# A Systematic Review of the Economic Impacts of the Shrinking Lake Chad Basin: Challenges and Pathways for Sustainable Development

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***Abstract-*** ***Over the past six decades, the Lake Chad Basin has undergone dramatic environmental transformation, marked by a severe reduction in water resources that has disrupted traditional livelihoods and precipitated widespread socio-economic instability. This systematic review aims to synthesize extant literature on the challenges facing the basin and evaluate potential pathways for sustainable development. A comprehensive search of peer-reviewed articles, policy reports, and technical documents was conducted using multiple electronic databases, and the gathered literature was analyzed thematically. Key findings indicate that climatic shifts and unsustainable water management practices have been primary drivers of the lake's shrinkage, leading to reduced agricultural productivity, fisheries collapse, and heightened resource conflicts. Moreover, persistent governance weaknesses and rapid population growth have compounded these environmental challenges, further undermining regional stability. The review concludes that a holistic, multi-stakeholder approach—integrating technical innovations, robust governance reforms, and community-driven resilience strategies—is essential to break the cycle of fragility and promote inclusive, long-term development in the Lake Chad Basin.***

***Indexed Terms-*** ***Lake Chad Basin, Sustainable Development, Environmental Degradation, Governance, Resilience***

## I. INTRODUCTION

The Lake Chad Basin, once a vital freshwater resource in Africa, has undergone a dramatic transformation over the past six decades. Covering approximately 25,000 square kilometers in the 1960s, the lake has now diminished by about 90%, currently spanning a mere fraction of its former size (World Bank, 2022). This significant reduction has profoundly affected the livelihoods of over 50 million people across Chad, Nigeria, Niger, and Cameroon, who rely on the lake for agriculture, fishing, and livestock rearing (Brookings Institution, 2017).

Several factors have contributed to the lake's shrinkage. Climate change has led to erratic rainfall patterns and increased temperatures, resulting in higher evaporation rates (Climate Refugees, 2020). Additionally, overuse of water resources for irrigation and the construction of upstream dams have reduced inflow into the lake (UN Africa Renewal, 2019). Population growth has further escalated the demand for water, exacerbating the lake's depletion (Global Tipping Points Report, 2023).

The economic ramifications of Lake Chad's decline are extensive. The reduction in water availability has led to decreased agricultural productivity, adversely affecting food security and income for local farmers (World Bank, 2022). Similarly, the fisheries sector has suffered substantial losses, with declining fish stocks impacting the primary source of protein and livelihood for many residents (Institute for Security Studies, 2020). Overall, the region has experienced an estimated 6% loss in welfare, with Chad alone facing a 9% decline (World Bank, 2022).

Despite the existing body of research, there remains a critical gap in comprehensive analyses that integrate the multifaceted economic impacts of the lake's shrinkage with sustainable development strategies. Many studies have focused on environmental and social aspects, yet a holistic economic perspective is lacking. This gap hinders the formulation of effective policies and interventions tailored to the unique challenges of the Lake Chad Basin.

This systematic review aims to bridge this gap by synthesizing current literature on the economic impacts of the shrinking Lake Chad Basin. It will critically examine challenges across various sectors, including agriculture, fisheries, and trade, and explore sustainable development pathways that have been proposed or implemented in the region. By providing a comprehensive analysis, this study seeks to inform policymakers, stakeholders, and researchers about effective interventions and policies that can foster economic resilience and sustainable development in the Lake Chad Basin.

## II. MATERIAL AND METHODS

This study employed a systematic review approach to synthesize existing research on the challenges and pathways for sustainable development in the Lake Chad Basin. The review followed a structured protocol to ensure a comprehensive and unbiased collection, selection, and analysis of relevant literature.

## III. THE STUDY AREA

The study area for this research is the Lake Chad Basin, a vast and ecologically complex region located in the heart of West and Central Africa (Figure 1). Historically, Lake Chad was one of the largest freshwater bodies in Africa, covering an area of approximately 25,000 square kilometers during the 1960s. Today, it has dramatically contracted to a mere fraction of its former size, reflecting severe environmental degradation and a long-term decline in water availability (Figure 2).

