

A SYSTEMATIC REVIEW OF CLIMATE CHANGE AND LOCAL VULNERABILITY AROUND LAKE VICTORIA, TANZANIA

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Corresponding Author: Emmanuel Lwankomezi Geography Department, St. Augustine University of Tanzania, Box 307 Mwanza, Tanzania	Abstract: The Lake Victoria Basin in Tanzania faces rising threats from climate change which endanger both its natural systems and human communities. The review examines current literature on climate change vulnerability through a systematic assessment that focuses on local settings and socio-ecological systems and institutional reaction patterns. The flow Diagram for Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology was used. The study systematically reviewed studies up to July 2024 (N=28) published on the Scopus, Web of Science, Google Scholar and JSTOR. The results show current state of literature on climate vulnerability, how literature frame vulnerability concept, variables involved and future perspectives. The existing research fails to maintain consistent theoretical frameworks while neglecting essential intersectional and place-specific aspects of vulnerability. The review identifies key climate change threats which combine declining water levels with erratic rainfall and increased food insecurity and vector-borne diseases and ecosystem degradation to create intensified human vulnerability. The review advocates for a vulnerability framework which integrates justice principles to understand local experiences while guiding policy development and adaptation planning. The Lake Victoria region needs future research to develop stronger methodologies and include marginalized perspectives for building resilience against growing climate stress.
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Introduction

Recently, climate change has posed threats and global environmental challenges that heavily impact ecosystems, people's livelihoods, and lives. Climate change has manifested in different forms, and its complexity is unique because of the socio-economic vulnerabilities around Lake Victoria in Tanzania (Akwan et al., 2025; Muthoka, Ouko, et al., 2024; Shinhu, 2024). Over the last decades, increased temperatures, unpredictable rainfall patterns, and more frequent extreme weather conditions have been evident, significantly upsetting the lake's ecological balance (Marcus, Hannah, n.d.; Ogotu et al., 2024). These changes disproportionately affect local communities that rely on it for a living, making them more susceptible to its adversities. Even though there exists extensive literature about climate change on a global scale (Arabadzhyan et al., 2021; Dore, 2005; Salimi et al., 2021; Woolway et al., 2020), there is a need for further investigation into its local impacts, particularly around Lake Victoria, to appreciate its discrete susceptibilities and coping mechanisms fully.

The concept of climate vulnerability is very important in appreciating the impacts of climate change on communities, ecosystems, and economies. However, most approaches for defining vulnerability are general and do not consider localized dimensions necessary to design working adaptation strategies (J. X. Kasperson, 2005; Schröter et al., 2005). Within the Lake Victoria basin, the exposure to risks by local people arises from not only environmental changes but also socio-economic levels, politics, and cultures, which worsen exposure and reduce coping mechanisms (Gabrielsson et al., 2013; Muthoka, Ogello, et al.,

2024; Muthoka, Ouko, et al., 2024; Nyboer et al., 2022). The vulnerability concept to climate change must no longer be based only on physical dangers but on social disparities that increase the possibilities for marginalized groups to be affected. The paper posits that the conventional definition of vulnerability is a simplification of the intricate interactions in areas such as Lake Victoria, where there is an intersection between poverty, poor governance structures, and environmental deterioration.

According to Ford (2024), traditional definitions of climate vulnerability do not adequately capture the deep social and political causes that magnify these threats. It usually refers to the inability of a system to absorb or adapt to climate change-induced impacts. This idea does not fully capture the broader reasons for inequalities in society. Nonetheless, common understanding has focused on exposure, sensitivity, and adaptive capacity; however, if we only understand vulnerability in physical terms, we miss how inequalities generated by an unjust system manifest themselves through varied climate impacts due to disparities related to poverty levels, lack of access to governance incentives. Some scholars (Lanlan et al., 2023; Macharia & Kiage, 2024) suggest that the overly narrow view is not only simplistic but also dangerous, owing to its failure to recognize that poor people living under marginal conditions bear most of these difficulties just because they are already disadvantaged economically in longstanding ways. Without recognizing these root problems, decision-makers may perpetuate rather than alleviate vulnerability. A comprehensive approach to climate vulnerability must consider intersectionality



and other structural determinants that drive inequalities and those that increase resilience against threats.

