



## THE IMPACT OF CLIMATE CHANGE ON THE DISTRIBUTION AND ABUNDANCE OF PLANT AND ANIMAL SPECIES

Esievo, Ware Lawrence

Lawrence.esievo@evomeclimited.com

Department of Environmental Management, Faculty of Social Sciences  
Ignatius Ajuru University of Education

### Cite this article:

Esievo, Lawrence. (2024), The Impact of Climate Change on the Distribution and Abundance of Plant and Animal Species. International Journal of Environmental and Natural Sciences Research, 2(1), 1-16.

DOI: [10.13140/RG.2.2.28078.32321](https://doi.org/10.13140/RG.2.2.28078.32321)

### Manuscript History

Received: 10 Feb 2024

Accepted: 07 Mar 2024

Published: 22 Mar 2024

Copyright © 2024 The Author(s).

This is an Open Access article distributed under the terms of Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International (CC BY-NC-ND4.0), which permits anyone to *share, use, reproduce an* redistribute in any medium, *provided the original author and source are credited.*

### ABSTRACT

This study provides a comprehensive analysis of the impacts of climate change on the distribution and abundance of plant and animal species in Nigeria, highlighting the crucial interplay between environmental changes and biodiversity. The research employs an extensive literature review approach, synthesizing information from academic articles, government and NGO reports, and case studies. The focus is on understanding how altered climatic conditions due to global warming - such as changes in temperature, precipitation, and extreme weather events - are affecting Nigeria's rich and diverse ecosystems. Key findings indicate that climate change is leading to significant shifts in species distribution and abundance. Species adapted to specific environmental conditions are either migrating to more favorable areas or facing the risk of extinction due to habitat loss and changing ecological dynamics. The study reveals that these changes have profound impacts not only on ecological balance but also on the socio-economic fabric of Nigeria, particularly in communities heavily dependent on natural resources. Additionally, the research explores the efforts being made in Nigeria regarding adaptation and mitigation strategies in response to climate change. It assesses the effectiveness of these strategies in conserving biodiversity and promoting sustainable economic growth and development. The study emphasizes the need for robust policy interventions, increased research and monitoring, community engagement, and international collaboration to effectively address the challenges posed by climate change to Nigeria's biodiversity. In conclusion, the study underscores the urgent need for integrated and proactive approaches to mitigate the adverse effects of climate change on biodiversity. It calls for enhanced conservation efforts, policy reforms, and global cooperation to preserve Nigeria's unique ecosystems and ensure the sustainability of its natural resources for future generations. This comprehensive assessment aims to inform policymakers, conservationists, and stakeholders, contributing to the global discourse on climate change and biodiversity conservation.

**Keywords:** Climate change, distribution and abundance, plant, animal, species



## INTRODUCTION

The study of the impact of climate change on the distribution and abundance of plant and animal species in Nigeria is a crucial area of research, considering the significant ecological, economic, and cultural implications. Nigeria, with its diverse ecosystems ranging from the Sahel Savannah in the north to the dense rainforests in the south, provides a unique context to understand the dynamics of climate change and its effects on biodiversity.

Climate change, primarily driven by global warming due to anthropogenic activities, is causing significant alterations in weather patterns, resulting in phenomena like increased temperatures, erratic rainfall, severe droughts, and rising sea levels. These changes have profound effects on the habitats and the survival of various species. In Nigeria, the increasing desertification in the north and the erosion and inundation of coastal areas in the south due to rising sea levels are vivid examples of these impacts (Ayanlade, 2017).

The distribution and abundance of species are directly influenced by climatic conditions such as temperature, rainfall, and humidity. As these parameters shift, there is a corresponding change in the habitat ranges of various species. For instance, species that are adapted to cooler climates may find it increasingly difficult to survive as temperatures rise, leading to a possible decline in their population or a shift in their geographical range. Similarly, changes in rainfall patterns can affect the growth and survival of plant species, which in turn impacts the animals that depend on these plants for food and shelter (Ogboi, 2019).

Nigeria's rich biodiversity, including endemic species, is at risk due to these climate-induced changes. The potential loss of biodiversity not only threatens the ecological balance but also has socioeconomic repercussions. For example, many rural communities in Nigeria depend on natural resources for their livelihoods, and the depletion of these resources could have dire consequences for their survival (Udofia, 2018).

