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Original Paper

Impacts of Climate Change on Food Security and Sustainable Water Resources in Nigeria

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Abstract

This study evaluates the impacts of climate change on food security and sustainable water resources in Nigeria. Stratified samples were taken from North Central States of Benue and Plateau, and South-South Cross River State and Akwa-Ibom. These four states are among the thirty six states in Nigeria that have been badly hit by climate change. This study used soft and hardware computer applications including German 12 handheld GPS, and Integrated Land and Water Information System (ILWIS), for data collection. Quantitative and qualitative data were collected for the evaluation. The GIS information software package was used to manipulate and perform feature identification, recognition, classification, calculation, and ground-trotting. A structured questionnaire was also used to collect data on some livelihood activities, the influence of livelihoods activities on water resources, food security, and climate change impacts. Data analysis, found that the forest and water bodies are shrunken. Industrial activities such as oil exploration and exploitation, mining, by Multinational Corporations, illegal mining, grazing, unsustainable farming practices, fishing and hunting for bush meats, bush fire, timber exploitation and deforestation have contributed to climate change. The study recommends climate action and climate diplomacy, building local capacity for resilience, engaging the private sector, partnerships and international assistance.

Keyword

internally displaced persons, climate change-related migration, droughts, floods, water scarcity, food security

1. Introduction

The climate of any place is the average condition of its weather with respect to temperature, pressure, humidity, winds and precipitation over a long period of time. In West Africa, climate has considerable impact on the localization of primary production and seasonal migration. Climate change, which is a significant global challenge, is any complex interactions of the major climate system components; the atmospheric, oceanic, land, and biosphere which give rise to earth's climatic conditions with associated impact on humans and the natural environment. According to the Intergovernmental Panel on Climate Change (IPCC, 2007), greenhouse gases have led to warming up the world and is projected to get much worse during the course of the 21st century. This scientific body was set up in 1988 by the United Nations and the World Meteorological Organization to consider the impacts of climate change. The Africa inaugural climate change conference 2023 was just concluded in Nairobi, Kenya, after the Paris Summit and according to William Samoei Ruto (2023), climate change is not a Global North issue, or a Global South issue, it is our collective challenge and it affects all of us, we need to come together to find common, global solutions. Climate change is particularly serious for developing countries, and Africa as a continent is regarded as highly vulnerable with limited capability to adapt. According to Nyong (2023), climate change is primarily caused by the accumulation of greenhouse gases (GHGs) in the atmosphere, which trap heat from the sun and lead to a warming effect on the earth's surface and lower atmosphere. GHGs include carbon dioxide (CO2), methane (CH4), nitrous oxide (N20), and fluorinated gases. This warming causes long-term changes in statistical distribution of weather patterns over time. In the context of this study, climate change refers to the changing environmental, physiological, bio-physiographic, geographic, agricultural and socioeconomic phenomenon that threatens water resources and impacts on livelihoods, health, education, crop production, livestock (animal husbandry), forestry and fisheries. Changes in agricultural practices over the years have resulted in immeasurable environmental costs; low yields due to adverse climatic and soil conditions, bush burning, hunting and fishing, absence of drainage facilities, poor irrigation and fertilization.

Climate change is having profound impacts on global communities; the ravaging impact of global warming (heat waves), forest fire, flooding, earth quake, wild storm (typhoon) etc., cannot be over-emphasized in America, Germany, Canada, Australia, France, Japan, China, India, Pakistan and across Africa. These have threatened water, food and energy security in Africa and Nigeria in particular. The economic growth and sustainable development are largely impacted by climate change. In a study by Eneji et al. (2022), human livelihood activities impact on climate change and water resource availability. Similarly, a study by Gerlitz, Vorogushyn and Gafurove (2020) on climate-informed seasonal forecast of water availability in Central Asia found that hydro-climatologically droughts led to serious water shortages, resulting in crop failures and shortfalls, significant economic loss and inter-state political tensions. Robust forecasts of anomalous climatic and hydrological conditions