While most of the literature has focused on climate change's ecological consequences (Ali et al., 2021; Kajuni et al., 2024; McClanahan, 2024; Obuya et al., 2024; Rawat et al., 2024), little information is available regarding the threats and socio-economic impacts faced by communities surrounding Lake Victoria. The areas surrounding this lake are endowed with natural resources that support farming, fishery, and tourist activities, but they are mostly vulnerable to climate change. This has led to falling fish catches and crop yields, compromising local livelihoods and food security (Agol et al., 2021; Jatav et al., 2024; Nassali et al., 2020). In addition, the degradation of the environment arising from climate change results in waterborne diseases targeted explicitly at the already vulnerable group. Consequently, the economic impact of these conditions is worsened by inadequate government intervention policies along with poor infrastructure, leaving little room for effective adaptation strategies within such societies (Agol et al., 2021; Marcus, Hannah, n.d.; Muthoka, Ouko, et al., 2024). While studies on vulnerability to climate change exist in Tanzania (Ahmed et al., 2011; Gwambene et al., 2023; Kangalawe et al., 2017; Mkonda, 2022; Paavola, 2008), few have focused on the unique climatic, socio-economic and cultural dimensions that uniquely predispose this region susceptible to climate variability. This systematic review fills the vacuum through a comprehensive analysis of research studies that look into this localized vulnerability, bringing out the specifics of climate effects at Tanzanian shores facing Lake Victoria.

This study aims to systematically review previous literature by providing a progressive approach and in-depth examination of the existing concept of vulnerability around Lake Victoria. Specifically, the study will focus on (i) the framing of the climate change vulnerability concept, (ii) describing the methodology, and instruments and (iii) describing threats and consequences of climate change. This systematic review contributes to the knowledge of climate change vulnerability through our localized approach in Lake Victoria. The paper will also critically examine the current definition of vulnerability and its methodological shortcomings while examining the socio-economic risks associated with climate change. What is proposed here, therefore, is a better-refined appreciation or grasp of the issue about narrowing it down or making it less abstract and interpretable beyond locality regarding adaptation measures that are more truthful at the local level and countrywide. For this reason, the focus of this research is to question the general discourse around climatic vulnerability since local perspectives and adaptive capability hardly come up when responding to climate change.

Theoretical Framework

This study is primarily grounded in vulnerability and the political ecology framework suggested by Sovacool (2021). The vulnerability framework encompasses different dimensions of vulnerability existing in communities facing climate change consequences. According to Yu et al. (2021), vulnerability combines exposure, sensitivity, and adaptive capacity. The Lake Victoria area, for instance, is a good scenario given that it addresses environmental changes and its interaction with socio-economic factors. The changes in the environment around Lake Victoria exacerbated by climate variability, directly determine the

rate at which local communities are exposed to climatic threats. The exposure to climatic changes is worsened by poverty levels and subsistence farming practices, resulting in a lack of adequate resources for adaptation, leaving them vulnerable.

The political ecology framework in this review addresses the socio-political contexts that drive environmental challenges and shape responses to climate change. Environmental changes are embedded in complex social and political dynamics that include power relations (Nightingale et al., 2022), historical injustices (Kojola & Pellow, 2021), and economic dependencies (Hanger-Kopp et al., 2022). In emphasizing these dynamics, Political Ecology criticizes approaches that consider environmental problems without analyzing their relationship with social problems related to access to resources and decision-making processes. This implies that vulnerability to climate change is not just about being physically exposed but encompasses systemic inequalities that determine how communities interact with, adapt to, and recover from natural shocks.

The study transcends an ecological perspective on climate vulnerability by assuming a political ecology framework. It will explore how historical injustices, governance mechanisms, and external pressures escalate local susceptibility to climate change in Lake Victoria. Climate change does not passively affect Communities in these locations but rather shapes their vulnerabilities through activities other than themselves, like policies made by other actors outside, including international markets, affecting the resource needs of these communities and putting certain interests above others in climate policies made locally (Kojola & Pellow, 2021; Muthoka, Ogello, et al., 2024; Nyboer et al., 2022). For example, Commercial fishing-oriented regulations may sideline indigenous fishermen, reducing their access to resources and eroding their traditional livelihoods. This example illustrates that employing strategies without considering political context may lessen and exacerbate climatic risks to local inhabitants. Consequently, it's possible to argue that on matters dealing with climatic vulnerability, a broader perspective comprising environmental interactions structured by wider political and economic forces is needed through applying the Political Ecology lens.

Moreover, examining climate change from the political ecology standpoint implies that social justice and equity should be included besides ecological aspects in resilience and adaptation efforts (Kojola & Pellow, 2021; Nightingale et al., 2022). Policies for tackling vulnerability to weather shifts in or around Lake Victoria must confront prevailing power imbalances by providing equal chances through resource allocation, enabling community involvement in making adjustments. Usually, conventional approaches prioritize technical solutions, e.g., infrastructure development or technology, without considering issues of control over such interventions. For this reason, political ecology insists otherwise by asking questions about who is involved in adaptation strategies and benefits and who is left out here. Consistent with these thoughts, inclusive empowerment-centred responses are needed for adaptation strategies to climate that are relevant to marginalized populations, such as small-scale fishers and peasant farmers, who experience negative impacts from climatic conditions.

