstream (during the final consumer use of the energy). Continued reliance on fossil fuel-based energy sources is a barrier to emissions reductions, particularly as energy demand continues to increase around the world. (International Energy Agency (n.d.). Data and statistics, 2014).

## **2.3 ArcMap**

ArcMap is the former main component of Esri's ArcGIS suite of geospatial processing programs. Used primarily to view, edit, create, and analyse geospatial data. ArcMap allows the user to explore data within a data set, symbolize features accordingly, and create maps. This is done through two distinct sections of the program, the table of contents and the data frame. In October 2020, it was announced that there are no plans to release 10.9 in 2021,[2] and that ArcMap would no longer be supported after March 1, 2026. Esri is encouraging their users to transition to ArcGIS Pro.

### **Functionality**

ArcMap users can create and manipulate data sets to include a variety of information. For example, the maps produced in ArcMap generally include features such as north arrows, scale bars, titles, legends, neat lines, etc. The software package includes a style-set of these features. As well as the ability to upload numerous other reference styles to apply to any mapping function.

The ArcGIS suite is available at four license levels: Basic, Standard, or Advanced (formerly ArcView, Arc Editor, or Arc Info), and Pro. Each step up in the license provides the user with more extensions that allow a variety of querying to be performed on a data set. Pro is the highest level of licensing, and allows the user to use such extensions as 3D Analyst, Spatial Analyst, and the Geostatistical Analyst as well as numerous new functionalities at each new release.

### **Layout**

The layout of ArcMap may seem overwhelming at first glance, but when a second look is taken what is seen is two distinct sections of ArcMap. The data frame where information is spatial and the table of contents where data is aligned in terms of importance symbology is changed.

### **Data frame**

The section of ArcMap where data is spatially applied from the table of contents. The data comes in features, rasters, and layers. While working in the spatial sector of the data, ground units (miles, kilometers, feet, meters, etc...) are used and represented in the coordinate system defined. This is where the views can be changed between Layout and Data View. The data will be ordered according to the order in the Table of Contents.

The user can create multiple data frames within one table of contents. The data frame while in that view will only view a single data frame at a time.

### **Table of Contents**

The table of contents is the way that ArcMap represents what data is available to put into the data frame and how each layer is symbolized. The normal way to organize the layers is from top to bottom. With the base map elements such as a street map or DEM listed at the bottom the thematic map layers can be placed above to convey the message the map is being designed for.

Other forms to view the table of contents include listing layers by source; visibility; and selection. The most basic form is to stay with drawing order as described above. **Views**

Views are put into place to allow a user to choose between either data view or layout view. To choose between these views there are two buttons in the bottom left of the data frame to choose from. Navigating through the menus is another option, View > Layout View or View > Data View.

### **Layout**

The purpose of layout view is for the final design of a map. This is the view where the placement of the essential map elements is inserted, such as the north arrow, scale bar, etc. While in this view the user also has control of the data frame just as they would in the Data View, but is mainly

concerned with the page space and formatting of spacing.[5] If multiple Data Frames are used, they can be combined while in the layout view to fit onto one single page.

### **Data View**

This is the geographic view of the data a user imports. The user can explore, display, and query data and edit files if the correct extensions are owned. The bulk of geographic processing will happen while in this view, such as symbology, import of data, editing, coordinate system definition. Only one Data Frame can be viewed at a time while in this view.

### **File types**

ArcMap is run using primarily Shape Files and in more recent versions Geodatabases can be used to store larger sets of data. These file formats are what are uploaded into the program to view spatial data. Users can also upload database files to link important attribute information to spatial data. Comma separated values (.csv) can be used, as long as they are converted to a database file before uploading into the program.

When a map is saved a new file extension is created (.mxd). This file does not save the layers or spatial data with it, only the relative pathnames. What this means is if the data used in the map is not in the same location as the previous time it was opened there will be an error. This assists with keeping the file small and reduces the amount of redundancy in data management.

### **Printing**

There are three main printing techniques and one multipage technique. The multipage technique can be found in a help page on ESRI's website.

In layout view after completing all desired formatting saving the layout view as a .pdf then printing from there will reduce the amount of possible miscommunication within the computer. Keeping what the user did exactly what they get when they print.

While in data view for the user to zoom to their desired extent then go to File > Print

In layout view after completing all desired formatting moving directly to File > Print will print out the specified layout.

#### **2.4 Climate change in Nigeria and its Effect**

Climate change in Nigeria is evident from temperature increase, rainfall variability (increasing in coastal areas and decline in continental areas). It is also reflected in drought, desertification, rising sea levels, erosion, floods, thunderstorms, bush fires, landslides, land degradation, more frequent, extreme weather conditions and loss of biodiversity. All of which continues to negatively affect human and animal life and also the ecosystems in Nigeria. Although, depending on the location, regions experience climate change with significant higher temperatures during the dry seasons while rainfalls during rainy seasons help keep the temperature at milder levels. The effects of climate change prompted the World Meteorological Organization, in its 40th Executive Council 1988, to establish a new international scientific assessment panel to be called the International Panel on Climate Change (IPCC). The 2007 IPCC's fourth and final Assessment Report (AR4) revealed that there is a considerable threat of climate change that requires urgent global attention. The report further attributed the present global warming to largely anthropogenic practices. The Earth is almost at a point of no return as it faces environmental threats which include atmospheric and marine pollution, global warming, ozone depletion, the dangers of pollution by nuclear and other hazardous substances, and the extinction of various wildlife species.

The escalation of climate variability in Nigeria has led to heightened and irregular rainfall patterns, exacerbating land degradation and resulting in more severe floods and erosion. As one of the top ten most vulnerable countries to the effects of climate change, Nigeria has experienced a worsening of these environmental challenges. By 2009, approximately 6,000 gullies had emerged, causing destruction to infrastructure in both rural and urban areas of the country.



Figure 2.2: Lake Chad (Mark Notaras and Obijiofor Aginam, 2009)



Figure 2.3: The banks of Lake Chad are strewn with garbage. Pollution is one cause of the environmental crisis currently facing Africa's fourth-largest water basin (Willem Van Cotthem, 2015)

There are few comprehensive reports that provide useful evidence of various impacts of climate change experienced in Nigeria today. The vast majority of the literature provides evidence of climate change holistically and this does not help in providing sustainable solutions to the impacts experienced. However, the agricultural sector should be given more focus especially

the existence in diverse regions where large farming is not dominantly practiced. More deliberations should concentrate on other mitigation and adaptation measures in literature which often takes the form of recommendations, rather than examples of what has already been achieved.