reduced regional vulnerability to hydro-climatic extremes and thus can serve as a scientific basis for national and trans-national water resource management. Their study concluded that a continuous engagement in the field of capacity development and knowledge dissemination at various institutional levels (including academia, government, forecast centers and water management institutions) appears necessary in order to stimulate a multi-disciplinary network and to support a sustainable regional collaboration in combating climate change impacts. The poor developing countries of sub-Saharan Africa who contribute the least to the problem of climate change (than the industrialized nations of the Global North), but bear an unfairly large part of the burden of climate change. People of Africa and Asia are migrating in search of food, water, and safety from climate change. Africa is most at risk because of poverty, building without plan approval, deficit infrastructure. There is a model forecast by the United Nations High Commission for Refugee (UNHCR) that climate change may lead to a 3 percent of the population (totaling more than 143 million people) in three regions-Sub-Saharan Africa, South Asia and Latin America to migrate within their country of origin by 2050. According to the World Economic Forum (WEF, 2023), the global economy is facing an increased risk of stagnation as climate change is striking harder and more rapidly than expected.

2. Methodology and Methods

The methodology of this study include empirical literature review, theoretical review in order synthesize the facts. The methods of this study are both soft and hardware computer applications including German 12 handheld GPS, and Integrated Land and Water Information System (ILWIS), for data collection. Both quantitative and qualitative data were collected for the evaluation. The GIS information software package was used to manipulate and perform feature identification, recognition, classification, calculation, and ground-trotting, with the aid of the Department of Geography and Regional Planning Information, University of Jos. A structured questionnaire was also used to collect data on some livelihood activities, the influence of livelihoods activities on water resources, food security, and climate change impacts. Simple percentages, chi-square analysis, tables, charts and graphs are adopted for data analyses.

2.1 Statement of Research Problem

Africa currently faces security threats; (life and asset security, food security, water security, social security, military and police security, political and economic security etc), exacerbating by climate change. There is serious environmental crisis and environmental costs of climate change in Nigeria that needs further and continuous evaluation. The main problem of this research is food and water insecurity exacerbating by climate change. There is scarcity of food, caused by the insecurity and scarcity of water resources for most of Nigerian farmers. Agriculture is at the center of socio-economic life. Human activities have impacted the land, forestry and fishery resources, livestock and crops. In the

last decade, compared to other decades, farmers are experiencing a drying tendency, severity of drought and floods have impacted food security, there is reduction in the amount of rainfall and extreme heat waves conditions. The forests and small streams are disappearing. Desertification seems to have environmental impacts that go beyond the areas known to be directly affected. There is a sharp decrease in soil moisture and inter-annual variability caused by climate change fluctuations. Animal farming is basically to meet the nutritional needs of the people and generate income to the farmer. However, in the present era, we have observed that animal breeding; animal nutrition and management are highly impacted by climate change and random variability in weather. Migration of pastoralist in search of water and greener pastures is causing farmer-herder clashes in Nigeria that have caused many lives and property. Green pasture and water scarcity, rooted in migration has become the root cause of farmer-herder conflicts in Nigeria and other African countries. Large scale migration is rated as the fifth most important risk in the world, is also driven by climate change (WEF, 2023). Climate change has impacted on vegetation, atmosphere, surface runoff, eco-hydrology, and necessitated reduced employment rates, crop and animal yields, incomes and financial assets. The dependence on the unpredictable weather, the thin sheet of soil that covers much of the landscape with its mysteries like a fascinating puzzle, and the biological rhythm as well as the capacities of plant and animal life, has many implications. The production effort of the farmer is not usually very good, often poor. The outputs reflect the vagaries of weather and the endless heterogeneity of climate itself. This has characteristically limited agricultural productivity and leaves the farmer with little or no control over time cycle, sun shine, rainfall, water resources, heat waves, cold, wind, flood and drought. There is a decrease in available water resources. The demand for irrigation has increased significantly beyond the supply of irrigation, constrained by availability of water resources with a decrease in annual runoff of rivers and streams. The reduction in rainfall, increase in drought and decrease in crop yield is currently disturbing. The expectation is that if the factors causing climate change are not mitigated, there will be further water shortages amidst food insecurity; water resource scarcity will be worse and unsustainable in the future which will further hinder plant and animal nutrition.