Methodology

A systematic literature review is a secondary study in which specific research questions guide the author towards gathering the most meaningful materials on a single topic in adherence to a structure design (Bresser et al., 2024). The identification, screening, eligibility, and synthesis relied on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (O’Dea et al., 2021; Rethlefsen et al., 2021) because it gives straightforward operating principles and an orderly way of carrying out revising activities given that it comes with a flowchart (Figure 1).

The systematic study uses a comprehensive approach to investigate how vulnerability to climate change is framed, threats and consequences of climate change, and methods, instruments, and samples employed in the existing studies. The review process starts with an extensive search for relevant peer-reviewed articles,

technical reports, and literature, as Van Dinter et al. suggested (2021). Databases such as Scopus, Web of Science, Google Scholar and JSTOR were employed. Keywords and phrases like “climate change vulnerability”, “Lake Victoria”, “adaptation strategies”, “socio-economic impacts” and “climate change threats”, among others, formed part of the search strings considering a study’s aims. This systematic review incorporated any study published up to July 2024 because it would help understand current climate change vulnerability issues. The study considered the following inclusion criteria: (a) articles published up to July 2024, (b) articles published in the English language, and (c) articles with empirical data or theoretical frameworks addressing climate change vulnerability. The exclusion criteria for this study were (a) studies conducted outside the Lake region, (b) articles that are associated with climate change vulnerability but lack empirical data or a theoretical framework, (c) articles that focus on climate change without including adaptation or vulnerability.

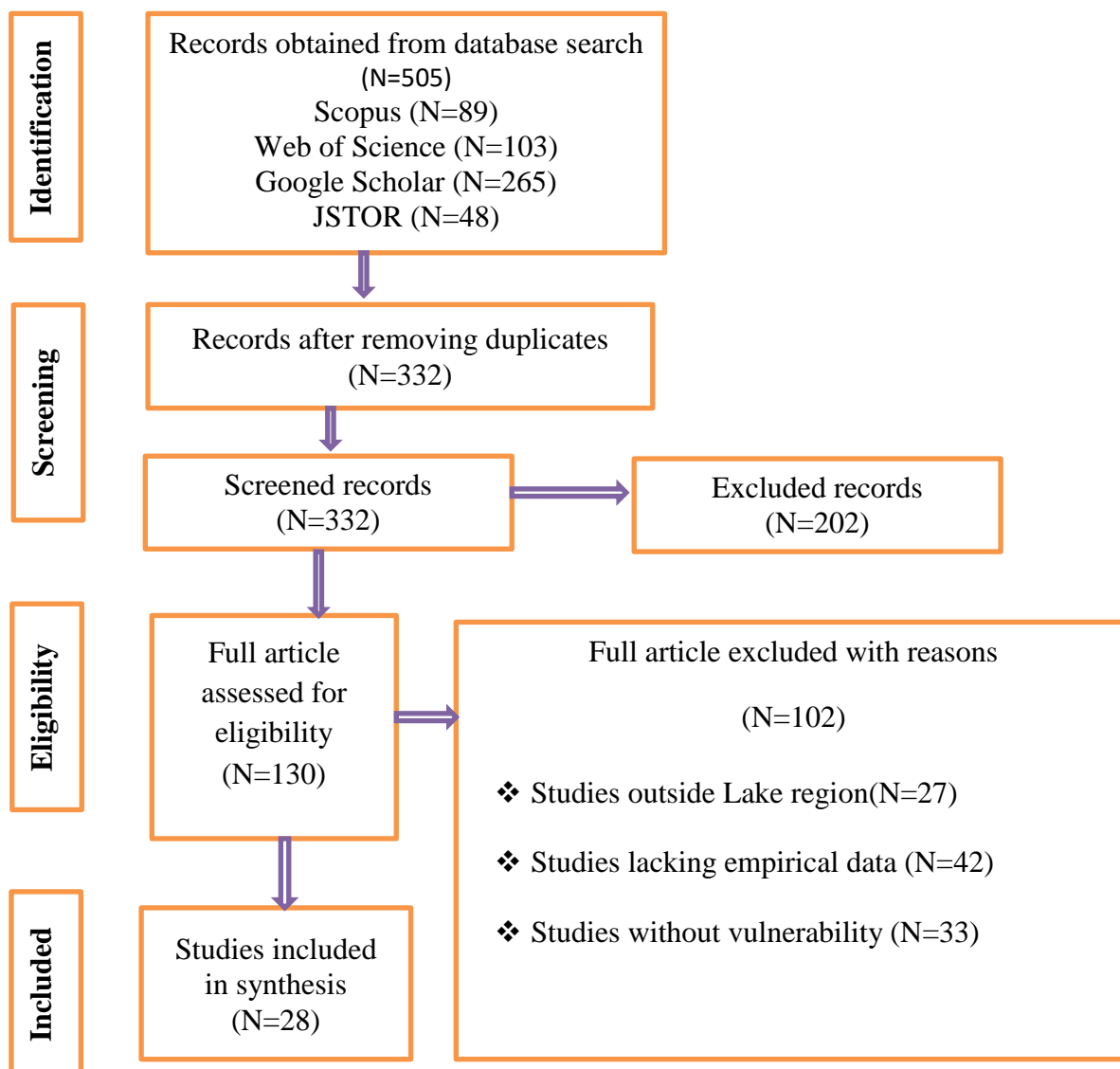


Figure 1: Flow Diagram for Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)