Furthermore, the loss of biodiversity due to climate change can lead to a decrease in ecosystem services, such as water purification, pollination, and carbon sequestration, which are vital for human well-being and environmental sustainability (Emmanuel, 2020). The alteration in species distribution and abundance also has implications for conservation strategies, as current protected areas may no longer be suitable for the species they were designed to protect.



This study seeks to comprehensively analyze the impact of climate change on the distribution and abundance of plant and animal species in Nigeria, using a combination of field observations, historical data analysis, and climate modeling. The outcomes of this study are expected to provide insights into the extent of climate change impacts on Nigerian biodiversity and inform policy decisions and conservation strategies to mitigate these impacts.

Understanding the impact of climate change on biodiversity in Nigeria is not only essential for conserving its unique ecosystems but also for ensuring the sustainability of the natural resources that are vital for the country's socio-economic development.

The problem of climate change and its impact on the distribution and abundance of plant and animal species in Nigeria is a pressing environmental issue that demands immediate attention. This problem is multifaceted and encompasses various aspects of ecological, economic, and social concerns.

At the ecological level, climate change poses a significant threat to biodiversity. Nigeria, being a country with a rich diversity of ecosystems, is experiencing drastic changes in its climate patterns. These changes are leading to habitat loss, shifts in species distribution, and in some cases, species extinction. The rising temperatures and changing rainfall patterns are altering the natural habitats, making them less suitable for the current resident species. For example, species in the Sahel Savannah are experiencing habitat loss due to desertification, while coastal ecosystems are being impacted by rising sea levels and increased salinity (Ayanlade, 2017).

The economic implications of these ecological changes are profound. In Nigeria, a large proportion of the population depends on agriculture and natural resources for their livelihoods. Changes in the distribution and abundance of species can disrupt the ecological balance, leading to reduced agricultural yields and loss of biodiversity, which in turn affects food security and income sources. The decline in fish populations due to altered aquatic ecosystems, for instance, directly impacts the fishing industry, a crucial economic sector for many communities (Ogboi, 2019).

Socially, the impacts of climate change on biodiversity can lead to resource conflicts and displacement of communities. As resources become scarce, competition for these resources can intensify, leading to conflicts among communities. Additionally, the loss of natural resources and



the resultant economic hardships can force communities to migrate in search of better living conditions, leading to internal displacement and social unrest (Udofia, 2018).

Another critical aspect of this problem is the loss of ecosystem services. Ecosystem services such as pollination, water purification, and climate regulation are vital for human survival and well-being. The disruption of these services due to changes in species distribution and abundance can have far-reaching consequences for environmental sustainability and human health (Emmanuel, 2020).

The current conservation strategies and policies may not be adequate to address the rapidly changing environmental conditions. There is a need for dynamic conservation approaches that take into account the projected changes in climate and their impact on biodiversity. The establishment of protected areas, for example, needs to be re-evaluated in light of the shifting habitats to ensure the continued survival of species.

The problem of climate change and its impact on the distribution and abundance of plant and animal species in Nigeria is a complex issue with ecological, economic, and social dimensions. This problem not only threatens the unique biodiversity of Nigeria but also has significant implications for the livelihoods, food security, and well-being of its population. Addressing this issue requires a holistic approach that encompasses scientific research, policy-making, and community engagement. Hence this study will seek to examine the periodic assessment of current and future climate change impacts on biodiversity in Nigeria and the ecological interaction between climate change and biodiversity in Nigeria.

## **Conceptual Review**

### **Climate Change**

The concept of climate change encompasses a broad range of environmental changes and is a subject of increasing concern and study in the context of global sustainability. It refers to significant and lasting changes in the statistical distribution of weather patterns over periods that can range from decades to millions of years. These changes can manifest in various forms, including alterations in temperature, precipitation patterns, and the frequency and intensity of extreme weather events.



Climate change is predominantly driven by human activities, particularly the emission of greenhouse gases such as carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O). The burning of fossil fuels for energy, deforestation, and industrial processes contribute to the concentration of these gases in the Earth's atmosphere, leading to the greenhouse effect. This effect involves the trapping of the sun's warmth in the Earth's lower atmosphere, causing global temperatures to rise, a phenomenon commonly referred to as global warming (IPCC, 2014).

The impacts of climate change are diverse and far-reaching. One of the most evident consequences is the increase in global average temperatures. According to the National Aeronautics and Space Administration (NASA), the Earth's average surface temperature has risen by about 1.18 degrees Celsius since the late 19th century, a change driven largely by increased carbon dioxide emissions into the atmosphere (NASA, 2020). This warming is altering weather patterns, leading to more frequent and severe heatwaves, storms, and droughts.