This topical discourse is likely due to the need for much greater implementation of mitigation and adaptation measures in ensuring Nigeria produce more food all through the year round to feed the growing population. In addition, while there is some discussion about necessary capacity building at the individual, group and community level to engage in climate change responses, there is also more or less attention given to higher levels of capacity building at the state and national level.

The associated challenges of climate change are not the same across all geographical areas of the country. This is because of the two precipitation regimes: high precipitation in parts of the Southeast and Southwest and low in the Northern Region. These regimes can result in aridity, desertification and drought in the north; erosion and flooding in the south and other regions, neglected climate change actions is the issue of recycling of PET Bottles particularly in the locally. The use of polyethylene terephthalate also known as PET or PETE (a plastic resin materials used for making packaging materials such as bottles and food containers) is increasingly becoming paramount among manufacturers, as they used these PET bottles to package their products because it (PET) is an excellent barrier material with high strength, thermostability and transparency. Nigeria currently has no standard policy to regulate plastic waste; several efforts including legislations and contracts awarded for the installation of plastic waste recycling plants across the country have been marred by corruption and lack of political will by the government.

## 2.5 Greenhouse Gas Emissions

In the year 2018, Nigeria's total greenhouse gas emissions were 336 million metric tons of carbon dioxide equivalent (MtCO<sub>2</sub>e), which is less than 1 percent of global emissions. This means that emissions per person per year is less than 2 tons, compared to the global average of over 6 tons. These greenhouse gases, mainly carbon dioxide and methane are mostly generated from oil and gas production, land-use change, forestry, agriculture and fugitive emissions. The economy is very dependent on oil production, so it may be hard to reach the target of net zero emissions by 2060.

There are factors that promote greenhouse gas emissions. It is recorded that the transportation sector is responsible for 28% of the greenhouse gas emissions in 2021. The main source of these emissions is the combustion of fossil fuels, such as gasoline and diesel, in cars. The production of electricity, which makes up 25% of emissions, also adds to the emissions of greenhouse gases. The industrial sector, responsible for 23% of emissions, mostly employs fossil fuels for chemical reactions and energy production. 13% of emissions, including heat and refrigeration in buildings, come from the commercial and residential sectors. Livestock and agricultural soils are the main sources of agriculture, which contributes 10% of emissions. 12% of emissions are offset by land use and forestry, since managed forests have been a net sink for emissions since 1990.

In order to warm the biosphere to a temperature suitable for human habitation, greenhouse gases (GHGs) absorb and reemit a considerable portion of the  $161 \text{ W m}^{-2}$ , making them indispensable for life on Earth. Global surface temperatures have recently increased due to biosphere warming caused by rising GHG concentrations in the atmosphere. Since 1750, agriculture has produced 10–14% of all anthropogenic greenhouse gas emissions worldwide each year, directly influencing five of the main radiative sources of climate forcing. More greenhouse gases are impacted by agriculture than not.

### **Impacts On the Natural Environment: Temperature and Weather, Current Climate.**

Nigeria has three different climate zones: a Sahelian hot and semi-arid climate in the north, a tropical monsoon climate in the south, and a tropical savannah environment in the centre regions. While the core regions only get one rainy and one dry season, the southern parts see heavy rainfall from March to October. There is a lot of annual variances in the north, which causes droughts and flooding. The mean annual temperature of the country varies greatly between coastal and interior regions; the plateau has a mean temperature between 21°C and 27°C, while the interior lowlands typically see temperatures above 27°C. There is variation in rainfall from April to October, and the average annual temperature is 26.9°C.

Nigeria has a tropical climate with two seasons: (wet and dry). Inland areas especially those in the northeast, experience the greatest fluctuations in temperatures as before the outset of rains, temperatures sometimes rise as high as 44 °C and drops to 6 °C between December and February. In Maiduguri, the maximum temperature may rise to 38 °C in April and May while in the same season frosts might occur at night.

For example, in Lagos, the average high is 31 °C and low is 23 °C in January and 28 °C and 23 °C in June. The southeast regions especially located around the coast like Bonny Island (south of Port Harcourt), east of Calabar receive the highest number of annual rainfalls of around 4,000 millimeters.

### **Changes In Climate**

Climate change in Nigeria is shifting climate regions. The desert region in the North is receding North, steppe region in the North is set to expand southwards, the tropical savanna climate is expanding, and tropical monsoon regions in the South are moving northwards, replacing tropical rainforest.

## **Increase In Temperature**

The effects of the temperature increase are unbearable for residents, particularly those living in communities hosting gas flare plants. The increase in temperature causes bodily rashes, among other things, and hinders the growth of food crops. The availability of nutrients, plant and root growth, and seed germination are all affected by soil temperature. High temperatures hinder a plant's regular growth, photosynthesis, and flowering since they do not improve plant physiology.

Rising sea levels, fluctuating rainfall, higher temperatures, flooding, droughts, desertification, land degradation, and an increase in the frequency of extreme weather events are all contributing factors to Nigeria's changing climate. Forecasts indicate that this will continue to cause significant runoffs and flooding in several locations. Forecasts of the climate indicate that every biological zone will see a notable rise in temperature. Although there is some literature showing the effects of and solutions to climate change, the majority of it concentrates on the farming industry and specific farming locales. Increased focus must be paid to capacity building at the state and federal levels, as well as increased implementation of mitigation and adaptation measures.

The Nigerian Meteorological Service (NiMet) issues a warning about rising temperatures, especially in the north, which can lead to an increase in hospital admissions for elderly patients, neonates, and children due to heatstroke, cardiovascular, respiratory, and cerebrovascular illnesses.

Due to climate change, Northern Nigeria is seeing greater heatwaves and lengthier, more erratic rainfall. New problems such extreme droughts, floods, deforestation, pollution, and food shortages have resulted from this. Daily living has been impacted by climate change, and many individuals have had to modify their behaviour to cope. Due to the heat, some students have

missed classes or experienced health issues. Others have fallen behind in their academics and suffered from migraines. The extra strain might have a disastrous effect on Nigeria's underfunded, overcrowded, and fiercely competitive educational system. According to historical data from 2012 to 2019 used to examine trends in temperature and rainfall in Agbani, Enugu State. The climate from 2020 to 2050 was forecasted via Trend Regression analysis to be wetter and hotter. In 2018 and 2015 there were the most and lowest amounts of rainfall, respectively. The months of January, July, and March had the highest monthly mean rainfall, respectively. Also, between 2020 and 2050, farmers expect a wetter environment.

