

Livelihood-led Environmental Degradation and its Consequences for Habitability of the Area Around Lake Chivero, Zimbabwe: A Systematic Review

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Abstract

This systematic review examines how livelihood activities relate to environmental degradation in the Lake Chivero Catchment Area, Zimbabwe, and evaluates the impacts on the area's long-term habitability. Motivated by the lake's serious ecological decline over the past 30 years, despite being a vital water source for over 2.4 million people, a population 10 times its original capacity, the study employs the Social-Ecological Systems (SES) Framework and Institutional Analysis and Development (IAD) Framework. It synthesizes evidence from 67 peer-reviewed studies found through a systematic search of the Scopus, Google Scholar and Web of Science databases, following PRISMA guidelines. Results show that livelihood activities, such as sand mining, brick moulding, urban farming and informal waste disposal, although providing short-term survival benefits, have

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collectively caused significant environmental harm. Indicators reveal a reduction in lake depth from 28 to 18 metres, an elevenfold increase in nutrient inflows between 2000 and 2012 and sedimentation filling 18% of the lake's capacity. Institutional failures, including weak enforcement of environmental laws, underfunded sewage systems and poor governance, have worsened these ecological stresses. The review advocates a comprehensive intervention plan that includes infrastructure upgrades, enforcement of the polluter-pays principle, alternative livelihoods and ecological restoration to prevent a predicted "2050 Doomsday Scenario" in which the lake may become unusable. Without such integrated efforts, the study warns that the lake's habitability will remain critically endangered, risking human health and ecological stability.

Keywords: livelihood strategies, institutional failure, sustainable livelihoods

INTRODUCTION

The rapid degradation of urban water bodies across the Global South represents one of the most pressing yet under-appreciated environmental crises of the 21st century, with Lake Chivero in Zimbabwe standing as a stark testament to how survival strategies can systematically undermine the ecological foundations upon which cities depend. This man-made reservoir, constructed in 1952 to secure water supplies for Harare, has transformed from a vital ecological and economic asset into what experts now describe as one of Africa's most polluted urban lakes, raising urgent questions about the sustainability of current livelihood practices and governance frameworks (Matsengarwodzi, 2025; Mukamuri, 2026). Despite extensive scientific documentation of deteriorating water quality, biodiversity loss and sedimentation, the fundamental

contradiction at the heart of this crisis remains insufficiently addressed.

The very activities that sustain the livelihoods of Harare's poorest residents, urban agriculture, sand mining, brick moulding and informal waste disposal, are simultaneously accelerating environmental degradation that threatens the habitability of the entire region (Macheka *et al.*, 2021; Nciizah, 2022). This systematic review examines the complex nexus between livelihood strategies and environmental decline in the Lake Chivero Catchment Area, employing the Social-Ecological Systems (SES) and Institutional Analysis and Development (IAD) frameworks to analyse how institutional weaknesses, infrastructure failures and poverty-driven coping mechanisms interact to produce cumulative ecological damage. While existing research has separately documented pollution sources, governance challenges and livelihood dependencies (Nhapi *et al.*, 2004; Kariati, 2025), no comprehensive synthesis has systematically integrated these dimensions to explain how everyday survival practices contribute to large-scale environmental degradation and diminished habitability. The study addresses this gap by asking: How do livelihood activities in the Lake Chivero Catchment Area contribute to environmental degradation and what are the consequences for the area's habitability? By examining the interconnected roles of sedimentation, nutrient loading, institutional failure and the political economy of enforcement, this study aims to inform integrated governance approaches that can reconcile immediate livelihood needs with long-term ecological sustainability, offering lessons applicable to similar urban water bodies across sub-Saharan Africa.

BACKGROUND

Sub-Saharan Africa faces a complex environmental dilemma. The livelihood activities that support millions, such as urban

agriculture, sand mining, brick making and informal trading, are gradually damaging the ecological basis they depend on (Zivhave and Dzvairo, 2022). The region's rapid urbanisation is unmatched worldwide, with cities like Kampala in Uganda seeing their built-up area grow from 7.14% in 1989 to 55.10% in 2015, often taking over agricultural land at rates exceeding 66% of new urban expansion (Damoah and Boglo, 2025). This demographic and spatial change, along with population increases, limited institutional capacity and poor infrastructure, has heightened stress on sensitive ecosystems. Between 2001 and 2015, approximately 13% of wetlands and 23% of savannahs and forests were converted (Kiribou *et al*, 2024). Data from the region show that urban growth without strong investments in human capital and governance exacerbates ecological decline through increased resource extraction, pollution and land-use changes. Thus, the environmental crisis is not driven by population growth only, but also by interactions among poverty, policy shortcomings and survival needs.