Another significant impact of climate change is the rising of sea levels. The increase in global temperatures is causing the melting of ice caps and glaciers, and the expansion of seawater as it warms, leading to a rise in sea levels. This poses a significant threat to coastal communities and low-lying areas, increasing the risk of flooding and potentially leading to displacement of populations (Church, 2013).

Climate change also has profound effects on ecosystems and biodiversity. Changes in temperature and precipitation patterns are altering habitats, thus affecting the distribution and behavior of plant and animal species. This can lead to shifts in the timing of natural events like migration and reproduction, and in some cases, can lead to species extinction. The loss of biodiversity can disrupt ecosystems, affecting their ability to provide services such as pollination, water filtration, and carbon storage (Pecl, 2017).

Agriculture is another sector significantly impacted by climate change. Changes in temperature and precipitation patterns can affect crop yields, soil fertility, and the incidence of pests and diseases. This not only impacts food security but also has socio-economic implications, especially in regions where agriculture is a primary source of livelihood (Lobell, 2011).

Furthermore, climate change poses significant health risks. Increased temperatures and changing weather patterns can lead to more frequent and intense heatwaves, which can cause heat-related illnesses and deaths. Changes in climate can also alter the distribution of vector-borne diseases



like malaria and dengue fever, and can increase the risks of water-borne diseases due to more frequent and severe flooding (McMichael, 2006).

Addressing climate change requires global cooperation and action. This includes reducing greenhouse gas emissions, transitioning to renewable energy sources, conserving and restoring forests, and developing sustainable agricultural practices. International agreements such as the Paris Agreement aim to strengthen the global response to the threat of climate change by keeping global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius (United Nations, 2015).

Climate change is a complex and multi-dimensional issue with significant environmental, social, and economic implications. It is a global challenge that requires coordinated action at international, national, and local levels to mitigate its impacts and adapt to its consequences.

### **Distribution and Abundance of Plant and Animal Species**

The distribution and abundance of plant and animal species are fundamental concepts in ecology and biogeography, significantly influencing ecosystem structure, function, and biodiversity. These concepts are inherently linked and play a crucial role in understanding ecological dynamics, species conservation, and environmental management.

#### **Distribution of Species**

The distribution of species refers to the geographic area over which a species is found. This distribution is determined by various biotic and abiotic factors including climate, soil type, availability of water, interactions with other species (such as competition, predation, and symbiosis), and historical and evolutionary processes. For example, the distribution of a particular plant species might be confined to regions with specific temperature and moisture conditions (Gaston, 2003).

Climate is often the primary factor influencing the distribution of species. Temperature and precipitation patterns define the suitable habitats for different species. For instance, cacti are predominantly found in arid and semi-arid environments due to their adaptations to limited water availability (Nobel, 1988). Similarly, animal species like polar bears are adapted to cold environments and are thus primarily found in Arctic regions (Stirling and Derocher, 2012).



Geographical barriers such as mountains, rivers, and oceans also play a significant role in species distribution. These barriers can limit the movement of species, leading to geographical isolation and, over time, to speciation. The Wallace Line, for example, is a faunal boundary line that runs through Indonesia and represents the boundary between the ecozones of Asia and Australasia, significantly influencing the distribution of animal species in these regions (van Oosterzee, 1997).

### **Abundance of Species**

Abundance, on the other hand, refers to the number of individuals of a species within a given area. It is a measure of how common or rare a species is in its habitat or across its distribution range. Abundance can vary over time and space due to various factors, including environmental changes, availability of resources, predation pressure, and competition with other species.

Resource availability is a key determinant of species abundance. For plants, factors like sunlight, soil nutrients, and water availability can limit growth and reproduction, thereby influencing their abundance in an area. In animal populations, food availability, habitat quality, and the presence of predators or competitors are critical factors determining abundance (Krebs, 2001).

Human activities have significantly influenced the distribution and abundance of species worldwide. Habitat destruction, pollution, overexploitation, and the introduction of invasive species have altered ecosystems, often leading to the decline or extinction of native species. For example, deforestation in tropical regions has led to the loss of habitat for a vast number of species, reducing their distribution and abundance (Foley, 2005).

