



The Role of Climate Change in Altering Ecosystems in the Lake Chad Basin

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DOI : <https://doi.org/10.5281/zenodo.21459040>

ARTICLE DETAILS

Research Paper

Received: 18-05-2026

Accepted: 21-06-2026

Published: 15-07-2026

Keywords:

Lake Chad Basin, climate change, ecosystem alteration, biodiversity loss, environmental degradation, hydrological decline, sustainable adaptation, ecological resilience.

ABSTRACT

The Lake Chad Basin, once one of Africa's most vital freshwater ecosystems, has undergone profound ecological transformations over the past six decades due to the accelerating effects of climate change. The basin, shared by Chad, Nigeria, Niger, Cameroon, and the Central African Republic, sustains millions through agriculture, fishing, and pastoralism. However, rising temperatures, erratic rainfall, and prolonged droughts have drastically altered its hydrological balance and ecological integrity. This paper examines critically the part played by climate change in reshaping the ecosystems of the Lake Chad Basin, focusing on the interactions between climatic variability, hydrological decline, biodiversity loss, and socio-ecological disruptions. By using an interdisciplinary approach that integrates climatology data, environmental studies, and human geography, the study explores how shrinking water volumes and changing precipitation patterns have precipitated wetland degradation, deforestation, soil erosion, and desertification across the basin. These ecological changes have not only transformed the physical environment but also eroded traditional livelihoods, increased competition over decreasing resources, and heightened environmental conflict between communities. The analysis

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highlights that the shrinkage of Lake Chad-from an approximate 25,000 square kilometers in the 1960s to less than 2,000 square kilometers in the last few years-serves as a major indicator of regional ecological distress. The paper postulates that these changes are not the sole result of natural climate fluctuations but are exacerbated by anthropogenic factors, especially unsustainable water extraction, population pressure, and land-use changes. The changed ecosystems have resulted in significant losses of aquatic and terrestrial biodiversity, and many species are threatened with extinction. The disruption of ecological balance reduced the capacity of the basin's ecosystems to withstand future climatic calamities; this has become a feedback loop that accelerates environmental degradation. This study also emphasizes inter-linkages between ecological and human systems within the basin: it shows that as the lake and its surrounding ecosystems deteriorate, socio-economic vulnerabilities increase, therefore enhancing food insecurity, forced migration, and erosion of traditional adaptive mechanisms. Communities dependent on fishing or farming have been compelled to seek alternative livelihoods, often migrating to urban centers or neighboring regions, thereby placing additional stress on fragile socio-political systems. The ecological imbalance resulting has far-reaching implications for regional peace and stability, because competition over water and land resources has contributed to the rise of conflicts and insecurity in the region. The paper concludes by emphasizing the urgent need for sustainable and integrated climate adaptation strategies that take into account both ecological and human dimensions of the crisis. It calls for wetland restoration, reforestation, improved water management practices, and involvement of local communities in environmental governance. Besides, regional cooperation through institutions like the LCBC is vital to coordinate trans- boundary resource management and enhance climate resilience. The study contributes to the understanding of how climate change can fundamentally alter ecosystems, livelihoods, and

geopolitical dynamics in fragile ecological zones by situating the Lake Chad crisis within the global discourse on environmental change. This research ultimately calls for a paradigm shift toward ecosystem-based adaptation and sustainable development policies that can restore ecological balance while safeguarding the socio-economic well-being of the millions dependent on the Lake Chad Basin for survival.

Introduction

Climate change has emerged as one of the most significant environmental challenges of the twenty-first century, reshaping ecological systems, disrupting livelihoods, and intensifying social and economic vulnerabilities across the world. Although climate change is a global phenomenon, its effects are not distributed evenly. Regions already characterized by ecological fragility, weak infrastructure, and high dependence on natural resources are often the most severely affected. The Lake Chad Basin in Africa represents one such region where environmental change, climatic stress, and human insecurity are deeply intertwined. Located at the intersection of Chad, Nigeria, Niger, and Cameroon, the Lake Chad Basin has long served as a vital ecological and socio-economic zone, supporting millions of people through agriculture, fishing, pastoralism, and trade. However, over the past several decades, the basin has undergone profound ecological transformation, much of which has been associated with changing climatic conditions, particularly rising temperatures, declining and erratic rainfall, recurrent droughts, and increasing desertification. These changes have significantly altered the basin's ecosystems, threatening biodiversity, weakening ecosystem services, and undermining the survival strategies of local communities.