Geographically, Lake Chad is situated in the Sahel region with an approximate latitude range of 11°N to 15°N and longitude range of 12°E to 18°E. Its central coordinates are roughly 13°N latitude and 14°E longitude, though the lake's irregular shape and the fluctuating water levels cause these values to vary over time. The basin spans several countries—primarily Chad, Nigeria, Niger, and Cameroon—with additional portions extending into the Central African Republic. This transboundary nature not only emphasizes the ecological importance of the lake but also underscores the complexity of its management, as the basin's resources are shared among multiple national jurisdictions.

The hydrological system of the Lake Chad Basin is characterized by an endorheic drainage network, where water inflow is predominantly derived from seasonal rivers and rainfall, while evaporation and sedimentation significantly influence water levels. The climate in the region is highly variable, with prolonged dry spells interspersed with intense, episodic rainfall events that contribute both to the lake's shrinkage and its occasional seasonal recoveries. These climatic conditions, combined with unsustainable water management practices and rapid population growth, have resulted in a complex socio-environmental dynamic that affects the livelihoods of millions who depend on the basin for agriculture, fishing, and pastoralism.

## IV. DATA SOURCES AND SEARCH STRATEGY

Multiple electronic databases were searched to gather peer-reviewed articles, policy reports, and technical documents related to Lake Chad's environmental degradation, socio-economic challenges, governance issues, and sustainable development pathways. Databases included Web of Science, Scopus, JSTOR, and Google Scholar, complemented by targeted searches of organizational websites such as those of the World Bank, UNDP, and regional agencies. The search strategy employed a combination of keywords and Boolean operators, including terms such as "Lake Chad," "sustainable development," "environmental degradation," "governance," "conflict," "resilience," "water management," and "climate change." The search was restricted to publications in English and spanned from the 1960s, when Lake Chad's decline began to be documented, to the present.

## V. INCLUSION AND EXCLUSION CRITERIA

Studies were included if they focused primarily on the Lake Chad Basin and addressed issues related to environmental change, socio-economic impacts, governance challenges, or development pathways. Both quantitative and qualitative studies, as well as review articles and policy reports, were considered. Publications that did not provide substantive analysis or were not directly relevant to the central themes of this review were excluded. Priority was given to studies that provided empirical data, robust

methodological approaches, or comprehensive policy analyses.

## VI. STUDY SELECTION AND DATA EXTRACTION

The initial search results were screened by title and abstract to identify potentially relevant studies. Full-text articles of selected papers were then reviewed for eligibility based on the inclusion criteria. Data extraction was conducted using a standardized form that captured key information including study objectives, methodologies, major findings, and policy recommendations. Special attention was given to studies that addressed multiple dimensions of the crisis in the Lake Chad Basin, such as those integrating environmental, socio-economic, and governance perspectives.

## VII. QUALITY APPRAISAL AND DATA SYNTHESIS

Each selected study was appraised for methodological rigor, clarity of presentation, and relevance to the research questions. Quality appraisal tools were adapted to evaluate both empirical and conceptual studies. The findings were synthesized using a narrative approach, organized thematically to highlight common trends, divergences, and gaps in the literature. Triangulation of data from various sources enabled a robust interpretation of the complex interplay between environmental degradation, resource conflicts, governance deficits, and development challenges in the region. The synthesis also identified emerging solutions, such as community-based adaptation, integrated water resource management, and regional cooperation mechanisms, while noting areas that require further research and policy innovation.