2.2 Research Questions

a. What are the impacts and the possible mitigation and adaptation measures for reducing the impacts of climate change, enhancing water and food security in Nigeria?

b. Does research and agricultural extension play any significant role in building resilience for local communities, introducing and adopting new innovation to mitigate the impacts of climate change in Nigeria?

c. Is there any significant relationship between climate change and the costs of livelihoods, incomes and employments in Nigeria?

2.3 Research Objectives

a. Investigate and evaluate the impacts of climate change on food security and water resources in the study areas using the research design.

b. Contribute to building peasant farmers resilience to climate change-related disasters

c. Find out agricultural interventions that will enhance quality food production in sustainable quantity.

2.4 Significance of the Study

Nigeria is one of the fastest growing economies in Africa, however, its growth potential is vulnerable to the impacts of climate change on agriculture and food security, biodiversity and ecosystem services; affecting energy sector, tourism and fisheries, industrial sector, health and education sectors. Furthermore, the impacts of climate change such as deforestation, desertification, the frequency and severity of floods, droughts and erosion have displaced people from their ancestral homes and communities (Eneji et al., 2017). Addressing climate change impacts is a necessary and sufficient condition for sustainable development in Nigeria and Africa as a continent. Agriculture is at the centre of Africa's livelihoods. Researches aimed at mitigating and combating climate change impacts are significant for improving agricultural productivity, food security, and reducing conflicts, resource scarcity, unemployment and poverty.

2.5 Theoretical Framework

Stakeholder's Theory

The definition of a stakeholder in the context of this study is "any group, organization or individual who can affect or is affected by the climate change. In general the concept is about what the organization should be and how it should be managed (Freeman, 1984)... Friedman (2006) states that the organization itself should be thought of as grouping of stakeholders and the purpose of the organization should be to manage their interests, needs and viewpoints. This stakeholder management is thought to be fulfilled by the managers of a firm. The managers should on the one hand manage the corporation (in this case, the ecosystem) for the benefit of its stakeholders in order to ensure their rights and their participation in decision making and on the other hand the management must act as the stockholder's agent to ensure the survival of the firm to safeguard the long term stakes of each group.

The definition of a stakeholder, the purpose and the character of the organization (the ecosystem) and the role of managers are very unclear and contested in the literature and has changed over the years. Even the "father of the stakeholder concept" changed his definition over the time. In one of his latest definitions Freeman (2004) defines stakeholders as "those groups who are vital to the survival and success of the corporation". In one of his latter publications Freeman (2006) adds a new principle, which reflects a new trend in stakeholder theory. In this principle in his opinion the consideration of the perspective of the stakeholders themselves and their activities is also very important to be taken into the

management of companies. He states “The principle of stakeholder recourse. Stakeholders may bring an action against the directors for failure to perform the required duty of care” (Freeman, 2004). All the mentioned thoughts and principles of the stakeholder concept are known as normative stakeholder theory in literature. Normative Stakeholder theory contains theories of how managers or stakeholders should act and should view the purpose of organization, based on some ethical principle (Friedman, 2006). Contextually, it means we are all stakeholders of the climate change. Combating the impacts of climate change will require actions from all stakeholders including the people most affected.

The original Stakeholder Theory introduces the concept of stakeholders in the strategic management of a Multinational Company. The purpose of the MNC is not anymore only to make profit for shareholders but also to defend an image and values respecting all stakeholders, Awosika (2008). There is of course a link between the wealth of Shareholders and the wealth of all Stakeholders because the MNC need a good reputation to sell its products and so to make profits. The Stakeholder Theory is very popular and is applied here because we are the world, we are the stakeholders, and .are worried about the sustainability of the actual ecosystem. With globalization, climate change impact is reshaping the world; companies take more and more importance and are in many cases more powerful than states. In these conditions, their action can have a huge impact on the society in general, and people ask such companies to have “ethic” and values. Companies should not only enjoy the rights of deregulation but also duties. And that is what stakeholders (and in particular rights activists) are asking for. Examples of such multinational corporations are Shell, Mobil, Total, Agip, Chemical Industries, Nike, Coca Cola, Google, Telecommunications, automobile and aviation industries etc.