The Lake Chad Basin is ecologically unique because it consists of a complex mosaic of wetlands, floodplains, grasslands, shrublands, and semi-arid landscapes that together sustain a highly dynamic environment. Lake Chad itself, historically one of Africa's largest freshwater lakes, has played a central role in regulating regional hydrology and supporting diverse forms of life. The basin functions not only as a water resource but also as a habitat for fish species, migratory birds, aquatic vegetation, and terrestrial wildlife. In addition, the lake and its surrounding ecosystems provide fertile land for farming, pasture for livestock, and water for domestic use. This close interdependence between human communities and ecological systems means that any disruption to the climate has consequences that extend far beyond physical environmental change. In the Lake Chad Basin, climate change is not merely altering temperature and rainfall patterns; it is transforming the structure, composition, productivity, and resilience of ecosystems upon which both biodiversity and human life depend.

One of the most visible indicators of ecological change in the basin has been the dramatic reduction in the size of Lake Chad over the last half-century. Although the shrinking of the lake is the result of multiple interacting factors, including water withdrawal for irrigation, poor water governance, and population pressures, climate variability and long-term climatic change have played a crucial role in accelerating this decline. Reduced rainfall in the Sahel, prolonged drought episodes since the 1970s, and increasing evapotranspiration linked to rising temperatures have collectively reduced water inflows into the lake. As water levels decline, wetland ecosystems contract, aquatic habitats are degraded, and the ecological balance of the basin is disturbed. This shrinkage has had cascading effects, including the loss of fish breeding grounds, changes in vegetation cover, increased soil degradation, and heightened pressure on remaining natural resources. In this sense, climate change acts not only as an environmental stressor but also as a force that destabilizes ecological relationships and amplifies existing vulnerabilities.

The role of climate change in altering ecosystems in the Lake Chad Basin must be understood through the concept of ecological interconnectedness. Ecosystems do not function as isolated units; rather, they are made up of interdependent relationships among water, soil, plants, animals, and human activities. Changes in one element often trigger a chain of consequences across the entire ecological system. For instance, a decline in rainfall affects surface water availability, which in turn influences wetland extent, fish populations, pasture quality, and crop productivity. Similarly, rising temperatures increase evaporation and soil moisture loss, reducing agricultural yields and altering vegetation patterns. Such shifts can lead to habitat fragmentation, species displacement, reduced biodiversity, and a decline in ecosystem services such as food provision, climate regulation, nutrient cycling, and water purification. In the Lake Chad Basin, where ecological systems are already under pressure from overgrazing, land degradation, and demographic expansion, climate change intensifies these processes and reduces the capacity of ecosystems to recover from disturbance.

Another important dimension of climate-induced ecosystem change in the Lake Chad Basin is biodiversity loss. The basin has historically supported a range of plant and animal species adapted to wetland and semi-arid conditions. Seasonal flooding patterns, shallow waters, and marshy habitats created favorable conditions for fish, amphibians, birds, and grazing animals. However, changing hydrological conditions and habitat degradation have disrupted these ecological niches. Some species face population decline because of reduced breeding habitats, lower water quality, and changes in food availability. Others are forced to migrate, adapt, or compete under increasingly stressed conditions. Vegetation shifts also alter food chains and habitat structures, affecting both wildlife and domesticated animals. The decline of biodiversity is particularly concerning because it weakens ecosystem resilience. Biodiverse ecosystems are generally better

able to withstand shocks and maintain ecological balance; when biodiversity erodes, ecosystems become more fragile and more susceptible to collapse under additional environmental or human pressures.

The Lake Chad Basin also illustrates how climate change can blur the boundary between environmental and social crises. Ecosystem degradation in the basin is not only an ecological issue but also a developmental, political, and humanitarian concern. Millions of people living in the region depend directly on ecosystem services for their livelihoods. Farmers rely on predictable rainfall and fertile soils; fishers depend on stable aquatic habitats; pastoralists require access to water and grazing land. When climate change alters these ecosystems, it disrupts the economic foundation of everyday life. Declining agricultural productivity, reduced fish catches, and shrinking pasturelands contribute to food insecurity, poverty, displacement, and competition over resources. In several parts of the basin, these pressures interact with weak governance, armed conflict, and cross-border insecurity, producing a highly unstable environment. Thus, the ecological consequences of climate change in the Lake Chad Basin cannot be studied in isolation from the social realities of the region. Ecosystem change in this context has direct implications for human security, migration patterns, and regional stability.