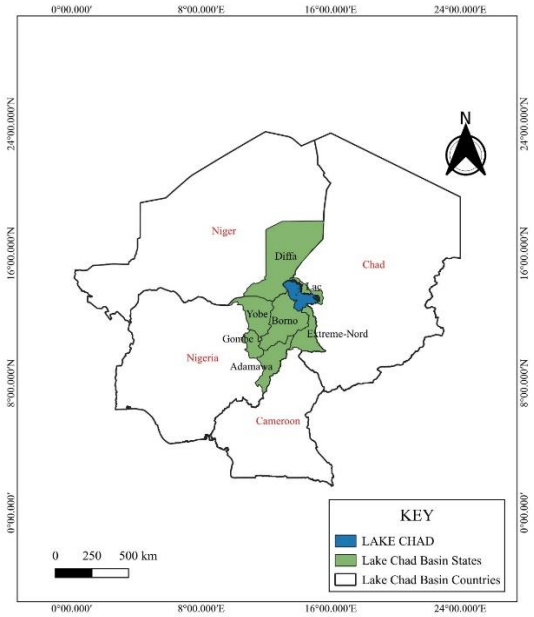
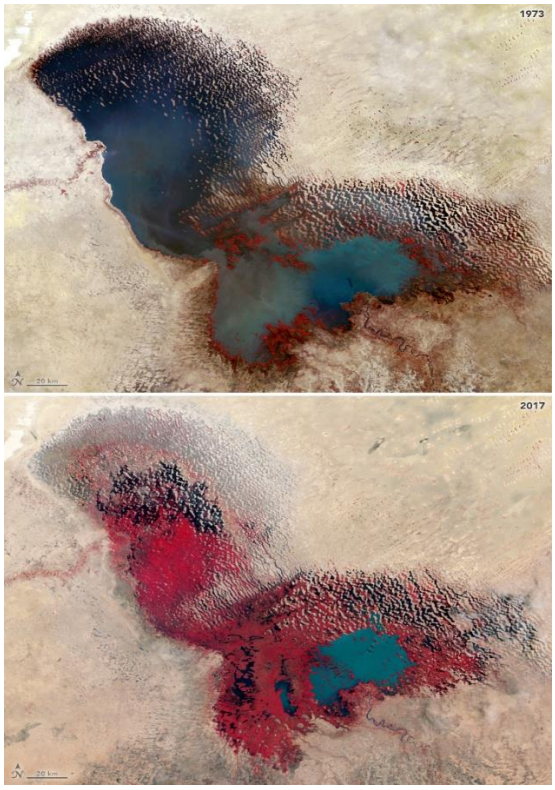



Figure 1: Lake Chad Basin




acquired December 1973 - March, 2017
https://landsat.visibleearth.nasa.gov/view.php?id=91291

Figure 2: Lake Chad Water Extent Shrinkage between 1973 and 2017

## VIII. CAUSES OF LAKE CHAD SHRINKAGE

Lake Chad's dramatic shrinkage over the past six decades is the result of a complex interplay between natural climatic shifts and human interventions. The lake, once sprawling over 25,000 square kilometers in the 1960s, has now contracted by nearly 90%, a transformation that has sparked considerable concern among researchers and policymakers alike. A growing body of literature highlights that declining precipitation patterns and rising temperatures—hallmarks of global climate change have fundamentally altered the hydrological regime of the basin. Mahmood and Jia (2018) provide robust evidence that reduced rainfall has significantly curtailed the discharge from the Chari-Logone river system, which historically sustained Lake Chad, while Zhao, Cook, and Vizy (2022) demonstrate that increased temperatures are accelerating evaporation rates, further diminishing the lake's water levels.

In addition to these climate-induced stresses, unsustainable water management practices have played a pivotal role in exacerbating the lake's decline. Isaac and Ackah (2020) argue that the over-extraction of water for irrigation, driven by rapid population growth and an expanding agricultural sector, has diverted critical water resources away from the lake. Mahmood and Jia (2019) quantify the impact of such anthropogenic pressures, attributing a significant portion of the reduced streamflow to human activities, including extensive water withdrawals and infrastructural developments such as dam construction. These modifications not only disrupt the natural seasonal flow but also prevent the lake from receiving the full benefit of its sporadic replenishments during wetter periods, thereby compounding the effects of climate change.