3. Results

Table 1. Multiplier Impacts of Climate Change and its Pathways on Nigeria

PATHWAYS	MULTIPLIER IMPACTS
1.	Natural resource scarcity (water, oxygen, energy, land etc) which leads to insecurity and conflicts between herdsmen and peasant farmers in extremely poor communities. Drying-up of Lake Chad and other lakes, streams, ponds and rivers, expensive dredging of River Niger and River Benue
2.	Resource scarcity leads to large scale migration, which is a risk and serious socioeconomic crisis of its own, impacts on livelihoods and wellbeing
3.	Food security risks, food price inflation, malnutrition, starvation and deaths for humans, plants and animals
4.	Oil and gas industrial activities, unemployment, loss of income and livelihoods
5.	Social security issues, forced displacement, crimes, kidnapping, banditry, cattle rustling, trans-boundary disputes, social exclusion, hate speech and hate

	deeds/actions
6.	Health and education risks, humanitarian assistance, human capital development stagnation
7.	Fiscal and monetary policy crisis, industrial policy implementation challenges, budgetary allocation challenges, macroeconomic instability
8.	Political unrest, corruption, government crackdown, war, coup d'état and other political challenges
9.	Poverty, high cost of energy, deforestation, desertification, earth quake, storm, heat waves, flooding, erosion, wild fire and aggregate environmental degradation
10.	Stakeholder actions, participatory and sustainable natural resource use planning. Capacity building and partnerships. Bringing science and technology education to bear on environmental and natural resources management, renewable energy and green growth, investment in sustainable livelihoods

In table 1, it can be deduced that the impacts of climate change on Africa are multi-faceted and compounded with chain reactions. Climate change has multiplier impacts on migration, conflicts and food security in Nigeria. Migrating herders and farmers' conflicts on the Plateau in particular and all over Nigeria, over scarce resources has cost many lives and forcing further migration and swelling the number of internally displaced persons. According to s report by the Internal Displacement Monitoring Centre, Nigeria has the highest number of internally displaced persons in Africa, with over 2 million people displaced as a result of climate change-related conflict and violence. In agriculture, specifically in the Niger-Delta, gas flaring and oil spillage have given rise to atmospheric contaminants. These include oxides of Nitrogen, Carbon and Sulphur (NO_2, CO_2, CO, and SO2), particulate matter, hydrocarbons and ash, petrochemical oxidants, and hydrogen sulphide (H2S) (Obioh, and Kindzierski, 1999; Etuonovbe, 2009). These contaminants acidify the soil, hence depleting soil nutrient. Some studies by Imevbore and Adeyemi (1981) have shown that the nutritional value of crops within such vicinity is reduced. In some cases, there is no vegetation in the areas surrounding the flare due partly to the tremendous heat that is produced and acid nature of the soil pH (Ubani & Onyejekwe, 2013). Oil spillage and Cultivation methods have led to serious erosion and considerable destruction of the soil, fish, wild life and useful vegetation have been indiscriminately harvested and destroyed with obvious modifications of the natural environment. These have altered the ecosystem, tempered with the extremes of cold or hot weather, modified soils as well as vegetations. Soil fertility has been degraded, ushering in food insecurity due to low productivity. The urban and regional economies have been seriously impacted by climate change and the activities of rural communities have also impacted on climate change; farming, hunting, fishing, pastoral activities, urban and community settlements,

lumbering and crafts making.