Results

Study characteristics

The systematic review process generated 28 articles presenting diverse characteristics regarding locations, methodologies, and instruments related to climate change vulnerability (Table 1). The 28 articles span four continents and 15 different countries, and most studies were conducted in East Africa.

Table 1: Studies included in the systematic review (N=28)

S/N	Authors And Year	Title	Journal	Country	Study Design
1	Adger, (2006).	Vulnerability	Global Environmental Change	Global, conceptual paper	Review paper
2	Dewan, (2013)	Hazards, Risk, and Vulnerability	Springer Netherlands	Dhaka, Bangladesh	Quantitative, GIS-based empirical study
3	Ototo, et al., (2022)	Forecasting the Potential Effects of Climate Change on Malaria in the Lake Victoria Basin Using Regionalized Climate Projections.	Acta Parasitologica	Kenya, Tanzania, Uganda	Historical epidemiological
4	Mahdaoui, & Alibou, (2022)	From Vulnerability to Urban Resilience to Climate Change	Springer International Publishing	Morocco	Quantitative
5	Thomas, et al., (2019)	Explaining differential vulnerability to climate change	WIREs Climate Change	Across countries	Qualitative meta-synthesis
6	Haasnoot, et al., (2024)	Lessons from a decade of adaptive pathways studies for climate adaptation	Global Environmental Change	Across countries	Literature review with meta-analysis
7	Morris, et al., (2024)	Advancing equitable partnerships: Frontline community visions for coastal resiliency knowledge co-production, social cohesion, and environmental justice	Geoforum	New York and New Jersey, USA	Qualitative,
8	Kojola, & Pellow, (2021)	New directions in environmental justice studies: Examining the state and violence	Environmental Politics	United state	Review paper
9	Nyboer, et al., (2022)	Climate change adaptation and adaptive efficacy in the inland fisheries of the Lake Victoria basin	People and Nature	Uganda	mixed-methods
10	Kajjser, & Kronsell, (2014).	Climate change through the lens of intersectionality	Environmental Politics	Sweden	Qualitative and theoretical
11	Okereke, & Dooley, (2010).	Principles of justice in proposals and policy approaches to avoided deforestation: Towards a post-Kyoto climate agreement	Global Environmental Change	Across countries	Normative, theoretical analysis
12	Eriksen, et al., (2021)	Adaptation interventions and their effect on vulnerability in developing countries: Help, hindrance or irrelevance?	World Development	Developing countries	Qualitative, systematic review
13	Rajkovich, et al., (2024)	New York State Climate Impacts Assessment Chapter 04	Buildings. Annals of the New York Academy of Sciences	New York State	Review paper
14	Agol, et al., (2021)	Ecosystem-based adaptation in Lake Victoria Basin; synergies and trade-offs	Royal Society Open Science	Kenya	Qualitative case study
15	Kajuni, et al., (2024)	Land cover changes between 2010 and 2020 in Lake Victoria basin in	Elsevier	Tanzania	Multi-source remote sensing data