### **Ecosystems**

An ecosystem is a complex and interconnected community of living organisms, their physical environment, and the interactions between them. It encompasses both biotic (living) and abiotic (non-living) components, functioning as a dynamic system where various species interact with one another and with their surroundings. Ecosystems can vary in scale, from small microhabitats to large biomes such as forests, oceans, and grasslands.

The concept of ecosystems was first introduced by the British ecologist Arthur Tansley in 1935, who defined it as "the whole system. including not only the organism-complex, but also the whole complex of physical factors forming what we call the environment". This definition highlights the importance of considering both living organisms and their environment when studying ecosystems.

Ecosystems are characterized by the flow of energy and the cycling of nutrients. Energy enters an ecosystem through primary producers, such as plants or algae, which capture sunlight and convert it into chemical energy through photosynthesis. This energy is then transferred to higher trophic levels as organisms feed on each other, forming food chains and food webs. Ecosystems are sustained by the cycling of nutrients. Nutrients, such as carbon, nitrogen, and phosphorus, are essential for the growth and survival of organisms. These elements are recycled within the

ecosystem through various processes like decomposition, nutrient uptake by plants, and consumption by animals. This recycling ensures a continuous supply of nutrients for the organisms within the ecosystem.

Ecosystems provide numerous ecological services that are vital for the well-being of both the natural world and human society. For instance, forests act as carbon sinks, absorbing and storing large amounts of carbon dioxide, a greenhouse gas that contributes to climate change.[38] Wetlands play a crucial role in water purification and flood control. Coral reefs provide habitat for numerous marine species and act as natural barriers against storms.

Ecosystems are facing numerous threats due to human activities, such as deforestation, pollution, climate change, and habitat destruction (Millennium Ecosystem Assessment, 2005). These disturbances can disrupt the delicate balance of an ecosystem, leading to species extinction, loss of biodiversity, and the degradation of ecosystem services. Improper disposal of plastics and used nylon bags in a drainage system

To better understand and manage ecosystems, scientists employ various approaches, including ecological modelling, field observations, and experimentation. These tools help researchers study the interactions between organisms, identify key ecological processes, and assess the impacts of human activities on ecosystems. Ecosystem management strategies aim to promote sustainable practices that maintain or restore the integrity and functioning of ecosystems.

Years ago, Nigeria experienced climate change disaster which happened in the Northeastern region which is now Borno and Yobe states the territory along the southern part of Lake Chad dried up. Due to logging and over dependence on firewood for cooking, a greater part of Nigeria's Guinean forest-savanna mosaic region has been stripped of its vegetation cover. Similarly, the forest around Oyo State has been reduced to grassland. The lack of sufficient cover

trees and other vegetation can cause natural change, desertification, and soil breaking down, flooding, and extended ozone exhausting substances in the environment.

## **2.6 Effects of climate change on water demand in Nigeria**

Our climate is changing at an alarming rate and it's making it even harder for the world's poorest people to get clean water. More frequent and extreme flooding is polluting fragile water sources; longer droughts are drying up springs. People need a reliable supply of water that keeps pumping through flood, drought and natural disaster. Because with clean water, they can stay disease free, go to school, earn a living and be better prepared for whatever the future brings.

2020 was the joint hottest year on record and Only 2016 matched its heat. Globally, temperatures are rising, which means the weather is becoming more extreme, resulting in either too much or too little water. In fact, a staggering 90% of all natural disasters are water-related, and they're massively impacting people's lives.

Before the spread of COVID-19, millions of people in Nigeria were already struggling with a public health catastrophe. A shocking 3 in 10 people in Nigeria don't have clean water close to home, putting them under constant threat from waterborne diseases like cholera. The more our climate changes, the more challenging this becomes.

Every day, already fragile water supplies are at even greater risk of disappearing completely. The world has made huge progress in giving everyone, everywhere the clean water that is their right. Yet climate change threatens to set us back decades and push more people into extreme poverty.

Climate change is a long-term shift, alternation or change in the type of climate prevailing over specific location, a region or the entire planet (Ayoade, 2004). Climate change could also be seen as a change in the variability of climate even if average

weather conditions remain unchanged (Hengeveld et al., 2002). Variability is an inherent attribute of climate and climate (global or local) has never been static. What is crucial is the degree of variability that the change is subjected to as well as the duration and impact of such variability on man and the ecosystem.

A critical look into the palaeoclimatology of the world indicates clearly that the global climate has never been static, rather, it has gone through various changes (warming and cooling) in the geologic past. This has brought about many controversies concerning the current global warming. While some see it as a pointer of an impending danger when reflecting on the implications of similar condition between 5000 BC and 3000 BC (Odjugo, et al, 2000). view it as a normal climatic variation and nothing to make noise about or draw conclusion from (Clerk, 2002 and Mshelia, 2004). From whichever angle it is viewed, available evidence from measurements and global climatic models such as General Circulation Models (GCMs), Atmosphere-Ocean General Circulation Models (AOGCMs) and Hadley Centre Climate Models (HadCM) among others show that the world is experiencing warming for the past few decades (Akitikpi, 1999; Environment Canada, 1999; Odjugo, 2000b; Hengeveldk, et al., 2002; Buba, 2004; Nyelong, 2004 and Hengeveld, Whitewood and Fergusson, 2005). The on-going global warming has been observed by many research works to affect and will continue to impact not only on extreme weather conditions like flood, drought, desertification among others (Smith, 1994; Lambert, 1995; Environment Canada, 1999; Odjugo, 2000b and Odjugo and Ikhuoria, 2003), but on human health (Weihe, 1979; Sloof, 1996; Martens et al., 1999; Odjugo, 2000a;), agriculture (Reilly, 1996; Karim et al., 1998; Parry et al., 1999; Sorte, 1999 and Odjugo, 2001) and hydrothermal conditions (Akitikpi, 1999; Arnell, 1999; van Deursen, 2000: Buba, 2004; Nyelong, 2004 and Porbeni, 2004).