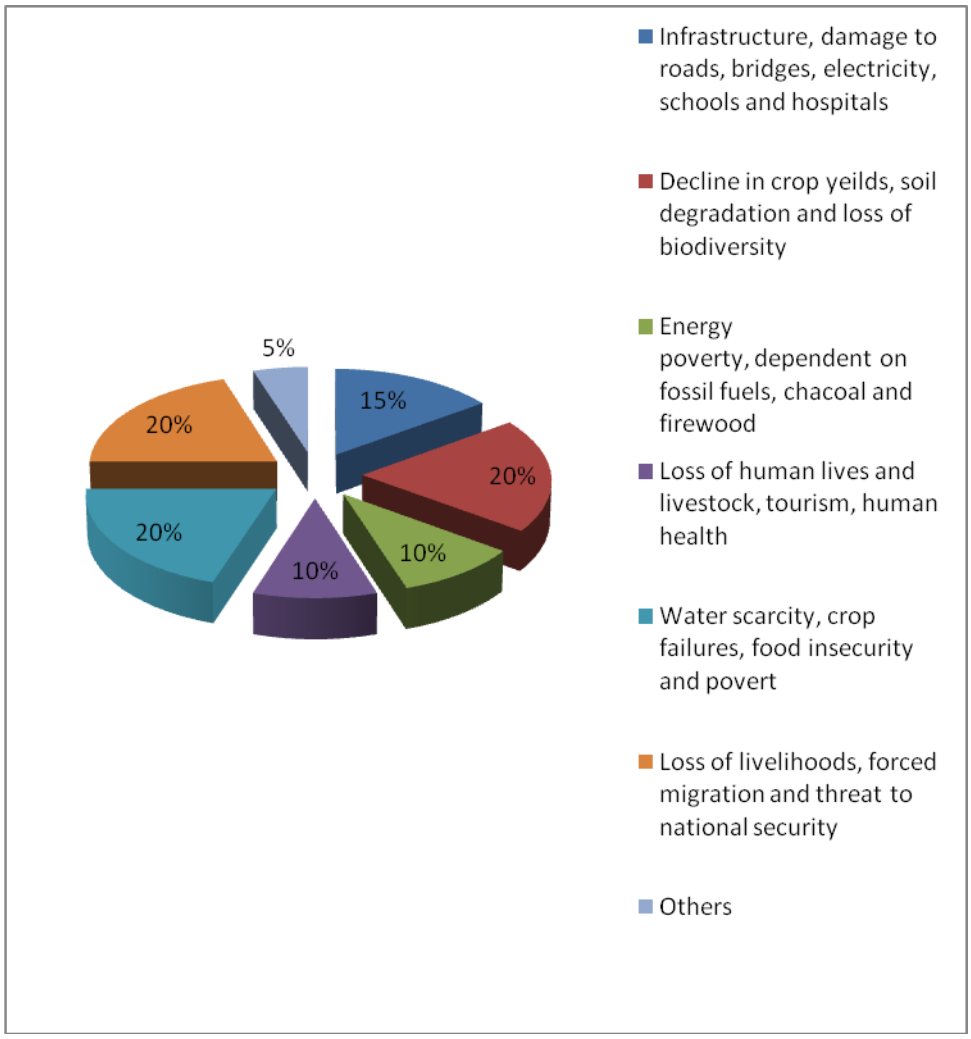

Figure 1.