Conservation efforts often focus on understanding and managing the distribution and abundance of species, particularly those that are rare or endangered. Protected areas, wildlife corridors, and habitat restoration are among the strategies used to maintain or enhance species abundance and distribution.

The study of the distribution and abundance of plant and animal species is critical for understanding ecological patterns and processes, for conserving biodiversity, and for managing natural resources sustainably. As human-induced environmental changes continue to impact ecosystems, understanding these concepts becomes increasingly important for ecological research and conservation efforts.



## **Methodology**

The methodology for this study on the impacts of climate change on biodiversity in Nigeria primarily involves an extensive review of existing literature. This literature review approach is chosen to provide a comprehensive understanding of the current state of knowledge, encompassing various aspects of the subject matter. The primary focus is on academic and scientific articles, reports from relevant governmental and non-governmental organizations, and case studies that specifically address the effects of climate change on the biodiversity of plant and animal species within Nigeria. This includes examining theoretical backgrounds, previous empirical studies, and current discussions surrounding the topic. The literature review also extends to an examination of the current progress and effectiveness of adaptation and mitigation strategies implemented in Nigeria to combat the effects of climate change, particularly in relation to preserving biodiversity and promoting sustainable economic growth and development.

In conducting this literature review, electronic databases such as JSTOR, ScienceDirect, and Google Scholar are utilized to source relevant academic and peer-reviewed articles. Keywords and phrases such as "climate change in Nigeria", "biodiversity impacts due to climate change", "adaptation strategies in Nigeria", and "mitigation of climate change effects on ecosystems" are used in search queries to ensure a wide yet focused collection of literature. Special attention is given to studies published in the last decade to ensure the relevancy and timeliness of the data. Moreover, official reports from international bodies such as the United Nations Framework Convention on Climate Change (UNFCCC) and local Nigerian environmental agencies are reviewed to understand policy implications and on-ground actions. This methodological approach allows for a holistic understanding of the impacts of climate change on biodiversity in Nigeria, providing insights into both the ecological consequences and the socio-economic dimensions of the issue, thus facilitating a comprehensive analysis crucial for suggesting future research directions and policy recommendations.

## **Findings and Discussion**

### **The Periodic Assessment of Current and Future Climate Change Impacts on Biodiversity in Nigeria**





The periodic assessment of current and future climate change impacts on biodiversity in Nigeria is an essential scientific and policy-driven process that involves regularly evaluating and documenting the ongoing and potential future effects of climate change on the country's diverse ecosystems and species. This process is crucial for understanding the extent of climate-related changes and for devising effective strategies to mitigate and adapt to these impacts. The assessment encompasses various dimensions, including ecological, socio-economic, and cultural aspects, and is informed by a range of scientific, observational, and traditional knowledge sources.

### **Ecological Impact Assessment:**

The ecological component of the assessment focuses on understanding how climate change affects the distribution, abundance, and health of plant and animal species in Nigeria. This involves monitoring changes in species' ranges, phenology (the timing of biological events), population dynamics, and ecosystem functions. For example, studies have shown shifts in the distribution of species as they move to higher altitudes or latitudes in response to changing temperature and precipitation patterns (Parmesan & Yohe, 2003). The assessment also looks at the health of ecosystems, such as forests, savannas, freshwater systems, and coastal habitats, and evaluates how changes in these ecosystems affect biodiversity.

### **Socio-Economic and Cultural Dimensions:**

Beyond ecological impacts, the assessment also considers the socio-economic and cultural implications of biodiversity changes due to climate change. This includes understanding how changes in ecosystem services (such as pollination, water purification, and carbon sequestration) affect livelihoods, especially for communities that depend directly on natural resources. Additionally, the cultural significance of biodiversity, including traditional uses of plants and animals, cultural practices, and spiritual values associated with nature, is considered, as these are often integral to the identity and well-being of local communities (Adger, 2013).

### **Methodological Approaches:**

The methodologies used in these assessments typically include field observations, remote sensing, species distribution modeling, and ecological forecasting. These methods provide data on current biodiversity trends and project future changes under different climate scenarios. Long-



term ecological studies are particularly valuable, as they provide insights into the gradual impacts of climate change over time.

### **Policy and Management Implications:**

The findings from these assessments have significant implications for conservation policy and management strategies. They inform the development of conservation plans, including the establishment of protected areas, restoration projects, and the management of wildlife corridors that facilitate species migration in response to climate shifts. Furthermore, these assessments guide national and regional policies on climate change mitigation and adaptation, and contribute to international efforts such as the United Nations Framework Convention on Climate Change (UNFCCC) and the Convention on Biological Diversity (CBD).