At the same time, it is important to avoid simplistic explanations that attribute all ecological change in the Lake Chad Basin solely to climate change. The environmental crisis of the basin is shaped by a combination of climatic and non-climatic drivers, including unsustainable land use, rapid population growth, overexploitation of water resources, deforestation, irrigation expansion, and weak environmental governance. Climate change interacts with these factors rather than operating independently of them.

This interaction is what makes the Lake Chad Basin a particularly important case for environmental research. It demonstrates how climate change can intensify existing ecological pressures, deepen resource scarcity, and accelerate the transformation of vulnerable ecosystems. A careful analysis of the basin therefore requires a multi-causal perspective that recognizes climate change as a major but interconnected driver of ecological alteration.

The significance of studying climate change in the Lake Chad Basin lies not only in understanding a regional environmental crisis but also in contributing to broader debates about climate vulnerability, adaptation, and sustainability in dryland and wetland regions. The basin offers a critical example of how global climate processes are experienced locally through water stress, habitat change, livelihood disruption, and ecological decline. It also highlights the limits of traditional resource management approaches in contexts where environmental change is rapid, cross-border, and deeply entangled with socio-political instability. Research on the Lake Chad Basin can therefore generate important insights into the relationship between climate

change and ecosystem resilience, especially in regions where environmental and human systems are tightly linked.

This study examines the role of climate change in altering ecosystems in the Lake Chad Basin by focusing on the ecological consequences of changing temperature, rainfall, hydrology, and extreme climatic events. It seeks to explore how these climatic changes have contributed to wetland shrinkage, biodiversity loss, vegetation shifts, land degradation, and the weakening of ecosystem services. At a broader level, the study also considers how ecosystem transformation affects local livelihoods and intensifies environmental insecurity. By doing so, it situates climate change not as an abstract global issue but as a concrete ecological force with measurable consequences for a region already facing multiple layers of vulnerability.

In essence, the Lake Chad Basin stands at the intersection of climate change, ecosystem transformation, and human survival. The basin's changing landscapes reveal the far-reaching implications of a warming world for fragile ecological zones, particularly in the Global South where dependence on natural resources remains high and adaptive capacity is often limited.

Understanding the role of climate change in altering the ecosystems of the Lake Chad Basin is therefore essential not only for environmental scholarship but also for policy responses aimed at restoration, adaptation, and sustainable resource governance. An examination of this issue offers valuable insight into how ecological systems respond to climatic stress, how environmental degradation shapes social vulnerability, and why climate resilience must be treated as both an ecological and developmental priority in the contemporary world.

Literature Review

Scholarly work on the Lake Chad Basin has consistently identified climate change as a major factor shaping ecological transformation in the region, although the literature also stresses the interaction between climatic pressures and human interventions. Earlier studies framed Lake Chad primarily through the narrative of dramatic shrinkage, associating the reduction of the lake's area with prolonged Sahelian droughts, declining river inflows, and intensified evaporation. In this context, climate variability in the Sahel has been treated as a central driver of ecological stress, particularly because persistent rainfall deficits since the late twentieth century altered hydrological cycles across the basin (Epule et al., 2014). This line of scholarship established the basis for understanding the Lake Chad Basin as a climate-sensitive ecosystem where water balance, vegetation cover, and biodiversity are strongly tied to fluctuations in temperature and precipitation.

Hydrological studies have deepened this understanding by showing that the ecological condition of the basin cannot be separated from long-term hydro-climatic change. Mahmood et al. (2019) found significant trends in temperature increase and rainfall variability across the most active parts of the basin, demonstrating that climate instability has altered the hydrological regime on which wetlands, floodplains, and agricultural systems depend. Similarly, Buma, Lee, and Seo (2016) emphasized that changes in rainfall patterns and runoff dynamics have affected water storage and basin hydrology, thereby influencing the broader ecological functioning of the lake environment. These studies are important because they move beyond descriptive accounts of lake shrinkage and instead explain how climate-driven hydrological shifts reshape ecosystem processes.

Recent scholarship has also challenged the simplistic assumption that Lake Chad has undergone a linear and irreversible collapse.