Environmental degradation further complicates the picture. The loss of vegetation cover and the onset of desertification have weakened the natural capacity of the surrounding landscape to retain moisture and recharge groundwater, essential processes for sustaining Lake Chad. Gbetkom et al. (2023) emphasize that this degradation creates a feedback loop in which reduced water levels lead to further loss of vegetation, thereby accelerating soil erosion and diminishing the land's water retention abilities. This interplay between environmental degradation and hydrological stress underscores the multifaceted nature of the crisis, where each factor amplifies the others, leading to a self-reinforcing cycle of decline.

While some researchers, such as Pham-Duc et al. (2020) and Sylvestre et al. (2024), note that seasonal variations in precipitation may occasionally yield temporary recoveries, these intermittent gains are largely insufficient to counteract the long-term trends driven by both climate variability and human overuse. The commentary by Mariama Sow (2017) adds a policy perspective, noting that proposals to recharge the lake—such as diverting water from the Ubangi River—reflect an emerging consensus that innovative and integrated water resource management strategies are urgently needed. Collectively, these studies argue that without a comprehensive and coordinated approach addressing both climatic and anthropogenic drivers, Lake Chad's shrinkage will likely continue, with profound socio-economic and ecological repercussions for the region.

## IX. ECONOMIC IMPACTS

The persistent shrinkage of Lake Chad has precipitated a complex crisis that is simultaneously environmental, economic, and social, with far-reaching implications for the region's development and stability. As Lake Chad receded from its vast expanse of approximately 25,000 km² in the 1960s to a fraction of that size today, its contraction has directly undermined traditional livelihood sectors such as agriculture, fisheries, and animal husbandry. Granguillhome et al. (2021) describe the Lake Chad Basin as an integrated yet fragile region where longstanding structural deficits including weak governance, limited infrastructure, and poor access to basic services compound the adverse effects of environmental change. The shrinking lake has not only diminished water resources critical for irrigation and fishing but has also accelerated land degradation, thus reducing the productivity of rain-fed agriculture and flood recession farming. Riebe and Dressel (2021) argue that although a reduction in water might theoretically expose new land for cultivation, the negative impacts on food security exemplified by lower crop yields and diminished fish stocks far outweigh any potential benefits.

The economic repercussions are multifaceted. Eriegha et al. (2019) report that climate change coupled with heightened water demand from agricultural activities has brought Lake Chad's fisheries resources to the brink of collapse, thereby stripping rural communities of a vital source of nutrition and income. They advocate for the implementation of culture-based fisheries (CBF) as a community-driven strategy to augment fish production through the careful stocking of water bodies, which may help to partially restore lost livelihoods. In parallel, the socioeconomic landscape has been further destabilized by conflict and forced migration. Idika-Kalu (2019) highlights that the once-flourishing Lake Chad Basin known for its vibrant markets, agricultural productivity, and diverse economic opportunities has been decimated by severe drought and, more recently, by the Boko Haram insurgency. This militant violence, which began in 2002 and has since spread across the basin, has not only inflicted direct harm through violent attacks and displacement but has also eroded local economies by disrupting trade, destroying infrastructure, and forcing communities to abandon their traditional livelihood practices.

The Joint Environmental Audit on the Drying Up of Lake Chad (GIZ, 2015) provides a detailed account of how the lake's shrinkage has reconfigured both its hydrological and economic landscapes. The audit demonstrates that the dramatic reduction in the lake's surface area exacerbated by erratic rainfall patterns and unsustainable water management practices es in water access and economic opportunities. This, in turn, has fueled a vicious cycle of poverty and underdevelopment. Jedwab et al. (2023) quantify the overall welfare losses in the region, estimating a decline of approximately 6 percent in the basin with losses in Chad reaching as high as 9 percent thereby highlighting the severe economic ramifications of environmental degradation.