In Zimbabwe, the link between livelihoods and the environment is especially severe. The government introduced the Economic Structural Adjustment Programme (ESAP) in 1990, under the guidance of the International Monetary Fund and the World Bank, which led to significant reductions in public spending on infrastructure and social services. At the same time, rural-urban migration accelerated as rural livelihoods deteriorated (*ibid.*). The programme failed to re-allocate productive resources or enhance food access for urban poor populations, resulting in informal, environmentally damaging livelihoods becoming not just common, but necessary, for survival. In peri-urban areas such as Epworth, Hopley and Seke, sand poachers and illegal brick-makers visibly exemplify this situation: "If I quit I won't be able to look after my family," said one extractor, recognising his work is illegal but asserting, "I have to do anything to bring food on the table" (Zivhave and Dzvairo, 2022). These activities are

driven more by economic necessity than ecological disregard, caused by the state's withdrawal of livelihood support, the collapse of formal employment and the criminalisation of survival strategies when viable alternatives are unavailable.

Lake Chivero, built in 1952 on Zimbabwe's Manyame River to supply water to Harare and nearby towns, highlights the severe outcomes of the livelihood-environment conflict. Initially designed for 200 000 people, the reservoir now supports over 2.4 million people, an increase driven by natural population growth, rural-to-urban migration, displacement during the 1970s civil war and the rise of informal settlements (Mukamuri, 2026). This rapid demographic increase has not been matched by infrastructure development as over 150 000 households lack formal sewage connections and rely on pit latrines, septic tanks, or direct drainage into channels which flow into the lake. The impact has been severe. Sedimentation has reduced the reservoir's capacity by 18% (49 126 170.34 m³), with yearly capacity loss averaging 792 357m³ since 1953. Current sedimentation rates of 352.31m³ per km² per year suggest the reservoir's remaining useful life is about 106.63 years, raising concerns about a "2050 Doomsday Scenario" (*ibid.*).

Nutrient pollution has increased sharply, with combined nitrogen and phosphorus loads rising from 3 524 tonnes in 2000 to 38 940 tonnes in 2012. This surge is due mainly to untreated and partially treated sewage discharges. Sediment analysis reveals high proportions of mud (54%), sand (24%) and silt (22%), with mud sediments showing notably higher levels of total phosphorus, total nitrogen and organic carbon. Public health risks include cholera outbreaks, waterborne illnesses and increased cancer risks. Ecological and economic issues, such as water hyacinth overgrowth, ecosystem collapse and rising water treatment costs are also evident. The decline of Lake Chivero reflects systemic failures stemming from

demographic pressures, weak institutions, policy conflicts and economic challenges, turning this vital urban water resource into one of Africa's most polluted lakes.

THEORETICAL FRAMEWORK

This study is based on two closely related theoretical frameworks, the Social-Ecological Systems (SES) Theory and the Institutional Analysis and Development (IAD) Framework. Developed by Ostrom and colleagues, the SES Theory highlights the interconnectedness of human and natural systems, emphasising how social elements such as populations, institutions, livelihoods and governance interact continuously with ecological factors like water, soil, biodiversity and nutrient cycles through feedback loops (Alemu and Kombe, 2025). The IAD framework complements the SES Theory by offering a structured way to analyse the rules, norms and strategies influencing resource use. It divides institutional contexts into "action arenas", where participants, shaped by biophysical conditions, community traits and rules, make decisions that lead to various outcomes. Together, these frameworks reveal three crucial concepts: regime shifts, in which systems cross thresholds and undergo irreversible change; positive feedback loops which drive degradation; and scale mismatch, in which human activity levels do not match ecological capacities.