The concept of hydrological cycle is crucial in the discussion of water resources. The hydrological cycle consists of three components namely; the inflows, outflows and storage. If the inflows (recharge) to the aquifer are less, than the amount of stored water for possible usage will be reduced leading to scarcity. Ordinarily, the earth's water supply remains constant but man is capable of altering the cycle of that fixed supply through population increase, urbanisation, rising living standards, agriculture, industrial and economic growth. With these activities, man has placed greater pressure on the natural environment resulting to imbalance in the hydrological equation, which has started telling much not only on the climate but also water resources available at local, regional and global levels. Further alteration of the hydrological system can result in extremely negative consequences for rivers and their watersheds, lake levels and aquifers which will be detrimental not only to water resources currently available but to future generations (EPA, 1998). Although the availability of adequate and quality water is crucial to human health, and that water is second to air with regards to its importance to human life, little attention is being paid to how it will be impacted upon by climate change especially at local levels in the developing countries (Buba, 2004 and Nyelong, 2004). Moreover, Mshelia (2005) noted that climate change will impact on the hydrological cycle at a variety of spatial and temporal scales. The temporal scales may vary from very short intervals to annual scales while the spatial effect may be local, regional or global. It is on these premises that this paper investigated the impact of climate change on global and Nigeria water resources. This is important because, (Mshelia, 2005) noted that the impact of climate change on water resources will be felt by both

developed and developing countries, but more by the developing countries who cannot afford the cost needed for coping strategies. Nigeria is one of such developing countries that may be hardly hit, not only because about two-third of her landmass lies in the semi-arid region, but also is already under threat and stress of desertification and frequent drought (Odjugo and Ikhuoria, 2003, Chindo and Nyelong, 2004; Nyelong, 2004 and Odjugo, 2005).

Effects of climate change on water demand globally:

Climate change is significantly increasing global water demand while also reducing reliable freshwater supplies in many regions. This creates a growing imbalance between water availability and human needs for agriculture, industry, energy, and domestic use.

## **2.7 Major Effects of Climate Change on Global Water Demand**

Climate change has major impacts on global water demand by increasing water consumption, reducing freshwater availability, and intensifying competition for water resources.

### **1. Higher Temperatures Increase Water Use**

Higher global temperatures increase evaporation rates and raise water needs for households, agriculture, and industries. Hot weather also increases human consumption and cooling requirements in urban and industrial areas (United Nations, 2023).

Agricultural lands lose soil moisture more quickly under high temperatures, forcing farmers to use more irrigation water. This significantly increases freshwater demand globally.

Rising global temperatures increase evaporation from soils, rivers, and reservoirs. Hotter conditions also raise water consumption by people, crops, livestock, and industries.

For example:

- a) Farmers need more irrigation because soils dry faster.

- b) Cities use more water during heatwaves for cooling, sanitation, and drinking.
- c) Energy systems often require additional water for cooling power plants.

In some urban areas, studies project climate-related increases in water demand of up to 15% under high-emissions scenarios.

## **2. Agriculture Faces the Largest Pressure**

Agriculture accounts for about 70% of global freshwater withdrawals, and climate change is making farming more water-intensive. Rising temperatures and changing rainfall patterns increase crop water requirements and irrigation dependence (FAO, 2022).

Drought conditions also reduce soil moisture, meaning crops need more artificial watering to maintain productivity. Climate change increases agricultural water demand because:

- a) Crops experience greater heat stress.
- b) Droughts reduce soil moisture.
- c) Growing seasons become more water-intensive in many regions.

This is especially severe in:

- a) Sub-Saharan Africa
- b) South Asia
- c) Parts of the Middle East
- d) Western United States

Climate-related declines in agricultural productivity are already being observed globally.

### **3. More Frequent Droughts Increase Water Scarcity**

Climate change is increasing the occurrence and severity of droughts in many parts of the world. Reduced rainfall and prolonged dry seasons lower river flows, groundwater recharge, and reservoir levels (IPCC, 2022).

As freshwater supplies decline, competition for water among agriculture, households, and industries becomes more intense. Droughts reduce river flows, groundwater recharge, and reservoir levels, forcing societies to compete for limited water resources.

Regions already experiencing water stress are expected to become more vulnerable:

- a) Mediterranean regions
- b) Southern Africa
- c) Parts of China and India
- d) Southwestern North America

Research suggests billions more people could face moderate to severe water stress by 2050.

### **4. Population Growth and Urbanization Compound the Problem**

Climate change combines with population growth and rapid urbanization to increase water demand globally. Expanding cities require more water for drinking, sanitation, energy production, and industrial activities (UN-Water, 2021).

Urban heatwaves caused by climate change also increase domestic water consumption.

Climate change interacts with population growth and economic development. More people require:

- a) Drinking water

- b) Food production
- c) Energy generation
- d) Industrial manufacturing

Some studies show that socioeconomic growth may increase water stress even more than climate change itself in developing regions, although climate change worsens the impacts.

Rapidly expanding cities are especially vulnerable because urban water systems are often already strained.

## **5. Melting Glaciers Threaten Long-Term Water Supply**

Many rivers depend on glaciers and snowpacks for regular water supply. Climate warming is causing glaciers to melt rapidly, threatening long-term freshwater availability for millions of people (IPCC, 2022).

Although glacier melt may temporarily increase river flow, long-term reductions will affect irrigation, hydropower generation, and domestic water supply. Climate warming is shrinking glaciers worldwide, reducing long-term water availability for millions of people.

Areas at risk include:

- a) Himalayas
- b) Andes
- c) Alps
- d) Rocky Mountains

Initially, glacier melt may temporarily increase river flow, but long-term decline reduces dependable water supplies for irrigation and hydropower.

## **6. Water Quality Is Also Declining**

Climate change negatively affects water quality through flooding, higher water temperatures, and pollution concentration during droughts. Floods can contaminate water sources with sewage, chemicals, and waste materials (World Health Organization, 2023).

Poor water quality increases treatment costs and reduces the amount of safe freshwater available for use.

Climate change affects not only quantity but also water quality:

- a) Floods increase contamination from sewage and chemicals.
- b) Heat raises water temperatures, reducing oxygen levels.
- c) Drought concentrates pollutants in rivers and lakes.

Poor water quality increases treatment costs and limits usable freshwater supplies.

## **7. Extreme Weather Creates Unpredictable Water Demand**

Climate change disrupts the natural water cycle, causing irregular rainfall patterns, floods, and dry periods. This unpredictability makes water-resource planning more difficult for governments, industries, and farmers (UNESCO, 2023).