Moreover, the interplay between environmental decline and social disruption is evident in the observed demographic trends. Studies indicate that areas in close proximity to the shrinking lake have experienced markedly slower population growth, particularly in rural communities that depend on its resources. The reduction in available water has not only diminished agricultural productivity and fishery yields but has also forced many to migrate in search of better opportunities, thereby exacerbating rural depopulation and contributing to urban overcrowding.

Collectively, the literature underscores that Lake Chad's shrinkage is a catalyst for a broader regional crisis. The convergence of diminished natural resources, declining economic outputs, and escalating conflict creates a self-reinforcing cycle of environmental and socioeconomic fragility. Addressing this complex challenge requires an integrated policy response that not only focuses on immediate relief such as the implementation of culture-based fisheries to restore fish stocks and targeted interventions to support agriculture but also on long-term structural reforms. As Granguillhome et al. (2021) and the Joint Environmental Audit (GIZ, 2015) suggest, breaking the cycle of underdevelopment and fragility will necessitate coordinated efforts to improve infrastructure, enhance regional governance, facilitate trade and connectivity, and implement sustainable natural resource management practices. Only through such holistic approaches can the Lake Chad Basin begin to transition toward a more resilient and inclusive economic future.

## X. CHALLENGES TO SUSTAINABLE DEVELOPMENT

The challenges to sustainable development in the Lake Chad Basin are complex and multidimensional, arising from the interplay of environmental degradation, governance weaknesses, resource conflicts, and economic vulnerabilities. Over the decades, the dramatic contraction of Lake Chad from its peak of approximately 25,000 km² in the 1960s to less than 10% of that area at its nadir has precipitated severe disruptions to traditional livelihoods such as agriculture, fisheries, and pastoralism. Jedwab et al. (2023) estimate that these environmental changes have resulted in overall welfare losses of around 6 percent in the region, with losses reaching up to 9 percent in Chad, where communities are most dependent on the lake. Riebe and Dressel (2021) further note that, although receding water might suggest increased land availability, the loss of critical water resources for irrigation and aquaculture overwhelmingly negates

any such potential benefits, thereby exacerbating food insecurity and deepening poverty.

The environmental crisis is compounded by governance challenges that have long plagued the basin. Granguillhome et al. (2021) described a region characterized by fragmented institutional frameworks and weak intergovernmental coordination among the riparian states, which impedes effective resource management and conflict resolution. In this context, the Lake Chad Basin Commission's Vision 2025 (LCBC, 2024) articulates a strategic framework for integrated river basin management emphasizing conservation, restoration, and enhanced regional cooperation to counteract the vicious cycle of underdevelopment. However, the implementation of such policies is hampered by persistent infrastructural deficiencies and a lack of data-driven decision-making, as underscored in the Joint Environmental Audit (GIZ, 2015).

Conflict and insecurity further complicate the region's development trajectory. Newman, Khiabani, and Chandran (2023) demonstrated that ecological stresses stemming from reduced water availability, erratic weather patterns, and resource mismanagement are closely linked with increases in agro-pastoral conflict and insurgency-related violence. Okpara et al. (2015) offer a salient perspective by arguing that conflicts in the Lake Chad Basin are not solely a product of water scarcity but are significantly influenced by pre-existing vulnerabilities such as poverty, institutional weakness, and socio-economic inequalities. These conditions create an environment in which even minor environmental perturbations can trigger violent outbreaks, particularly in areas where the adaptive capacity of local communities is severely constrained.

Adding another layer of complexity, the comprehensive assessment by Vivekananda et al. (2019) on "Shoring Up Stability - Addressing Climate and Fragility Risks in the Lake Chad Region" reveals that the people of Lake Chad are caught in a "conflict trap." Their research, based on extensive fieldwork, satellite data, and over 200 interviews, shows that decades of conflict, poverty, and human rights violations have fractured social bonds and weakened local governance. Although the lake's overall size has stabilized somewhat in recent years with the northern pool still experiencing high variability, the effects of climate change remain pronounced. Rising temperatures occurring 1.5 times faster than the global average along with erratic rainfall patterns, have created severe uncertainty for communities that depend on the lake for planting and fishing. This uncertainty, when combined with ongoing violent conflict and massive displacement, has intensified resource competition, driven recruitment into armed groups, and perpetuated cycles of instability and deprivation. The assessment by Vivekananda et al. (2019) concludes that addressing the region's fragility requires integrated interventions that not only tackle climate change but also promote social cohesion, strengthen governance, and support resilient livelihoods.