Analysing Lake Chivero using these frameworks illustrates how four livelihood activities, sand mining, brick-moulding, urban agriculture and industry, interact with institutional shortcomings to drive ongoing degradation. Sedimentation has reduced 18% of the reservoir's capacity, with annual losses of 792 357m³. Nutrient pollution has surged from 3 524 tonnes in 2000 to 38 940 tonnes in 2012 (Magadza, 2017; Mukamuri, 2026). The IAD Framework shows that weak institutions, such as outdated sewage systems, poorly enforced environmental policies and a lack of alternative livelihoods, fail to manage

human-environment interactions effectively, thereby enabling household activities to directly harm the lake without adequate safeguards (Ostrom, 2019). Critical thresholds have been exceeded, ammonia levels are seven times the safe limit, phosphate levels are nine times higher and lake depth has decreased from 28 to 18 metres, indicating a shift to a turbid, algae-rich regime. The frameworks reveal that degradation impacts are uneven: the urban poor bear a double burden as both contributors to and victims of pollution, while industrial polluters externalise costs with political support. This dual perspective underscores that Lake Chivero's crisis is not solely environmental but also a failure of social-ecological systems and institutions, requiring integrated solutions addressing infrastructure, enforcement, livelihoods and ecological restoration.

CONCEPTUAL FRAMEWORK

This framework explores the Livelihoods-Environment Degradation Nexus, showing how activities like food farming, income activities and water collection influence ecological systems. Although these actions may seem minor locally, their combined effect across many households can significantly impact biophysical systems. Based on the SES Theory and the IAD Framework the study first clarifies its core concepts. Livelihood strategies involve practices such as discharging waste into drainage, sand extraction, brick-making, farming on slopes and informal trading, all of which provide sanitation, shelter, income, or food to meet needs (Hertz and Schluter, 2015). While practical for households, these practices contribute to environmental issues like declining water quality, soil erosion and loss of biodiversity (Moyo, 1997). In Lake Chivero, this results in eutrophication, sedimentation, oxygen depletion, fish kills and toxin release from cyanobacteria.

The link between livelihood strategies and environmental degradation is heavily influenced by institutional failure, encompassing not only government agencies, but also laws, enforcement, infrastructure, funding and political motives that govern resource use. When effective, these institutions promote livelihood growth and environmental protection through measures like sewage treatment, pollution control and sustainability. When they fail, as near Lake Chivero, livelihoods directly harm the environment. Evidence includes outdated sewage systems serving over 2.4 million people, a lack of resources and political will to enforce environmental directives, limited enforcement of the 'polluter pays' principle and industries preferring fines to investment in proper treatment. This gap results in households polluting the lake directly, with no buffer zones.

The final part of the framework, habitability, evaluates whether a landscape can sustain human health, water safety, economic activities and social wellbeing over time. It exists on a spectrum, with a critical threshold beyond which recovery becomes difficult or impossible. Crossing this threshold can result in ecosystems failing to provide safe drinking water, support recreation, or introduce health risks through toxins. Lake Chivero illustrates this danger of ammonia levels at the Marimba River confluence are 3.5 mg/l, seven times the limit, phosphate levels are 4.4 mg/l, nine times the limit; nutrient inflows increased from 3 524 tonnes in 2000 to 38 940 tonnes in 2012; sedimentation has accumulated to fill 18% of the lake's capacity; and its depth has decreased from 28 to 18 metres (Mukamuri, 2026).

More than 150 000 households near Lake Chivero lack access to formal sewage infrastructure and, instead, rely on septic tanks or discharge waste into drainage channels that flow into the lake. Harare releases about 250 million litres of untreated

or partially treated sewage daily, with residents contributing 219 million litres. This is not due to negligence, but results from broken and underfunded systems that cannot reach their homes (Nhapi *et al*, 2004). Additionally, households extract sand and clay for survival purposes. This activity, though not vandalism, destabilises soils, causing erosion and sediment deposits into the lake. Currently, the lake bed is composed of 54% mud, 24% sand and 22% silt, with sediments coming from upstream farms and construction sites.

The framework highlights a dangerous feedback loop that worsens over time, where pollution makes water unsafe, reducing tourism and livelihoods. This leads households to harmful coping strategies like sand mining or deforestation, hindering ecological recovery and increasing stress. Not all livelihood strategies harm equally; impact varies by scale, location and institutions. For example, discharging sewage from one household is minor, but from a city, it can be disastrous. Similarly, small-scale sand mining causes local erosion, while large-scale operations reshape watersheds. The link depends on scale, population and governance—small, well-instituted communities can sustain livelihoods, but large, weakly governed populations risk collapse even from household activities.