		Tanzania. In <i>The Nile River System, Africa</i>			
16	Nassali, et al., (2020)	A Systematic Review of Threats to the Sustainable Utilization of Transboundary Fresh Water Lakes: A Case Study of Lake Victoria.	International Journal of Scientific and Research Publications (IJSRP)	Tanzania	Systematic literature review
17	Petty, et al., (2022)	Adaptation Planning: An Integrated Approach to Understanding Vulnerability in the Lake Victoria Basin	Frontiers in Climate	Kenya and Uganda	Mixed-methods research
18	Obuya, et al., (2024)	Socioeconomic consequences of cyanobacterial harmful algal blooms in small-scale fishing communities of Winam Gulf, Lake Victoria	Journal of Great Lakes Research	Kenya	Mixed-methods research
19	Cantelmi, et al., (2021)	Reviewing qualitative research approaches in the context of critical infrastructure resilience	Environment Systems and Decisions	Across countries	Systematic literature review
20	Nyamweya, et al., (2020)	A century of drastic change: Human-induced changes of Lake Victoria fisheries and ecology	Fisheries Research	Kenya, Uganda and Tanzania	Longitudinal
21	Odada, et al., (2004)	Mitigation of Environmental Problems in Lake Victoria, East Africa: Causal Chain and Policy Options Analyses. <i>AMBIO</i>	A Journal of the Human Environmen	Kenya, Uganda and Tanzania	Causal chain and policy options analysis
22	Sitoki, et al., (2010)	The Environment of Lake Victoria (East Africa): Current Status and Historical Changes	International Review of Hydrobiology	Kenya, Uganda and Tanzania	Longitudinal ecological assessment
23	Verschuren, et al., (2002)	History and timing of human impact on Lake Victoria, East Africa.	Biological Sciences	Kenya, Uganda and Tanzania	Palaeolimnological analysis
24	Awange, (2021)	Lake Victoria Basin: Droughts and Food Security. In J. Awange, <i>Lake Victoria Monitored from Space</i>	Springer International Publishing	Kenya, Uganda and Tanzania	Quantitative analysis using remote sensing and climate data
25	Liersch, et al., (2024)	Climate change perceptions, expectations, observations, and projections at Lake Victoria.	Environmental Research Communications,	Kenya, Uganda and Tanzania	Mixed-methods research
26	Wabwire, et al., (2020)	The Perception of Rural Households on Climate Change Effect on Rural Livelihoods in Lake Victoria Basin.	Ghana Journal of Geography,	Kenya	Mixed method
27	Muthoka, et al., (2024)	Socio-economic impacts of climate change and adaptation actions among smallholder fish farmers in Sub-Saharan Africa	Aquaculture, Fish and Fisheries,	Sub Saharan Africa	Review article
28	Ogega, et al., (2023)	<i>Extreme Climatic Events to Intensify in the Lake Victoria Basin Under Global Warming.</i>	Scientific Report	Kenya, Uganda and Tanzania	Quantitative design

Framing of the climate change vulnerability concept

It is observed that the framing of vulnerability to climate change concerning Lake Victoria is a mix of complex relationships of specific ecological, social and economic factors which define the local people encounter it. Several investigations stress the need to define vulnerability as a composite notion that includes exposure to catastrophic risks and the capacity to manage or contain them (Adger, 2006; Dewan, 2013). For example, certain scholars view vulnerability as a geo-social construct and observe how even the

simplest local livelihoods, especially those linked to fishing and farming, entangle plantation health (Mahdaoui & Alibou, 2022). This understanding, in turn, calls for an extension in framing that includes both environmental changes and socio-economic dynamics that can enhance the hazards surrounding a community.

The analysis also suggests that how the vulnerability is framed can differ across various audience groups. Normally, members of the community express their vulnerabilities in ways that have tangible real impacts, explaining the likes of food

security and health issues while referring to factors that affect such a group such as policymakers introducing 'where development' and the use of resources and broader quantitative analysis (Thomas et al., 2019). This can translate to incompetence in apprehending and handling the vulnerabilities since contextual Indigenous knowledge is often excluded when it comes to development issues that emphasize top-down policies. In this respect, it is important to extend the participants who design eradicated adaptations by mitigating the vulnerabilities of climate change to include the local population.

The considerable attention of the review was also drawn to the fact that how vulnerability is conceptualized has undergone a lot of change. In recent years, many researchers have sought to move away from mainly addressing risk towards adaptive resilience because resilience is the most efficient way of minimizing vulnerability and oppression (Haasnoot et al., 2024; Morris et al., 2024). This change is particularly necessary for Lake Victoria, where local populations have a rich culture and information on how they have been coping. Therefore, using frameworks that support resilience will lead to better and fairer climate change action.

Similarly, framing climate change vulnerability also touches the social justice debate. The research indicates that in the case of Lake Victoria and the surrounding countries, the traditionally disadvantaged, accustomed communities suffer the most from the impacts of ecological changes (Kojola & Pellow, 2021; Nyboer et al., 2022). This delicate balance, therefore, must involve an interrogation of power and sociopolitical and economic context where the resources and decision-making processes in a given locality that have some relief and adaptation measures tend to concentrate (Kojola & Pellow, 2021; Thomas et al., 2019). With this in mind, there is a provision for one to take a more affirmative action that looms over the endeavour to prepare and respond to disaster events, particularly climate-induced impacts. On the other hand, even after 19 years of climate debates, the perspectives of some marginalized communities have also not received the attention they deserve (Kajiser & Kronsell, 2014; Okereke & Dooley, 2010).

This review argues that, when discussing the climate change vulnerability framing in the Lake Victoria region, it is evident that a broad set of strategies concerning environmental protection, economic activities, and social justice is needed. The literature exposes that any successful adaptation methods must target the prevailing climate hazards and the deep-rooted structural causes of such hazards (Eriksen et al., 2021; Rajkovich et al., 2024). This proposition involves encouraging the production of relevant knowledge by including the communities, promoting empowerment, and ensuring their cases are factored into adaptation policies. Therefore, researchers can provide an interpretation of the existing conceptions of vulnerability that reflect and sustain local sensibilities and enhance the ability of societies to deal constructively with the challenges of climate change.