Collectively, these studies paint a sobering picture of the Lake Chad Basin as a region where environmental degradation, compounded by weak governance and socio-economic vulnerabilities, has fueled a persistent cycle of conflict and underdevelopment. The evidence suggests that breaking this cycle will require a holistic approach, one that integrates climate adaptation strategies, robust institutional reforms, and conflict-sensitive development initiatives. Only through such comprehensive, coordinated policy interventions can the Lake Chad Basin hope to transition from a state of chronic fragility to one of sustainable, inclusive economic growth and stability.

## XI. PATHWAYS FOR SUSTAINABLE DEVELOPMENT IN THE LAKE CHAD BASIN

Pathways for sustainable development in the Lake Chad Basin have been a subject of intense multidisciplinary inquiry, as scholars and practitioners confront a crisis that intertwines environmental degradation, governance failures, resource conflicts, and socio-economic vulnerabilities. Decades of shrinkage—from a historic surface area of approximately 25,000 km² to just a fraction of that—have precipitated severe declines in traditional livelihoods such as agriculture, fisheries, and pastoralism, resulting in estimated regional welfare losses of 6–9% (Jedwab et al., 2023; Riebe & Dressel, 2021). In response, a wide range of solutions has been proposed. Ambitious initiatives such as the Transaqua

Project (Campbell, 2020) aim to reverse water scarcity by transferring water from the Congo Basin, offering potential multiplier effects for regional economic revitalization and pan-African integration. However, these top-down, capital-intensive projects face significant challenges related to financial feasibility, political will, and the persistent fragmentation of governance across national borders (LCBC, 2024; GIZ, 2015).

Complementing these macro-level interventions, community-based strategies have emerged as critical pathways to resilience. Olowoyeye and Kanwar (2023) argue for enhanced water harvesting, the establishment of robust legal frameworks, and incentive-based policies that address the immediate decline in water quality and quantity. Moreover, Okeke-Ogbuafor et al. (2023) demonstrate that fishers and local communities possess a sophisticated understanding of resilience, which should inform context-specific fisheries management and adaptive strategies. Yet, the effectiveness of these initiatives is inherently linked to the broader governance environment, as evidenced by Okpara et al. (2015), who contend that water-related conflicts in the basin are exacerbated by preexisting vulnerabilities such as poverty, weak institutions, and socio-economic inequities.

A particularly instructive example of an integrated, multinational effort is the Lake Chad Basin Sustainable Development Programme (PRODEBALT), as detailed in the African Development Fund's (2018) Project Completion Report. PRODEBALT was designed to address the severe degradation trends affecting Lake Chad by aligning its interventions with the Strategic Action Plan and the LCBC Vision 2025. Its components spanned ecosystem protection, adaptation of production systems to climate change, institutional capacity building, and programme management. Through extensive stakeholder consultations and regional workshops, PRODEBALT sought to rehabilitate degraded ecosystems, enhance fisheries and pastoral infrastructure, and strengthen trans-boundary cooperation. Although the programme achieved tangible outcomes such as reforestation, dredging of critical canals, and the construction of pastoral wells it also encountered significant implementation challenges. These included gaps in baseline data, maintenance issues, and delays due to regional insecurity, which underscore the persistent difficulty of translating well-designed strategies into effective on-ground action (African Development Fund, 2018).