### **Challenges and Future Directions:**

One of the key challenges in conducting these assessments is the uncertainty associated with climate change projections and their impacts on biodiversity. This uncertainty necessitates a flexible and adaptive approach to biodiversity management and policy-making. Additionally, there is a need for increased collaboration between scientists, policy-makers, and local communities to ensure that the assessments are comprehensive and that their findings are effectively communicated and implemented.

The periodic assessment of the impacts of climate change on biodiversity in Nigeria is a crucial exercise that helps in understanding and managing the complex interactions between climate change and biodiversity. It provides valuable insights for conservation and sustainable development, ensuring that biodiversity and ecosystem services are preserved for future generations.

### **The Ecological Interaction between Climate Change and Biodiversity in Nigeria**

and coastal regions, are differentially impacted by climate change. For instance, in forest ecosystems, increased temperatures and changes in rainfall patterns can affect tree phenology and productivity. This, in turn, impacts the fauna that rely on these forests, including birds, insects, and mammals. Changes in forest composition and density can lead to the loss of habitat for forest-dependent species and may also alter the carbon sequestration capacity of these forests, further contributing to climate change (Ayansina & Oso, 2016).



In savanna ecosystems, which cover a significant portion of Nigeria, climate change can lead to more frequent and intense wildfires, exacerbated by longer dry seasons and increased temperatures. These wildfires not only destroy habitats but also release large amounts of carbon dioxide, perpetuating the cycle of climate change. Additionally, changes in the duration and intensity of rainy seasons can affect the growth patterns of grasses and trees, impacting the herbivores that depend on them and the predators that feed on these herbivores (Boko, 2007).

Freshwater ecosystems in Nigeria, such as rivers and lakes, are also vulnerable to climate change. Alterations in precipitation and temperature can affect water flow and quality, impacting aquatic biodiversity. Changes in water temperature can affect the life cycles and distribution of fish and other aquatic organisms, while changes in water flow can impact the availability of breeding and feeding grounds (Fashae, 2014).

Coastal regions in Nigeria are facing the impact of rising sea levels and increased frequency of extreme weather events, such as storms and floods. These changes can lead to the loss of coastal habitats such as mangroves, which are crucial for a variety of species, including fish, birds, and crustaceans. Additionally, ocean acidification, a result of increased carbon dioxide absorption by seawater, poses a significant threat to marine biodiversity, affecting coral reefs and the myriad of species that depend on them (Okonkwo, 2019).

### **Socio-Economic Implications:**

The interaction between climate change and biodiversity also has significant socio-economic implications in Nigeria. Biodiversity underpins many aspects of the Nigerian economy, including agriculture, fisheries, and tourism. Changes in biodiversity due to climate change can thus have direct impacts on food security, livelihoods, and the overall economic well-being of the population. For example, changes in fish populations due to altered aquatic ecosystems directly impact the fishing industry, a crucial economic sector for many communities in Nigeria (Oyebola, 2017).

The ecological interaction between climate change and biodiversity in Nigeria is a complex interplay of direct and indirect effects, impacting various ecosystems and species in different ways. Understanding these interactions is crucial for developing effective conservation and adaptation strategies to mitigate the impacts of climate change on Nigeria's rich biodiversity.



---

## Conclusion

This study has extensively examined the impacts of climate change on biodiversity in Nigeria, a topic of critical importance given the country's rich and diverse ecosystems. The findings reveal that climate change, driven by both natural and anthropogenic factors, is having profound and multifaceted effects on Nigeria's biodiversity. These impacts are not only ecological but also have significant socio-economic and cultural ramifications.

The loss of biodiversity and the degradation of ecosystems as a result of climate change are alarming. Key manifestations include shifts in species distribution, reduction in species abundance, and the threat of extinction for numerous endemic species. This biodiversity loss undermines the ecological balance, affecting ecosystem services essential for human survival and well-being. The consequences extend to food security, livelihoods, and cultural identity, particularly in a country where a large portion of the population is directly dependent on natural resources.

The study underscores the urgent need for effective strategies to mitigate and adapt to the impacts of climate change. While Nigeria has made some progress in this regard, there is a clear need for more robust and coordinated efforts. This includes implementing policies that address the root causes of climate change, such as reducing greenhouse gas emissions, promoting sustainable land use practices, and enhancing renewable energy use. Conservation efforts must be strengthened to protect vulnerable species and ecosystems, and to maintain the ecological integrity of the country.