Some regions experience excessive rainfall and flooding, while others suffer severe water shortages. Climate change destabilizes the global water cycle:

- a) Heavier rainfall and floods in some regions
- b) Longer dry periods in others
- c) More erratic seasonal patterns overall

This unpredictability makes water planning more difficult for governments, utilities, and farmers.

## **Global Consequences**

The combined effects of rising demand and declining reliability may lead to:

- a) Food insecurity
- b) Higher water prices
- c) Energy shortages
- d) Economic losses
- e) Migration and conflict over shared water resources

Recent UN-linked reports describe the world as entering a period of “global water bankruptcy,” where freshwater use exceeds sustainable replenishment in many regions.

## **Possible Solutions**

Countries and communities are responding through:

- a) Efficient irrigation systems
- b) Wastewater recycling
- c) Rainwater harvesting
- d) Desalination
- e) Smart water pricing
- f) Improved watershed management
- g) Climate adaptation planning

Reducing greenhouse gas emissions is also critical because limiting warming to 1.5°C could substantially reduce future water scarcity risks.

## **CHAPTER THREE**

### **METHODOLOGY**

#### **3.1 Study Area**

The location for my research work is the whole Egor local government area.

The Specific sites involved under Egor Local government area are Uselu, Uwelu, Egor, Evbogida, Ugbowo, Ago Osakwe, Oghoghugbo, Iguasa, Ogboyoko, Agigbigi, Ogunwenyi, Obayantor.

These areas were specifically covered when analysing the rainfall data under the Egor Local government. Egor is a Local Government Area of Edo State, Nigeria. Its headquarters are in the town of Uselu. Egor is one of the Local Government Areas that are part of the larger metropolitan area of Benin City.

It has an area of 93 km<sup>2</sup> and a population of 339,899 as at the 2006 census.

The postal code of the area is 300. Egor local government area is in Edo state, South-south geopolitical zone of Nigeria and has its headquarters in the town of Uselu. A number of towns and villages make up of Egor local government area and these include Okhoro, Use, Uwelu, Iguikpe, Ugbighoko, Iguediaye, Evbougide and Oghedaivbiobaa. The population of Egor local government area is estimated at 258,442 inhabitants with the area hosting members of several tribal groups such as the Esan, Bini, and the Owan. The area is home to Christians, Muslims, and traditional worshippers while the Bini, Owan and Esan languages are spoken in the area.

Egor local government area falls under the Tropical Savannah Climate while the LGA covers a total area of 93 square kilometres. The area experiences two major seasons, which are the rainy and the dry seasons while the average temperature of the area is at 28 °C. The estimated humidity level of the Egor local government area is estimated at 68 percent.



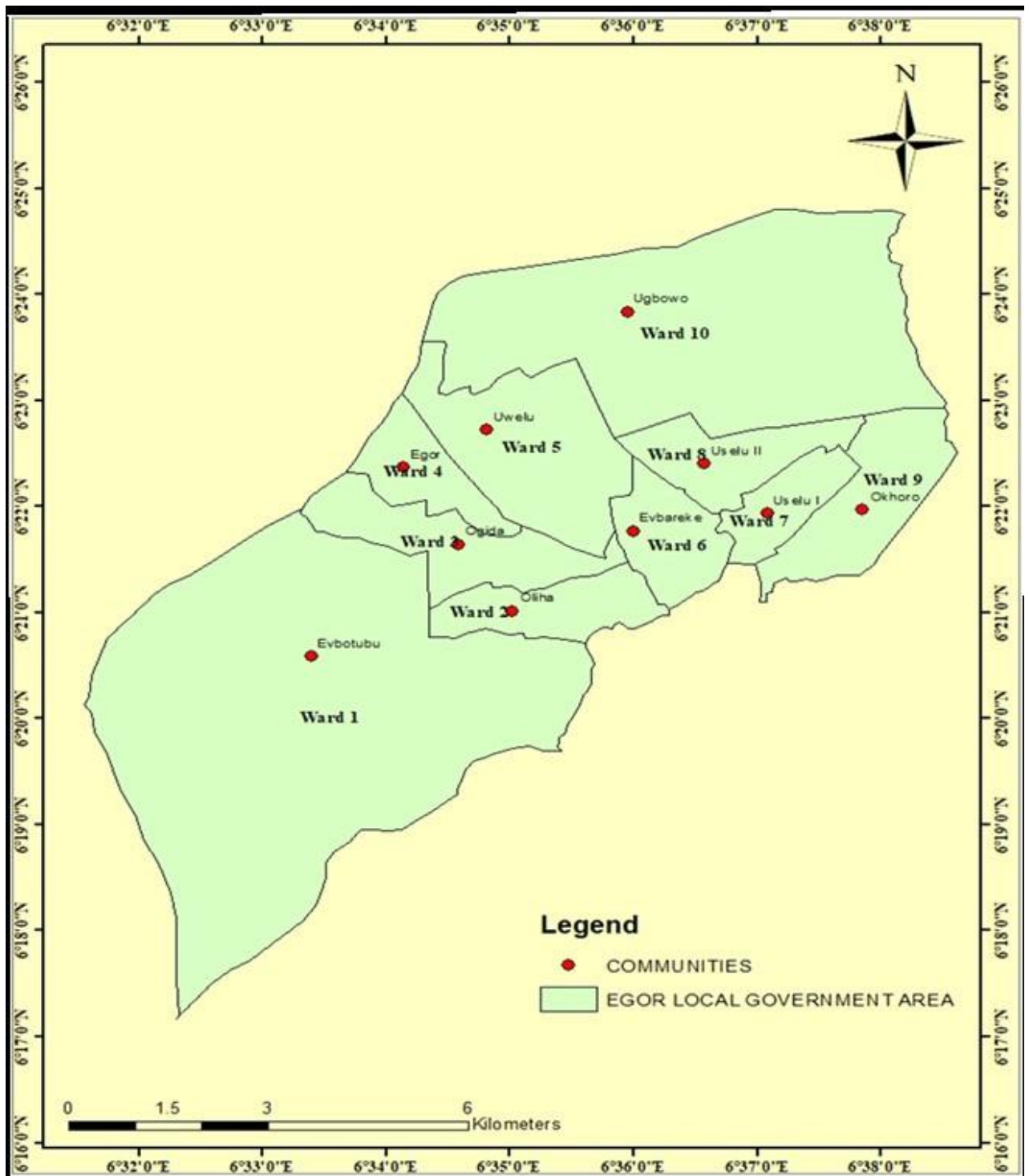


Figure 3.2: Another Study Area Map of Egor Local Government Area Nigeria.