Methodology, And Instruments Used

The scrutiny of how research agencies have used methodologies to study the Lake Victoria region in the context of vulnerability to Climate Change reveals an altogether rich image marked by the presence of diverse research designs and research techniques in the complexity of the studies. A sizeable part of this

literature uses quantitative techniques where researchers conduct household surveys to map out aspects of demographic profiles, employment activities and climate change perception (Agol et al., 2021; Kajuni et al., 2024; Nassali et al., 2020). Such surveys are usually initiated with stratified sampling to balance select categories of the population that may not initially come out clearly, and this would help analyze the vulnerability levels in these different segments. However, excessive quantitative dominance may not provide enough information on the problem's detailed nature and degree. Few studies employed qualitative techniques as a key component in addressing this factor, as these methods primarily focus on the people and their experience of climate change events (Nyboer et al., 2022; Petty et al., 2022).

The studies in question contain sample populations of people from several demographic backgrounds, such as fishermen, farmers, women, and the youth (Agol et al. 2021, 2021; Kajuni et al., 2024; Obuya et al., 2024). This mix is essential since it helps capture the different levels of vulnerability pervasive in a typical community. For instance, breaking the data down into geographical, age, and class variables is important to analyse people according to specific experiences or opportunities. These data representation analyses provide an enriched understanding of multifactorial vulnerability, clearly pointing out the need for specific action on different groups. The vast study on different aspects of vulnerability to climate change in the Lake Victoria basin points out the necessity of using quantitative and qualitative methods to address every topic. Although research instruments that yield statistical data, such as surveys, were considered adequate, qualitative methods were more ideal, eliciting the mechanisms by which unmitigated experience of vulnerability is brought about (Cantelmi et al., 2021). Using instruments and non-discriminatory sampling strategies represents a positive development in this area, enhancing the applicability of the study findings. A comprehensive methodology is instrumental in shaping best-fit adaptation strategies against the predicament of climate change in Lake Victoria.

Treats and Consequences of Climate Change

A large body of work on the threats to climate change and the impacts of such changes creates a rather scary picture. This review identified Lake Victoria as one of the regions challenged by climate change (Nyamweya et al., 2020; Odada et al., 2004; Sitoki et al., 2010; Verschuren et al., 2002). A key example that emerged from the review was the continued increase in the severity of drought occurrence, especially in the region's smallholder agriculture and fishery (Awange, 2021). The majority of the studies indicate that rainfall is disturbing in the way it is occurring in terms of seasons, as dry spells prove to be a lot longer, whereas the occurrence of heavy rains has risen (Liersch et al., 2024; Wabwire et al., 2020). This is probably the case because there are temporal variations of wet and dry periods during the year. These temporal variations are detrimental to crop production, fish breeding sequence, and availability, leading to a challenge in food security and ways of living in that community. The same studies suggest this is particularly true for the communities that rely on these natural resources. In the same review, another impact of climate change was assessed: the environmental alterations that have resulted in increased water-borne diseases. Extreme flooding and short duration and excessive rainfall events tend to increase the level of this challenge by contaminating water, which creates

conducive environments for the outbreak of diseases such as malaria, cholera, and typhoid (Muthoka, Ogello et al., 2024; Ogega et al., 2023; Ototo et al., 2022). The most affected victims of this health issue are the poor communities, particularly children and the elderly.

Discussion

Based on this systematic review, it has been realized that the concept of climate change vulnerability may not be very easy to understand, as seen in different literature. There has been a change in the view of vulnerability, which has started to be understood in a more complex and several dimensions, meaning biophysical, economic, and social issues. This perspective is also consistent with the definition of vulnerability by the Intergovernmental Panel on Climate Change (IPCC), emphasising three types of stressors: exposure, sensitivity, and adaptive capacity. For example, the scale of vulnerability is better appreciated when the focus is on the Lake Victoria region, where the rhythms of existence with the environment of all the people, especially the fishermen and the farmers, are different. This kind of framing stresses oversights in a more elaborate way of development planning, which combines social and economic aspects with environmental factors, something that is crucial since with so many people and so many animals, virtually all adaptations of most mitigation plans are adapted (A. M. Dewan, 2013; Morris et al., 2024; Nyboer et al., 2022).

However, a pronounced problem exists in the deficiency of local integration of vulnerability framing. This has to do with findings from different studies in the experience that while several studies identify local perspectives as key, there is still a noticeable tendency to prefer scientific data at the expense of indigenous knowledge systems. Such an omission will surely risk disenfranchising the already disadvantaged communities. Their ways of life and traditional values are essential aspects of how understanding and responding to vulnerability needs to be done (O'Brien & Wolf, 2010). Including local knowledge in the vulnerability framing allows for developing more effective and sociocultural relevant adaptive measures that the affected communities can display (Bardosh et al., 2017; Maru et al., 2014).