Furthermore, the study highlights the importance of ongoing research and monitoring to understand the evolving impacts of climate change on biodiversity. Such efforts are essential for adapting conservation strategies to changing conditions and for informing policy decisions. Collaboration at national and international levels is crucial in addressing this global challenge, as climate change knows no borders.

The impacts of climate change on biodiversity in Nigeria are significant and far-reaching, threatening not only the ecological balance but also the socio-economic fabric of the nation. Proactive and concerted efforts are required to safeguard Nigeria's rich biodiversity and to ensure the sustainable development and well-being of its people. As this study illustrates, understanding



and addressing the challenges posed by climate change to biodiversity is not just an environmental concern, but a necessity for the holistic development and resilience of Nigeria.

### **Recommendations**

Based on the findings of this study on the impacts of climate change on biodiversity in Nigeria, the following recommendations are proposed to address the challenges and mitigate the adverse effects:

**Strengthening Policy and Regulatory Frameworks:** The Nigerian government should develop and enforce more robust policies and regulations aimed at conserving biodiversity and mitigating climate change. This includes updating existing environmental laws to address current challenges posed by climate change, promoting sustainable land use practices, and ensuring the protection of endangered species and their habitats. The integration of climate change mitigation strategies into national development plans is crucial. Additionally, policies that incentivize the adoption of renewable energy sources and the reduction of greenhouse gas emissions should be prioritized.

**Enhancing Research and Monitoring:** There is a need for ongoing research and monitoring to better understand the evolving impacts of climate change on biodiversity. Investment in scientific research that focuses on the effects of climate change on different ecosystems and species in Nigeria is essential. This includes monitoring changes in species distributions, abundances, and ecosystem health. The data collected should be used to inform adaptive management strategies and policy decisions, ensuring they are based on the latest scientific evidence.

**Community Engagement and Education:** Efforts to combat the impacts of climate change on biodiversity should include active participation and education of local communities. Raising awareness about the importance of biodiversity and the effects of climate change can foster community-led conservation initiatives. Local communities should be empowered through education and resources to adopt sustainable practices such as agroforestry, sustainable fishing, and the use of renewable energy. Engaging communities in conservation projects can also provide alternative livelihoods that are less harmful to the environment.

**International Collaboration and Funding:** Climate change is a global issue, and its effective mitigation requires international cooperation. Nigeria should actively engage in international



climate change forums and initiatives to exchange knowledge, secure funding, and collaborate on climate action. Partnerships with international bodies, NGOs, and other countries can facilitate access to financial resources, technical expertise, and best practices in biodiversity conservation and climate change adaptation. Securing international funding can support large-scale conservation projects, research initiatives, and the implementation of advanced technologies to combat climate change effects.

Implementing these recommendations requires a multi-faceted approach involving government, non-governmental organizations, the private sector, local communities, and international partners. By adopting these strategies, Nigeria can make significant strides in preserving its rich biodiversity, ensuring ecological sustainability, and fostering a resilient future in the face of climate change.

## References

- Adger, W. N., (2013). Cultural dimensions of climate change impacts and adaptation. *Nature Climate Change*, 3(2), 112-117.
- Anwadike, B. C. (2020). Climate Change and Biodiversity in Nigeria. *Nigerian Journal of Environmental Sciences*.
- Ayanlade, A., Radeny, M., & Morton, J. F. (2017). Climate Change and Livestock: Impacts, Adaptation, and Mitigation. *Climate Risk Management*, 16, 145-163.
- Ayansina, A., & Oso, B. (2016). Impacts of Climate Change on Forest Biodiversity. *Journal of Environmental Science and Climate Change*.
- Boko, M., (2007). Africa. *Climate Change 2007: Impacts, Adaptation and Vulnerability*.
- Church, J. A., Clark, P. U., Cazenave, A., Gregory, J. M., Jevrejeva, S., Levermann, A., ... & Unnikrishnan, A. S. (2013). Sea-level rise by 2100. *Science*, 342(6165), 1445.
- Crawfor, R. M. M. (2005). Effects of Climate Change on Plant and Animal Species. *Journal of Ecological Studies*.
- Emmanuel, R., Joshua, S., & Johnson, A. E. (2020). Climate Change and Ecosystem Services: Implications for Sustainable Development in Nigeria. *Environment and Ecology Research*, 8(4), 200-209.