Interventions at Lake Chivero must address multiple feedback points simultaneously. Simply lecturing households without sewage solutions, issuing resource-limited orders, banning sand mining without alternatives, or focusing on a single issue will not be enough. A sustainable plan involves rebuilding infrastructure, adopting polluter-pays policies, offering alternative livelihoods and restoring ecological functions. Without this comprehensive approach, Lake Chivero could become unusable, risking the ‘2050 Doomsday Scenario’ and the loss of one of Africa’s key urban lakes.

LITERATURE REVIEW

Wetlands are known for providing critical ecosystem services, making them suitable for nature based solutions to address various environmental, economic and social challenges (Castellar *et al.*, 2021; Agaton and Guila, 2023). Unfortunately, worldwide, wetland areas are shrinking rapidly, though the full extent of this loss remains uncertain. Sustainable utilisation of wetlands and their accompanying ecosystems is influenced by various interconnected aspects, including fast population growth, increase of agriculture, utilisation of chemical inputs, irrigation practices, invasive species, variations in societal behaviours, infrastructure development, urbanisation, overgrazing, unrestricted access to resources, drought, climate change and policy changes (Zekarias *et al.*, 2021; Li *et al.*, 2023a, 2023b; Kundu *et al.*, 2024).

However, numerous studies highlight the crucial role of wetlands in supporting livelihoods (McCartney *et al.*, 2015; Aazami and Shanazi, 2020; Kakuba and Kanyamurwa, 2021). Livelihoods are linked to the UN Sustainable Development Goals (sSDGs), which are central to sustainable development (Birkmann *et al.*, 2022). Livelihoods involve resources that meet basic needs like food, water, shelter and income (Esteves *et al.*, 2024). Achieving SDGs depends on sustainable livelihoods, addressing poverty, hunger, inequality and environmental degradation (Lile *et al.*, 2023). SDGs emphasise livelihoods with targets for poverty (Goal 1), food security (Goal 2), decent work (Goal 8) and sustainable cities (Goal 11) (Elamon *et al.*, 2023; Madzivhandila and Asha, 2024). Sustainable livelihoods support these goals through economic empowerment, social inclusion and environmental sustainability (Mahato *et al.*, 2023). The link between livelihoods and SDGs shows the interconnectedness of economic, social and environmental development.

Worldwide wetland loss varies among countries and continents. Africa features high loss rates, especially Ethiopia (0.70%-4.42%) annually (Zekarias and Gelaw, 2023), while Asia's Bangladesh sees more loss than India or China (Ghosh and Pal, 2023; Let and Pal, 2023). North America, including the US and Canada, experiences an annual loss of less than 1% (Campbell *et al.*, 2022). Multiple studies highlight agricultural expansion (both subsistence and commercial), urbanisation, population growth, climate change impacts like droughts and weak governance as key drivers of environmental degradation in Zimbabwean wetlands and lakes (Macheka *et al.*, 2021; Nciizah, 2022). In the Lake Chivero Catchment Area, land-use changes, such as increased cropland and built-up areas, are closely tied to human population growth. Poorly planned livelihood activities harm productive ecosystems vital for sustainable development.

This systematic review compiles peer-reviewed research on the relationship between livelihood activities and environmental degradation in the Lake Chivero Catchment Area, focusing on institutional and governance factors that influence it. It highlights four recurring themes in the literature: (1) the link between livelihoods and the environment in urban and peri-urban areas of sub-Saharan Africa; (2) the ways in which certain livelihood activities cause environmental harm; (3) institutional and governance failures that sustain degradation; and (4) impacts on habitability and human well-being. These themes help analyse how survival strategies, institutional shortcomings and ecological limits interact to drive ongoing environmental decline.

THE LIVELIHOOD-ENVIRONMENT NEXUS IN SUB-SAHARAN AFRICA

Research indicates that rural and peri-urban livelihoods in sub-Saharan Africa depend heavily on natural resources. Households engage in activities such as urban farming, sand

mining, brick making, informal trading and gathering fuelwood and water, all of which rely on ecosystem services (Connolly-Boutin and Smit, 2016). This dependence is driven by necessity, poverty, economic challenges and limited formal employment, which push families to utilise natural resources for survival. Studies reveal that natural resources offer a cost-effective source of income for poor households, with land playing a vital role in providing food, water, fuel and other essentials. However, this dependence creates a tension, as these activities ensure immediate survival, they often harm the ecological foundations crucial for future well-being.