Further, the UNDP (2018) background paper on resilience for sustainable development in the Lake Chad Basin argues for a paradigm shift from purely humanitarian responses toward integrated development interventions that build long-term adaptive, transformative, and absorptive capacities. This dual approach emphasizes the need for modernizing the agricultural and livestock sectors, expanding agribusiness value chains, and strengthening regional trade, while also investing in robust governance reforms to enhance policy coordination, social service delivery, and accountability mechanisms. In this context, initiatives like PRODEBALT serve as both a model and a cautionary tale: they illustrate the potential of integrated, participatory approaches to reverse environmental degradation and stimulate socio-economic recovery, while also revealing the critical gaps that remain in funding, institutional capacity, and cross-border coordination.

Moreover, studies by Newman, Khiabani, and Chandran (2023) and Wakdok and Bleischwitz (2021) further illuminate how environmental stresses including erratic rainfall, reduced water flows, and climate-induced degradation are closely linked with the surge in agropastoral conflicts and insurgency-related violence. These factors, coupled with heavy-handed security measures that sometimes exacerbate social divisions, create a complex feedback loop that deepens regional fragility. Griffin (2020) also documents how the changing hydrography of Lake Chad has provided strategic opportunities for violent extremist groups, further complicating the sustainable development challenge.

In summary, the pathway toward sustainable development in the Lake Chad Basin necessitates a holistic, multi-dimensional strategy that integrates technical innovations, robust governance reforms, and community-driven resilience approaches. While transformative projects like Transaqua and

comprehensive programmes such as PRODEBALT offer visionary models for reversing environmental degradation, their long-term success is contingent upon addressing deep-rooted structural deficits, enhancing regional coordination, and ensuring that local communities are fully engaged in the decision-making process. Only through such a coordinated, integrated approach can the chronic fragility of the Lake Chad Basin be transformed into a foundation for resilient, inclusive economic growth and lasting regional stability.

## CONCLUSION

This study set out to explore the multifaceted challenges and potential pathways for sustainable development in the Lake Chad Basin, highlighting the profound interplay between environmental degradation, socio-economic vulnerabilities, governance deficits, and conflict. The research reaffirms that the dramatic shrinkage of Lake Chad over the past six decades has not only disrupted traditional livelihood sectors such as agriculture, fisheries, and pastoralism but has also triggered a cascade of economic losses, food insecurity, and social displacement. Key findings reveal that the lake's contraction is driven by a combination of natural climatic shifts, such as erratic rainfall and increased evaporation, alongside unsustainable human interventions like over-extraction of water and inadequate management of shared resources. These dynamics have amplified existing vulnerabilities, exacerbated regional conflicts, and undermined the capacity of local communities to maintain their traditional ways of life.

The broader implications of these findings are significant. They suggest that the challenges facing the Lake Chad Basin are emblematic of the wider struggles of fragile, transboundary regions, where environmental degradation and socio-political instability are deeply intertwined. Addressing these issues requires an integrated approach that combines technical innovations such as improved water harvesting, ecological restoration, and climate-smart agriculture with robust governance reforms and participatory, community-driven strategies. This dual strategy not only holds the potential to restore the lake's ecological and economic functions but also to foster greater regional stability and inclusive growth.

Despite the valuable insights gained, the study acknowledges several limitations. There is a notable scarcity of comprehensive baseline data and longitudinal empirical studies in this conflict-affected region, which hinders the precise measurement of intervention impacts and the formulation of fully informed policies. Additionally, the complexity of overlapping environmental, economic, and social challenges means that not all factors could be explored in depth, particularly in relation to the salient local socio-cultural dynamics and the long-term effects of policy interventions.

Future research should focus on developing robust, disaggregated baseline datasets and conducting in-depth longitudinal studies to capture the dynamic evolution of environmental and socio-economic conditions in the basin. Further investigation is needed to assess the feasibility and impact of large-scale water transfer projects and to evaluate innovative, community-driven adaptive strategies. In addition, interdisciplinary studies that examine the causal links between climate change, resource scarcity, and conflict will be essential for designing comprehensive, conflict-sensitive development frameworks. Only by addressing these research gaps can policymakers and stakeholders build a more resilient and sustainable future for the Lake Chad Basin.

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