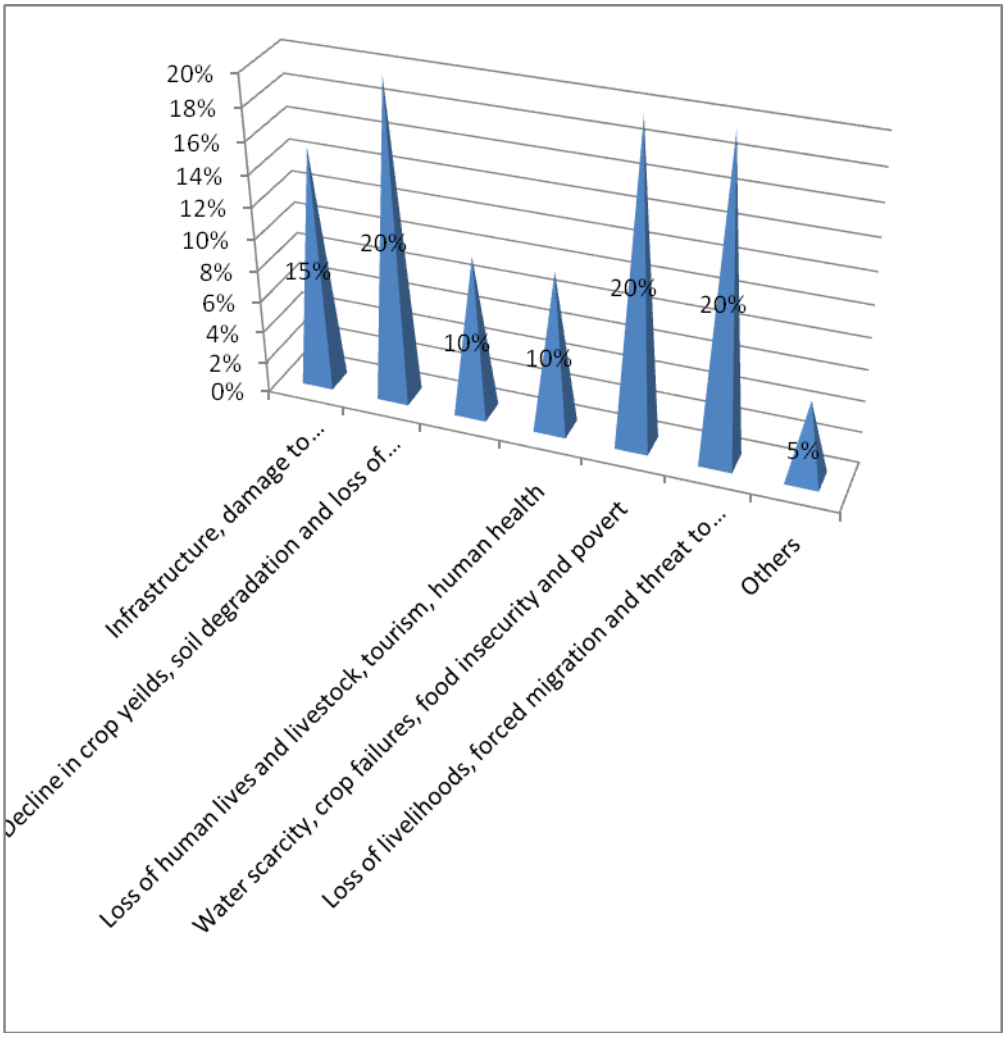

Figure 2.

Table 2. Analysis of the Impact of Climate Change and the Challenges

IMPACT	5	4	3	2	1	EVA
Impact of climate change on agriculture and food production	54%	26.8%	12.6%	9.6%	9.6%	4.06
Impact of climate change on farm yield/productivity	44.8%	38%	20.5%	8.6%	8.6%	4.02
Impact of climate change on water resources	38%	38%	8%	8%	8%	3.90
Impact of climate change on energy resources	7.6%	62.6%	7.6%	7.6%	14.4%	3.46
Impact of climate change on infrastructure	8.6%	54%	8,6%	14.4%	14.4%	3.28
Impact of climate change on human health	38%	38%	8%	8%	8%	3.90
Impact of climate change on farmers' income	33%	33%	8.6%	16.8%	8.6%	3.66
Impact of climate change on employment and livelihoods	7.8%	30%	30%	16.1%	16.1%	2.97
Impact of climate change on sustainable poverty reduction	8%	15.4%	15.4%	53.2%	8%	2.42

Impact of climate change on food security	7.8%	46%	7.8%	23%	15.4%	3.07
Impact of climate change on pests and diseases and the adoption of innovation	23%	44%	0.8%	16.1%	16.1%	3.42
Impact of climate change on migration and internally displaced persons	15.4%	69%	7.8%	7.8%	-	3.99

Source: Field Survey, 2023.

5= most severe impact. 1= remote impact. EVA= Evaluation of weighted mean score.