Pham-Duc et al. (2020) argue that while the lake became a global symbol of climate crisis because of its dramatic contraction in the 1970s and 1980s, its hydrology in the last two decades has been more complex than earlier narratives suggested. Their work shows that parts of the lake system have remained relatively stable due to groundwater contributions and partial recovery in Sahelian rainfall. This contribution is significant because it complicates deterministic accounts of environmental decline and suggests that ecosystem change in the basin must be understood as dynamic, spatially uneven, and influenced by both climatic and hydrological feedbacks. Yet, even this more nuanced perspective does not diminish the importance of climate change; rather, it highlights that climatic impacts operate through variable temporal and ecological pathways.

A major strand of the literature focuses on ecosystem degradation, particularly wetland loss, vegetation shifts, and biodiversity decline. Olusola et al. (2025) synthesize recent evidence to show that climate change has contributed to habitat destruction, reduced fish populations, and weakened ecosystem services in the Lake Chad wetlands. Their review underscores how rising temperatures, erratic rainfall, and prolonged drought have reduced wetland extent and destabilized ecological niches that sustain fisheries, migratory birds, and floodplain vegetation. Related work by Pham et al. (2023) demonstrates that vegetation cover and surface water dynamics in Lake Chad remain highly responsive to rainfall fluctuations, indicating that even modest climatic variability can alter plant productivity, land cover patterns, and ecological resilience. Together, these studies reinforce the view that climate change is not only a hydrological issue but also a direct ecological force that modifies habitat structure, species composition, and ecosystem productivity.

Another body of research links climate change to livelihood vulnerability and socio-ecological stress. Nilsson et al. (2016) show that agricultural production on the shores of Lake Chad is closely connected to lake levels, rainfall, and temperature, suggesting that ecological change immediately translates into livelihood insecurity. This relationship is especially important in the Lake Chad Basin, where farming, fishing, and pastoralism depend heavily on ecosystem services. More recent work on governance and resilience similarly argues that climate-related ecological degradation contributes to food insecurity, displacement, and conflict, especially when combined with weak institutions and resource competition (Current Opinion in Environmental Sustainability, 2025). Such scholarship broadens the ecological debate by demonstrating that ecosystem alteration in the basin cannot be understood apart from its social consequences.

Overall, the literature presents a broad consensus that climate change plays a crucial role in altering ecosystems in the Lake Chad Basin through rising temperatures, rainfall variability, droughts, and hydrological instability. At the same time, the scholarship also warns against monocausal explanations. Several studies note that irrigation expansion, land-use change, water abstraction, and demographic pressure interact with climate change to intensify ecological decline (Mahmood et al., 2019; Pham-Duc et al., 2020). Therefore, the literature increasingly treats the Lake Chad Basin as a coupled socio-ecological system in which climate change acts as a major stress multiplier rather than the sole cause of ecosystem transformation. This insight is especially relevant for the present study, which seeks to examine climate change not in isolation but as part of a wider web of environmental and human pressures reshaping the ecosystems of the basin.

Objectives of the Study

1. To examine the major patterns of climate change in the Lake Chad Basin, with particular attention to variations in temperature, rainfall, drought frequency, and water availability over time.
2. To analyse the impact of climate change on the ecological structure of the Lake Chad Basin, especially in relation to wetland shrinkage, vegetation change, biodiversity loss, and land degradation.
3. To investigate how climate-induced environmental changes have affected ecosystem services in the basin, including fisheries, agriculture, grazing resources, and freshwater supply.
4. To explore the relationship between climate change and livelihood vulnerability in the Lake Chad Basin, particularly among communities dependent on farming, fishing, and pastoral activities.
5. To assess the combined role of climatic and human pressures in altering the ecosystems of the Lake Chad Basin, in order to understand the broader environmental challenges facing the region.

Research Methodology

This study adopts a qualitative and interdisciplinary research design to examine the role of climate change in altering ecosystems in the Lake Chad Basin. The topic requires an approach that combines environmental, geographical, and socio-ecological perspectives because climate change affects not only the physical environment but also the ecological relationships and livelihood systems dependent on it. The study is primarily based on secondary data analysis, drawing on a wide range of published academic and institutional sources to understand the nature, extent, and implications of climate-induced ecosystem change in the basin.