The results confirmed the importance of adopting an intersectional perspective in assessing climate change vulnerability (Phuong et al., 2023). It is noted in the review that certain marginalized groups, such as women, young people, and indigenous peoples, suffer more from climate change due to existing social inequalities. Researching vulnerability without the ability to grasp these issues undermines the essence of discussing social groups as capable of fending off certain risks. Recognizing the breadth of vulnerability, the stakeholders and the policymakers, therefore, can come up with some, perhaps serviceable albeit less overall, targeted ways of addressing the vulnerability that has already affected the marginalized communities.

Moreover, there is a new trend in the study of the influence caused by climatic changes in the environment, which is regarding the vulnerability of different communities that are part of the environment. It was found that resilience-oriented approaches focus on the strengths of communities in the face of climatic pressures rather than the weaknesses that may occur (Tanner et al., 2015). As such, it is clear that such a perspective encompasses understanding the risks and the strategies of various populations in

copied with or avoiding the risks. The study finds that using resilience perspectives will aid in developing actions and norms that enable local people to engage their endogenous coping and response capacity in dealing with the climate change crisis. Therefore, incorporating resilience principles in the process of vulnerability assessments positively impacts the implementation of adaptation measures and the advancements associated with the sustainable development of societies.

Similarly, how different ecological and socio-economic development features relate to each other complicates the climate change vulnerability study in the Lake Victoria region. Although the concept of vulnerability has been evolving toward a more systematic understanding and treatment, its relation to local knowledge, intersectionality and other disparities remains an issue that needs further research and development (Kuran et al., 2020). By employing resilience-based approaches and working with the communities, researchers can contribute to a better understanding of vulnerability and its effective management through adaptive responses (Awange, 2021; Maru et al., 2014). This holistic approach is necessary when considering improving the resistance of societies experiencing climate change.

Literature on climate change vulnerability around Lake Victoria reveals different research population strata and tools used in the assessed records. There is a significant embrace of both the positivist and interpretivist paradigms of climate change science. This arises from the understanding that a deeper terrain of knowledge requires a proper and comprehensive contextualization (Gabrielsson et al., 2013). By employing data analysis, especially through quantitative techniques like household surveys, a researcher can obtain empirical evidence to discern recurrence and the linkages of vulnerability factors (Nyamweya et al., 2023). Nonetheless, it is clear from the beginning that quantitative theory tends to ignore vulnerable people and is short of inclusive analysis, including subjective experiences of different marginal groups. Therefore, qualitative theory still has its place in providing further explanations for communitarian thoughts.

According to the results, qualitative techniques that include focus group discussions and structured or unstructured interviews have been effective in capturing the more contemporary time-specific survival struggles of people in such ecosystems (C. Nyamweya et al., 2023; Nyboer et al., 2022; Obuya et al., 2024). The use of these approaches in the study of the effects of climate change has defined and understood poverty in multiple forms, including social and cultural factors. For example, Collective knowledge and collective experiences are drawn in a typical focus group. Researchers can identify the type of adaptation – a development project that is going on, with the knowledge that achieves power and attention, building the nature of communities. These methods benefit the quality of the data collected as the methodological system encourages relationships with the community and more active and engaging research.

Moreover, it is paramount to mention that the research approach used took representation very seriously while drawing the study sample (Kendall, 1969; Muyodi et al., 2010). Studies show that different population samples, such as fishermen, small-holder farmers, women, and young people, can be included in field research activities. Such representation is essential in understanding all components of vulnerability traits among the population studied. Using numerical, analytical tools, separation of

the dependent variables into gender, age, and wealth distribution helps the analysts zero in on what the particular conditions of these groups are for which adaptation shall be necessary. This suits the new concept of social equity and justice, where the needs of the vulnerable are not excluded in the climate change assessment and adaptation process. In the discussion of methods, tools, and data collection in the context of climate change and the Lake Victoria Basin, it is appropriate to state that it is essential for the research processes to adopt a mixed methodology approach. While unequivocally, quantitative methods help provide necessary statistical descriptions, qualitative techniques help understand the local context. Together, all these various instruments and more inclusive sampling methods assist in increasing the value and usefulness of the research. Finally, such elaborate methodological tools are important in developing responsive adaptation mechanisms to deal with multiple challenges associated with climate change in the Lake Victoria region.