4. Discussion of Findings

Nigeria is well endowed with vast human and material resources that can guarantee food security, sustainable economic growth and development, but hindered by climate change. Data analysis, found that the forest vegetation cover is fast disappearing, the forest and water bodies are shrunken. Food insecurity has increased, ambient temperature and carbon accumulation had seriously increased, while rainfall has seriously reduced, there is the crisis of unsustainable water resources, leading to forced migration and loss of livelihoods, (Eneji & Babagario, 2019). The impacts of climate change have resulted in changing rainfall patterns, rising temperatures, causing droughts, drying up of rivers and streams. These have further resulted in water scarcity for agriculture, lack of access to clean water and sanitation for communities, households, schools, hospitals, markets and industries. The chain reaction is that these have negative implications for human and animal health, food security and nutrition. Climate change has negative impacts on sustainable poverty reduction. In Nigeria, agriculture employs over 70% of the population, relying majorly on rain-fed cultivation which has become particularly susceptible to climate change impacts, resulting to underutilization of existing production capacity, supply-side crisis, and high malnutrition rates especially for children and women. The energy impact of climate is also severe as Nigeria has not achieved significant progress in renewable energy. High electricity tariff has pushed more vulnerable population into the use of charcoal and firewood. Hydropower generation is constrained by water scarcity, caused by climate change as rainfall patterns have reduced water levels. Hydroelectric dams for public projects and most boreholes for households and communities can no longer guarantee off season supply of water. This has resulted in frequent power outages, epileptic power supply that cost so much for households, small and medium scale enterprises. Unfortunately, human activities such as greenhouse emissions, irrigated farming and draining of water bodies for various purposes, overgrazing, clogging of water ways with disposable plastics and water proof bags and dirt have given way for the adverse consequences of climate change too, manifested in forms of flooding, gully erosion, irregular pattern of rainfall, high temperature and worst of all, escalated violence occasioned by the struggle over resource use. Decrease in water availability and quality in some areas in most cases has been responsible for increased health and

sanitation problems such as diarrhea disease which, together with changes in vector-borne disease patterns.

Wildlife reserves, national parks and beaches attractions are also threatened by climate change impacts. The African Union has launched the Great Green Wall Initiative with the aim to restore degraded land and create a green belt across the Sahel region to combat desertification and improve livelihoods, (Nyong, Adesina, & Osman-Elasha, 2006), but this initiative is yet to be well extended to the Niger-Delta region probably because the region is known for its tick rainforests but they are fast disappearing. In Plateau State and Benue State, climate change has resulted to the emergence of pests and diseases that affect agricultural productivity; Irish potatoes, tomatoes, cabbage and fruit crops are infested and under-produced. Tomato leaf miner disease for instance is said to be caused by a pest known as Tuta absoluta (Timilsena et al., 2022; Skendzig et al., 2021). Increased insecurity, herders-famers' conflicts caused by climate change have affected the production of Miango pepper, corn, rice, sorghum and other cash crops and stable foods. Farmers now organize themselves into farming days and only go to their farms in groups to avoid attack by herders. This security situation has led to food shortages and increase in food prices, making it challenging for millions of poor Nigerians, including civil servants to access foods. The hardship is worsened by the removal of fuel subsidy by the President Tinubu's government on assumption of office on May 29, 2023. Federal and State governments are making little effort to distribute food palliatives, but to no avail. In addition, there are increased incidences of natural disaster in Nigeria and the entire African continent due to the impact of climate change; the Libya Floods Crisis, Morocco Earthquakes, Egypt-Algeria Wildfire are a few examples which Nigeria is not exempted . Climate change is causing the loss of biodiversity, degradation of Nigeria's ecosystems; desertification and deforestation as shown in the pie-chart. These have had severe consequences on the Nigerian economy and people. In Nigeria, priority sectors such as agriculture, energy, water resources are sensitive to climate change and variability. Lives and livelihoods are vulnerable to climate change, (Nwagbara et al., 2012). The River Benue, one of the major rivers in Nigeria which rises from North-west Cameroun has always shrink (requiring dredging) during dry seasons, flooded in the rainy seasons due to excess rainfall prompting the release of more water from the Lagdo Dam in Cameroon. The result is increased, unprecedented river overflow which has always flooded the whole of Nigeria from Adamawa, Taraba, through Benue, to Cross River, Akwa-Ibom, Rivers, and Edo, Anambra, Imo and all the Western states of Nigeria. Thousands of lives have been lost to this crisis. More than two million homes destroyed, forced migration, 30 million people internally displaced, social and economic infrastructures, farms, businesses and other sources of livelihoods are lost. There is erosion, land slide, poor crop yields due to loss of soil fertility, ethnic/tribal violent conflicts and war and shortage of rainfall. When you evaluate the number of people internally displaced by natural disasters, those displaced by herders-farmers' crisis, religious crisis and