- Fashae, O. A., (2014). Climate Change and Freshwater Ecosystems in Nigeria. *International Journal of Environmental Science*.
- Foley, J. A., DeFries, R., Asner, G. P., Barford, C., Bonan, G., Carpenter, S. R., ... & Snyder, P. K. (2005). Global consequences of land use. *Science*, 309(5734), 570-574.
- Gaston, K. J. (2003). *The Structure and Dynamics of Geographic Ranges*. Oxford University Press.
- Hansen, J., Sato, M., Ruedy, R., Lacis, A., & Oinas, V. (2000). *Global warming in the twenty-first century: An alternative scenario*. Proceedings of the National Academy of Sciences.
- Idowu, O. A., Ayoola, M. B., Opele, A. I., & Ikenweiwe, N. B. (2011). Climate Change and Biodiversity in Nigeria. *Journal of Environmental Science and Policy*.
- IPCC. (2014). *Climate Change 2014: Synthesis Report*. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC.
- Krebs, C. J. (2001). *Ecology: The Experimental Analysis of Distribution and Abundance*. Benjamin Cummings.
- Lobell, D. B., Schlenker, W., & Costa-Roberts, J. (2011). Climate trends and global crop production since 1980. *Science*, 333(6042), 616-620.
- McMichael, A. J., Woodruff, R. E., & Hales, S. (2006). Climate change and human health: present and future risks. *The Lancet*, 367(9513), 859-869.
- NASA. (2020). *Global Climate Change: Vital Signs of the Planet*.
- Nigeria Fifth National Biodiversity Report. (2015). *Ministry of Environment, Nigeria*.
- Nobel, P. S. (1988). *Environmental Biology of Agaves and Cacti*. Cambridge University Press.
- Ogboi, K., Ede, P. N., & Okafor, U. (2019). Impacts of Climate Change on Biodiversity: Adaptation and Mitigation Strategies. *International Journal of Environmental Science and Technology*, 22(2), 123-132.
- Okonkwo, C., (2019). Impact of Climate Change on Coastal and Marine Biodiversity in Nigeria. *Marine Biodiversity Journal*.
- Oyebola, O. O., (2017). Climate Change and Fishery Resources in Nigeria. *Journal of Fisheries and Aquatic Science*.

- Parmesan, C., & Yohe, G. (2003). A globally coherent fingerprint of climate change impacts across natural systems. *Nature*, 421(6918), 37-42.
- Parmesan, C., & Yohe, G. (2003). *A globally coherent fingerprint of climate change impacts across natural systems*. Nature.
- Pecl, G. T., Araújo, M. B., Bell, J. D., Blanchard, J., Bonebrake, T. C., Chen, I. C., ... & Williams, S. E. (2017). Biodiversity redistribution under climate change: Impacts on ecosystems and human well-being. *Science*, 355(6332).
- Sala, O. E., (2000). Global Biodiversity Scenarios for the Year 2100. *Science*.
- Stirling, I., & Derocher, A. E. (2012). Effects of climate warming on polar bears: a review of the evidence. *Global Change Biology*, 18(9), 2694-2706.
- The Intergovernmental Panel on Climate Change (IPCC). (2007). *Climate Change 2007: The Physical Science Basis*.
- The National Academy of Science. (2020). *Global Climate Change Trends and Evidence*.
- Udofia, S. I., Sam, E. F., & Ekanem, E. E. (2018). Climate Change and Crop Production in Nigeria: An Overview. *International Journal of Agriculture and Earth Science*, 4(1), 1-10.
- United Nations Environment Programme. (2010). *Global Biodiversity Outlook*.
- United Nations. (2015). *Paris Agreement*. United Nations Framework Convention on Climate Change.
- USAID Report on Biodiversity and Tropical Forestry Assessment. (2002). United States Agency for International Development.
- Van Oosterzee, P. (1997). *Where Worlds Collide: The Wallace Line*. Cornell University Press.
- Walter, L., Ulisses, R., Abdul-Lateef, B., Andréia, F., Serafino, T., Desalegn, W., Edmond, D., Adeleke, R., Felix, S., & Nicholas, M. (2021). Climate Change Adaptation in Africa. *African Journal of Environmental Science*.
- World Rainforest Movement. (1999). *Deforestation in Nigeria: Causes, Effects, and Solutions*.