An in-depth hazard illustrated in this review is how uncontrollable different times of rainfall result in limited farm produce occurrence and the availability of food. Several studies show that nutritionally dependent populations, including farmers, are at risk when weather impacts are considered, indicating that the observed changes will escalate fishing and crop yield activities (Muthoka, Ogello, et al., 2024; Nassali et al., 2020). The research demonstrates the pressing necessity for climate-smart agriculture practices and related resource management interventions to cope with the declines experienced earlier and weather shocks. While grazing and land tend to be the first likely to be impacted, this analysis also suggests that one of the concerning effects of climate change is that of waterborne diseases. In as much as the occupants could beam in distress signals once the areas along the Lake Nile, which predominantly flood during rains, the problem of polluting water sources, for instance, leading to Cholera and Typhoid issues, may arise (Bardosh et al., 2017). These environmental health risks are more prevalent among such groups as children and the aged, thus lessening society's ability to adjust and aid in its development (Mugisha et al., 2020). This outcome specifically scrutinizes the nexus between climate change and public health, affirming the need to address these two fields within a single framework. It is also important to ensure that measures of public health improvement are in tandem with educational efforts to respond to climate change in STD prevention (Yu et al., 2021).

Economic implications of climate change are also a dominant factor, as the study reveals the relationship between environmental degradation and scarce financial resources (McClanahan, 2024). Reviews show changes in climate in the region, such as in agriculture and fisheries. Consequently, many families face increasing resource scarcity, which results in higher poverty and unemployment levels in the communities. These results suggest that facing such limitations in economics means many answers are necessary, as positive change requires preserving the ecosystem and providing different sources of livelihoods and service provision, such as support in disasters. Furthermore, the review identifies several gaps in governance and policies that make it impossible to respond effectively to the impacts of climate change. The existing policies are typically narrow and lack an understanding of vulnerability in all dimensions. Most studies are critical of imposing economic-oriented solutions that override the quest for environmental protection and social resilience, typically built on this mode of

production (O'Brien & Wolf, 2010). The findings stress the urgency of putting in place a governance democracy that aims at the involvement of all people from all aspects in a particular system of power and control. Involving the public in the policy formulation procedures leads to better policy adherence and incorporation in the design of strategies for coping with the effects of climate change.

Conclusion, Implication, and Recommendation

Findings indicate that vulnerability cannot be defined as a combination of exposure to climate-related risks and other elements of the world, borders, and beyond. Such a dimension helps to rethink strategies to mitigate and adapt to the impacts of climate change in a more integrated perspective, which includes not only the ecological impacts but also the social challenges. There are many important issues raised about the current studies, especially the Indigenous people's involvement; it is therefore postulated that future research should shift from merely addressing critical research areas of climate change towards more interactive and engaging research. Most literature emphasizes that under current climate regulations focused on climate change, such interventions are ad hoc and scattered, and do not address the underlying issues causing vulnerability. For this reason, knowledge and practices of the community, and most importantly, local empowerment, must be given attention to make local governance more participatory. This arrangement makes regulations more practical and enforcement sustainable amidst the effects of climate change.

Considering the research challenges uncovered, it is suggested that mixed-method research should be placed at the front of the agenda for future research. This involves the application of not only quantitative data but also qualitative approaches, enabling a detailed account of vulnerabilities, especially in the case of less privileged populations. Furthermore, the research should look at the integrated rather than the generic concept of vulnerability, in terms of the influences of gender, age, and socioeconomic status on how people individually and within communities cope with changes in weather conditions. This can be facilitated by providing relevant inputs to the ongoing discussion on climate vulnerability and adaptation strategies, creating a stronger and more responsive policy while addressing the various perspectives that may come along with such actions.

How research is conducted about the construction of and responses to climate change vulnerability must change. Without including such stakeholders in finding the solutions, how would such communities be assisted in developing appropriate ways to help them face the current changes? This fundamental shift is necessary for enhancing resilience and sustainability within the Lake Basin region and beyond so that the most vulnerable are provided for under climate change uncertainties. To deal with the problem of climate change vulnerability in all its aspects, all the concerned parties, that is, researchers, policy makers, and the affected communities, will need to coordinate their efforts so that the anticipated changes are effected in the region. Therefore, the findings of the present systematic review call for immediate and resolute action in Lake Victoria to enhance adaptive capacity and protect the ecosystem from further degradation, which is at stake from the changing climate. The research indicates that vulnerability does not focus on environmental vulnerability alone but correlates strongly with environmental and governance

elements. Hence, therapeutic efforts towards climate change adaptation should safeguard all people's environmental rights and equity, starting with the most socio-economically disadvantaged. Such a strategy would require coping with climate change in the short term and addressing the issues that make the problems more difficult to iron out in the long term.

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No potential conflict of interest was reported.

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Data sharing is not applicable to this article as no new data were created or analysed in this study

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Emmanuel Lwankomezi: Conceptualization, writing – original draft, Methodology, Writing- Reviewing and Editing, Writing a dn checking references.

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