other political and economic unrest, it is evident that Nigeria has humanitarian crisis that has often snowball into forced cross-border migration. We are referring to the most populous black nation in the world.

Climate change has impacted on Industrial and agricultural activities, and vice versa have impacted on the environment. The field work revealed that mining, fuel wood gathering and unsustainable agricultural practices have caused the disappearance of forest and vegetation cover. Majority of the population in the study areas (90%) are totally dependents on the environment for their livelihoods, fuel wood for their domestic energy, access to electricity by the communities is very poor, renewable energy is completely absent for these farming communities. These have further impacted on the environmental resources like the forest cove, /trees, vegetation, water bodies and watershed in Nigeria. The severe consequences are multidimensional; on livelihoods, food insecurity, infrastructure damages, water scarcity, famers-herders' conflicts, deaths, climate change-induced migration, unemployment, poverty and crime. Climate change has hindered economic growth and development in Nigeria through its impacts on environmental resource availability, water scarcity, energy, infrastructure, and food supply and food demand disequilibrium. Heat waves, floods and drought have had devastating consequences on education, health, socio-political and economic lives in Nigeria. Agriculture as the mainstay of the economy and livelihoods has been constrained in terms of production and productivity. The water and food security risks which Nigeria faces currently are caused majorly by climate change. The threat to climate is a threat to all, requiring stakeholders' approach to combat. In order to fight climate change and degradation of environment, the poor need to have resource and livelihood access that is secured and sustainable. Increasing and securing the rights of impoverished people in the legal, political and economic sense will allow them to be resilient and more stable in fighting core exploitation.

Recommendations

1) Investing in joint research and development (JR & D) to mitigate the impacts of climate change. The impacts are complex and multidimensional requiring interdisciplinary researches, not limited to geographic and the natural sciences. Agreed that it requires innovative and science-based solutions to reduce greenhouse effects, but also researches in the social sciences, agricultural and medical sciences are also needed to deal with the livelihoods, humanitarian, income and employment impacts of climate change.
2) Agricultural extension services. Fast growing and drought-resistant, improved varieties of crops, crop diversification, vegetables, saplings or tree species should be provided by government and other treatments to enable farmers and those living in poverty to improve their food security, income and livelihoods.

3) Private sector engagements and improved industrial regulation, especially with respect to environmental policy. Private sector engagement is critical to combating climate change impacts and promoting sustainable development in Nigeria.
4) The geopolitics of climate change is shaped by various stakeholders' interests, risks, vulnerabilities, and responsibilities at international and national and local community levels. Multinational Corporations should take responsibility for emission of greenhouse gases, and also bear the cost proportionately.
5) International and local partnerships, cooperation and collaboration is needed, bilateral and multilateral development funding by development institutions are significant to combat the impacts of climate change, displacement, migration and the associated insecurities.
6) The amount of floods and droughts that have occurred in Africa and Nigeria in particular in recent times, are enough for the continent to declare a state of emergency on climate change, as well as doubling humanitarian assistance.

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Appendix

1. Abandoned Mining site in Yelwa, Jos, Plateau State now constituting a risk to resident communities. Thousands of such sites are found in Jos from tin mining and other minerals.

2. Heap of sand dug out as a result of tin mining in Bisichi, Jos-South, LGA, Plateau State

3. Abandoned tin mining site in Barkin Local Government Area of Plateau State