Figure 3.3: Egor Local Government Council Secretariat uselu, edo state.

Source: (Wikipedia, 2021.)



Figure 3.4: Aerial View of the places within the Egor Local Government.

Source: (ProperyPro, 2024)

### **3.2 Method Used in Carrying Out Research Work On Egor Local Government**

In ArcMap, investigating water demand due to climate change typically involves a combination of spatial analysis, data visualization, and modelling techniques. Here's a general outline of the steps you might follow:

#### **Data Acquisition**

Gather relevant spatial data including:

1. Land use/land cover data
2. Climate data (temperature, precipitation, etc.)
3. Hydrological data (stream networks, watershed boundaries, etc.)
4. Demographic data (population distribution, urbanization trends, etc.)
5. Infrastructure data (water distribution networks, reservoir locations, etc.)

#### **Data Preparation**

1. Import the data into ArcMap and ensure that it's properly formatted and projected to a consistent coordinate system.

#### **Spatial Analysis**

1. Overlay land use/land cover data with climate data to understand how changes in climate might impact land use patterns and water demand.
2. Analyze hydrological data to identify areas vulnerable to changes in water availability.
3. Use demographic data to assess population trends and their potential impact on water demand.

## **Modelling**

1. Utilize ArcMap's modelling capabilities (e.g., Model Builder) to create a water demand model that incorporates various factors such as population growth, land use changes, and climate projections.
2. Calibrate the model using historical data to ensure its accuracy in predicting current water demand.
3. Apply future climate change scenarios to the model to simulate potential changes in water demand over time.

## **Visualization**

1. Create maps and visualizations to communicate the results of your analysis, highlighting areas of high-water demand, vulnerability to climate change, and potential adaptation strategies.
2. Use symbology, charts, and graphs to effectively convey complex spatial patterns and trends.

## **Scenario Planning**

1. Explore different scenarios of climate change and socio-economic development to understand the range of possible outcomes and identify strategies for adaptation and mitigation.
2. Assess the effectiveness of various water management strategies (e.g., conservation measures, infrastructure upgrades) in addressing future water demand under different scenarios.

## **Documentation and Reporting**

1. Document your methodology, data sources, and assumptions to ensure transparency and reproducibility.
2. Prepare reports and presentations to communicate your findings to stakeholders, policymakers, and the public.

### **3.3 Materials and Methods for the Global Analysis**

Secondary climatic data (Rainfall and temperature) of Nigeria were collected from the Nigerian Meteorological Station, Lagos between 1960 and 2002 in 28 synoptic stations. This period is selected because drastic changes in Nigeria climate after the little ice age started in 1960s, which was attributed to rapid population growth, urbanization and deforestation (Dibie, 2001). Data on the area coverage changes and depth of Lake Chad waters between 1963 and 2000 were collected from the National Centre for Remote Sensing (NCRS) Jos, and the work of (Chindo and Nyelong, 2004). This is the period when satellite imagery and actual measurements data of the lake water is available (Chindo and Nyelong, 2004). These data allow for the analysis of regional (Nigeria) hydrothermal trend. World temperatures, precipitation, greenhouse gas emissions and water resources data since record started in these elements were collected from different sources like Intergovernmental Panel on Climate Change (IPCC), Environment Canada, Carbon Dioxide Information Analysis Centre

(CDIAC) online and Nigerian Environment Study/Action Team (NEST). With this data, the global climate and water resources trend is analyzed. The data were analyzed using percentages and time series analysis.

## CHAPTER FOUR

### DISCUSSION AND RESULT

#### 4.1 Causes of climate change

Both natural events and processes (Biogeochemical) and anthropogenic influences (Human) cause changes in climate. The major natural factors that enhance climate change include volcanic eruptions and changes in the intensity of sunlight reaching the earth. Changes in the intensity of sunlight reaching the earth can cause cycles of warming and cooling, like the four large glacial-interglacial swings during the past 400,000 years (Hengeveld et al., 2002). The essential anthropogenic factors responsible for climate change are changes in greenhouse gas concentration occasioned by deforestation, industrial and domestic wastes, water pollution and alteration in land use for agricultural practices. These causes of climate change are modelled in Fig. 1. The greenhouse gases are carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF<sub>6</sub>) among others. Of these GHGs released into the atmosphere, about 60% are absorbed by either the ocean, land biota or decomposed by chemical reaction, while the remaining 40% is concentrated in the atmosphere, which traps the short-wave radiation resulting in atmospheric warming (Odjugo, 2000).

#### 4.2 Impacts of Climate Change on Water Demand

Climate change has emerged as one of the most critical global challenges of the 21st century, significantly influencing natural and human systems. Among its many consequences, the impact on water resources—and particularly on water demand—has become increasingly evident. This discussion explores how climate change alters water demand patterns across domestic, agricultural, industrial, and environmental sectors, while also examining the underlying drivers and broader implications.

## **1. Climate Change and Changing Hydrological Patterns**

Climate change affects the hydrological cycle by altering precipitation patterns, increasing temperatures, and intensifying extreme weather events. Rising global temperatures lead to increased evaporation rates from water bodies, soils, and vegetation. This, in turn, reduces water availability while simultaneously increasing demand.

In many regions, rainfall is becoming more erratic, with prolonged droughts followed by intense rainfall events. Reduced and unpredictable water supply often compels communities, industries, and farmers to extract more water to meet their needs, thereby increasing overall water demand. Furthermore, declining surface water availability forces a shift toward groundwater extraction, placing additional stress on already limited resources.

## **2. Increased Agricultural Water Demand**

Agriculture is the largest consumer of freshwater globally, and it is highly sensitive to climatic variations. Rising temperatures accelerate evapotranspiration—the combined process of water evaporation and plant transpiration—thereby increasing the water requirements of crops.

As climate change leads to more frequent droughts and heatwaves, farmers are compelled to irrigate more frequently and intensively to maintain crop yields. Additionally, shifts in growing seasons and crop patterns may require more water-intensive crops in certain regions. In arid and semi-arid areas, this can result in a significant surge in irrigation demand, exacerbating water scarcity.

## **3. Rising Domestic Water Demand**

Climate change also influences domestic water demand. Higher temperatures increase water consumption for drinking, bathing, cooling, and sanitation. During heatwaves, households tend

to use more water for cooling purposes such as showers, landscaping, and air conditioning systems that rely on water.