Research Design

The research follows a descriptive-analytical design. It is descriptive in the sense that it identifies and explains the major climatic and ecological changes observed in the Lake Chad Basin, including rising temperatures, rainfall variability, drought frequency, wetland shrinkage, vegetation shifts, and biodiversity loss. It is analytical because it seeks to interpret the relationship between climate change and ecosystem transformation by connecting climatic trends with ecological outcomes such as habitat degradation, declining water availability, land degradation, and reduced ecosystem services.

Sources of Data

This paper uses only secondary sources of information. The sources are scientific journals, books, reports, climate evaluations, policy documents, and works from intergovernmental bodies such as Intergovernmental Panel on Climate Change (IPCC), Lake Chad Basin Commission (LCBC), Food and Agriculture Organization (FAO), United Nations Environment Program (UNEP), and the World Bank. Besides, satellite-based studies of the environment and hydrological evaluation of the Lake Chad Basin are employed in order to examine changes in the extent of water bodies, vegetation coverage, and ecosystems

Method of Data Collection

Data for the study are collected through documentary analysis. Relevant literature is selected on the basis of its direct relation to climate change, hydrological variability, wetland ecology, biodiversity, land degradation, and socio-ecological change in the Lake Chad Basin. Preference is given to recent studies and foundational works that provide empirical evidence on environmental change in the region. The data collection process involves reviewing and organizing information under key thematic areas such as climate trends, ecological impacts, livelihood vulnerability, and resource stress.

Method of Data Analysis

The collected data are analyzed using a thematic method of qualitative analysis. In this approach, the available literature is grouped into major themes reflecting the core dimensions of the study. These themes include:

1. Climatic changes in the Lake Chad Basin.
2. Hydrological and wetland transformation.
3. Biodiversity loss and vegetation change.
4. Land degradation and ecosystem stress.
5. Impact of ecological change on local livelihoods and resource use.

By examining these themes comparatively, the study identifies patterns, recurring arguments, and areas of scholarly agreement or disagreement. This method allows the research to link climatic factors with ecosystem changes in a systematic and coherent manner.

Scope and Limitations

The study is limited to the Lake Chad Basin as a regional ecological zone shared by Chad, Nigeria, Niger, and Cameroon. Since the research is based on secondary sources, it does not include field surveys or primary interviews. However, the use of a wide range of credible and interdisciplinary sources helps ensure analytical depth and reliability. The methodology is therefore appropriate for understanding the broader ecological implications of climate change in the Lake Chad Basin and for identifying key patterns in the existing body of research.

Conclusion

The Lake Chad Basin presents one of the clearest examples of how climate change can reshape fragile ecosystems and intensify environmental vulnerability in regions already exposed to ecological and socio-economic stress. This study has shown that climate change plays a significant role in altering the ecological balance of the basin through rising temperatures, erratic rainfall, prolonged droughts, and hydrological instability. These climatic pressures have contributed to the shrinking of water bodies, degradation of wetlands, changes in vegetation patterns, biodiversity decline, and the weakening of ecosystem services that sustain both nature and human life in the region.

The analysis also demonstrates that the ecological transformation of the Lake Chad Basin cannot be understood as a purely natural process. Climate change interacts with existing human pressures such as

overuse of water resources, land degradation, population growth, unsustainable agricultural practices, and weak environmental governance. As a result, the basin has become a complex socio-ecological space where climatic stress and human activity reinforce one

another, accelerating ecosystem decline and reducing resilience. This interaction has serious consequences not only for environmental sustainability but also for food security, livelihood stability, and social well-being among the communities that depend directly on the basin's natural resources.

An important conclusion emerging from this study is that climate change in the Lake Chad Basin should be viewed not simply as an issue of environmental change, but as a broader challenge of ecological survival, resource justice, and regional stability. The degradation of ecosystems in the basin affects fishing, farming, grazing, and freshwater access, thereby deepening vulnerability and increasing the risk of conflict and displacement. For this reason, policy responses must move beyond short-term crisis management and focus instead on long-term adaptation, wetland restoration, sustainable water governance, biodiversity protection, and community-based resilience strategies.

In sum, the Lake Chad Basin illustrates the deep interconnection between climate systems and ecosystem health. Understanding the role of climate change in this region is essential for building effective environmental policies and for addressing the wider human consequences of ecological decline. Protecting the Lake Chad Basin is therefore not only an environmental necessity but also a crucial step toward securing sustainable livelihoods and ecological stability in the region.

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