Urban areas, in particular, experience a notable rise in water demand due to population growth combined with climate-induced temperature increases. In developing regions, where water infrastructure may already be inadequate, this increased demand can strain supply systems and reduce access to safe drinking water.

#### **4. Industrial and Energy Sector Demand**

Industries and energy production systems are also affected by climate change. Many industrial processes require large volumes of water for cooling, processing, and cleaning. As temperatures rise, industries may require more water to maintain operational efficiency.

Thermal power plants, for example, depend heavily on water for cooling. Increased ambient temperatures reduce cooling efficiency, thereby increasing water demand. Additionally, shifts toward alternative energy sources, such as biofuels, may further increase water consumption due to irrigation needs.

#### **5. Environmental and Ecosystem Water Needs**

Climate change not only increases human water demand but also intensifies the water needs of ecosystems. Wetlands, forests, and aquatic ecosystems require sufficient water to maintain ecological balance. Rising temperatures and reduced water availability can disrupt these systems, leading to biodiversity loss.

To sustain ecosystems under changing climatic conditions, more water may need to be allocated for environmental flows. This creates competition between human and ecological water demands, complicating water resource management.

## **6. Regional Variability in Water Demand Impacts**

The impacts of climate change on water demand are not uniform across regions. In arid and semi-arid regions, the effects are more pronounced due to already limited water resources. These areas are likely to experience severe water stress as demand increases while supply diminishes.

In contrast, some high-latitude regions may initially experience increased water availability due to melting glaciers and increased precipitation. However, even in these regions, long-term changes may lead to seasonal imbalances and increased demand during warmer periods.

## **7. Socioeconomic Drivers and Feedback Effects**

Climate change interacts with socioeconomic factors such as population growth, urbanization, and economic development to further influence water demand. Rapid urban expansion increases the need for water infrastructure and services, while economic growth often leads to higher per capita water consumption.

Additionally, water scarcity induced by climate change can drive behavioral and technological changes, such as water conservation practices and the adoption of efficient irrigation systems. However, in some cases, increased demand may lead to over-extraction of water resources, creating a feedback loop that worsens water scarcity.

## **8. Implications for Water Resource Management**

The increasing and shifting water demand caused by climate change presents significant challenges for water resource management. Policymakers and water managers must adopt adaptive strategies to ensure sustainable water use. These strategies may include:

- a) Improving water-use efficiency across all sectors
- b) Investing in water-saving technologies

- c) Promoting integrated water resource management (IWRM)
- d) Enhancing water storage and distribution infrastructure
- e) Implementing policies that encourage conservation and equitable allocation

Climate-resilient planning is essential to balance water demand with available supply under uncertain future conditions.

### **4.3 Temperature Rise and Increased Water Demand**

Since 1860, about 145 years ago when scientific recording of temperatures actually started, studies have shown that global climate has experienced noticeable variations (IPCC, 1996; Hengeveld et al., 2002 and Ayoade, 2004). The world temperatures were below average until the late 1930s, when alternating cooling and warming started till the early 1980s, when a renewed and pronounced warming continued through the 2000s.

Rising temperatures across Nigeria lead to increased evapotranspiration, which raises water requirements for agriculture and domestic use. Higher temperatures also increase human water consumption for drinking, sanitation, and cooling.

Urban centres such as Lagos, Abuja, and Kano experience higher demand due to heat stress and population density. This aligns with global findings that water uses increases with temperature.

### **4.4 Changing Rainfall Patterns and Water Scarcity**

Nigeria is experiencing irregular rainfall patterns, including delayed onset of rains and shorter wet seasons. Northern regions are particularly affected by reduced precipitation and drought.

Reduced rainfall leads to:

- a) Increased irrigation demand
- b) Greater reliance on groundwater
- c) Seasonal water shortages

In semi-arid regions, these changes significantly raise water demand for agriculture and livestock.

#### **4.5 Agricultural Water Demand**

Agriculture remains the dominant water-consuming sector in Nigeria. Climate change increases crop water requirements due to:

- a) Higher evapotranspiration
- b) Reduced soil moisture
- c) Increased frequency of drought

Studies in northern Nigeria show that farmers are using more water sources and irrigation systems due to changing climate conditions. This increased demand places pressure on rivers and aquifers.

#### **4.6 Urbanization and Domestic Water Demand**

Rapid urbanization in Nigeria has led to increased domestic water demand. Climate change intensifies this trend by:

- a) Increasing water consumption during heatwaves
- b) Reducing reliability of water supply systems
- c) Increasing dependence on alternative sources such as boreholes

In many cities, water infrastructure cannot meet growing demand, leading to water shortages and inequitable distribution.

#### **4.7 Industrial and Energy Sector Demand**

Industrial activities require large volumes of water for production and cooling. Rising temperatures increase water demand in industries, especially in thermal power generation.

Climate change also influences water quality, which affects industrial usability and increases treatment costs.

#### **4.8 Environmental and Ecosystem Demand**

Climate change affects ecosystems such as wetlands, rivers, and lakes. Reduced water availability threatens biodiversity and ecosystem services.

Maintaining environmental flows becomes more challenging as human demand increases, leading to competition between ecological and economic needs.

#### **4.9 Regional Variability in Nigeria**

The impacts of climate change on water demand vary across Nigeria:

- a) **Northern Nigeria:** Severe drought, desertification, high irrigation demand
- b) **Southern Nigeria:** Flooding, water pollution, seasonal variability
- c) **Coastal areas:** Saltwater intrusion affecting freshwater supply

These regional differences highlight the need for location-specific water management strategies.

#### **5.0 Socioeconomic and Institutional Challenges**

Institutional weaknesses significantly limit Nigeria's ability to respond to climate-induced water demand challenges. Key issues include:

- a) Poor data management systems
- b) Weak policy implementation
- c) Limited public awareness
- d) Inadequate funding

These barriers hinder effective adaptation strategies.

**5.1 Result from The Analyses Done on Egor Local Government area in Benin City Nigeria Using ArcGIS (ArcMap)**

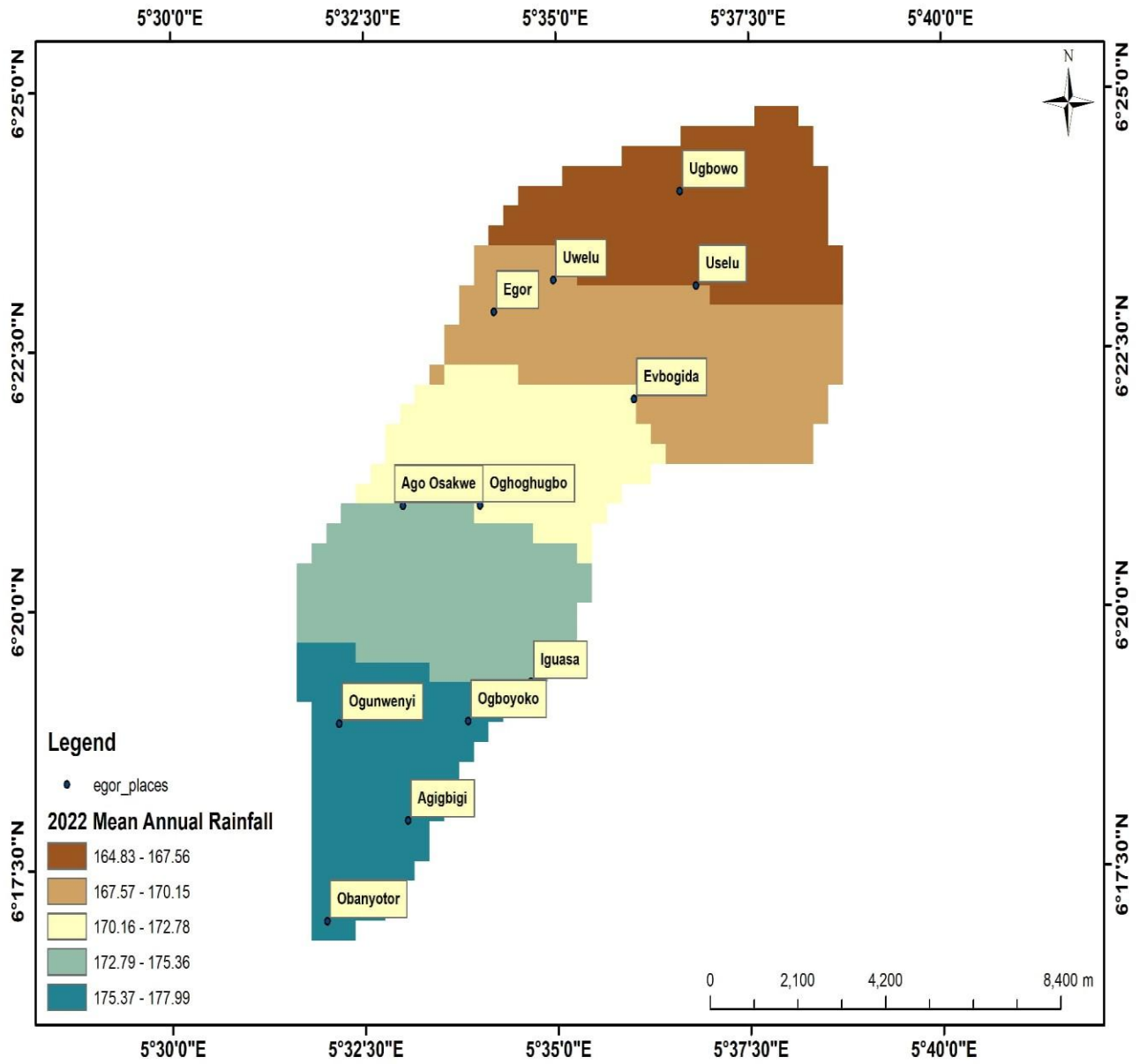


Figure 5.1: Rainfall Data obtained using ArcGis (ArcMap) for analysis.

## CHAPTER FIVE

### CONCLUSION AND RECOMMENDATION

The paper observed globally and in Nigeria, an increasing temperature and decreasing rainfall amount over the years especially since the 1970s. This observed changing climatic condition has started affecting the water resources in most parts of the world whereby 2.3, 3.2 and 3.7 billion people world-wide will likely experience increasing water stress by 2025, 2050 and 2085 respectively. Lake Chad has shrunk from 22902 km<sup>2</sup> in 1963 to a mere 304 km<sup>2</sup> in 2000, while the depth has dropped from 5.8 m to

2.2 m within the same period. While we advocate global reduction of greenhouse gases through sustainable technological development to reduce the effects of climate

change, we also advise strongly global reduction of sea and ocean pollution, deforestation and increased afforestation programme to enhance carbon sink. Finally, the changing climatic condition and dwindling water resources are pointers to impending water danger and its consequences on other sectors like agriculture, industry and tourism. It is hereby strongly suggested that countries currently stressed or that will experience water stress in the future like Nigeria, should start developing coping

strategies, which will take care of the water scarcity, accompanying climate change. The coping strategies should include the protection and effective management of the watersheds, the ground and surface water resources. The current plan of inter basin water transfer from the Congo Basin, a distance of about 1600 km is a welcome idea and may be a possible solution to avoid the total disappearance of the Lake Chad.

Climate change has a profound impact on water demand in Nigeria by increasing consumption across all sectors while simultaneously reducing water availability. Rising temperatures, erratic rainfall, and extreme weather events are key drivers of this trend.

The study highlights that without effective adaptation strategies, Nigeria may face severe water stress in the future. Sustainable water management, improved infrastructure, and climate resilient policies are essential to balance water demand and supply.

In conclusion, climate change has a profound and multifaceted impact on water demand. By altering temperature patterns, precipitation, and the frequency of extreme weather events, it increases water requirements across agricultural, domestic, industrial, and environmental sectors. The resulting pressure on water resources underscores the need for proactive and adaptive management strategies.

Addressing these challenges requires a combination of technological innovation, policy intervention, and public awareness. Without effective action, the growing imbalance between water supply and demand could lead to severe water shortages, economic disruptions, and environmental degradation.

Climate change has a significant impact on water demand in Nigeria. Rising temperatures, erratic rainfall, and extreme weather events increase water demand across all sectors while reducing availability.

### **Recommendations**

- a) Promote efficient irrigation techniques (e.g., drip irrigation)
- b) Invest in water storage and distribution infrastructure
- c) Strengthening institutional frameworks and policies
- d) Encourage water conservation practices
- e) Enhance data collection and climate monitoring systems
- f) Improve water management systems

- g) Promote water conservation practices
- h) Invest in irrigation technology
- i) Strengthening climate policies
- j) Increase public awareness

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