Various factors exacerbate this tension, as outlined in the literature. Population growth, urbanisation and agricultural expansion place increasing pressure on ecosystems, especially wetlands and lakes. In Zimbabwe, research points to agricultural expansion, urban growth, population increase, climate change impacts and weak governance as the main causes of environmental damage in these areas (Zekarias and Gelaw, 2023). Specifically, studies of the Lake Chivero Catchment Area reveal land-use changes, with more cropland and built-up areas closely linked to population growth. Poorly planned livelihoods tend to harm ecosystems critical for sustainable development. Additionally, ESAPs in the 1990s worsened urban issues by reducing public investment in infrastructure and encouraging rural-to-urban migration, as rural livelihoods declined, making informal, environmentally harmful jobs not just rational but often essential for survival.

A notable gap in the literature concerns how livelihood activities impact environments differently across various scales and settings. Although many studies document overall environmental degradation, fewer investigate how the relationship between livelihoods and environmental harm varies with factors such as population density, institutional capacity

and access to alternatives. This issue is particularly pronounced in peri-urban regions like the Lake Chivero Catchment Area, where formal employment options are scarce, infrastructure is underdeveloped and regulatory oversight is weak.

MECHANISMS OF LIVELIHOOD-LED DEGRADATION

The literature identifies four ways livelihood activities harm the Lake Chivero Catchment Area: sewage and waste disposal, sand mining, brick moulding and urban agriculture. While each impacts differently, their combined effects are greater. Domestic sewage, mainly from homes, businesses and public facilities, is the primary pollution source, with Harare discharging about 250 million litres daily, 219 million litres from residents, mostly untreated or poorly treated. Sewage infrastructure is degraded due to outdated systems, chronic underfunding, frequent equipment failures and weak regulation enforcement.

Between 2021 and 2025, the Environmental Management Agency (EMA) issued seven tickets and environmental protection orders to Harare for wastewater violations. However, enforcement remains weak due to limited resources and political support. Water quality issues persist: ammonia at Marimba River confluence reaches 3.5 mg/l, seven times the limit, while phosphate hits 4.4 mg/l, nine times the limit (Mbisva, 2025). Nutrient levels increased from 3 524 to 38 940 tonnes between 2000 and 2012, primarily due to sewage. Sand mining and brick-moulding further damage the environment, sand destabilises soils and accelerates erosion, increasing sediment, while brick-moulding removes clay needed for filtering pollutants (Matamanda, 2021). Sediment is composed of 54% mud, 24% sand and 22% silt, mostly from upstream erosion caused by deforestation, urban sprawl and agriculture. Since 1952, the reservoir has lost 49.13 million m³ (18%), with

a sedimentation rate of 352.31 m³/year/km², leaving an estimated lifespan of 106.63 years (Mukamuri, 2026).

Urban agriculture is identified as a third key mechanism. Studies show that farmers often farm along riverbanks, removing riparian vegetation and using fertilisers that runoff into lakes. Non-point pollution sources contribute about 493 tonnes of phosphorus each year, accounting for nearly half of the overall nutrient load. Using untreated sewage for irrigation creates a contamination cycle that leads to cyanobacteria blooms, which produce microcystin levels 20 times above the WHO safety limits. The research emphasises that, although urban agriculture is vital for food security, its negative effects on water quality are significant and lack proper regulation.

Industrial operations are often overlooked as a fourth mechanism in analyses of domestic sewage. The Manyame River, draining Chitungwiza and industrial zones, is now the largest source of nutrients and water flow, surpassing Marimba and Mukuvisi Rivers. Industries such as abattoirs, chemical plants and food processors often discharge effluent that fails to meet treatment standards, and facilities lacking proper wastewater treatment release untreated or minimally treated effluent into drainage channels (Magadza, 2017). The Manyame Catchment shows lower dissolved oxygen levels due to urban pollution, industrial discharge and organic loads, indicating diffuse pollution from rural livelihoods, not just urban sanitation. Chemically intensive farming, land speculation and wetland conversion for development, worsen environmental stress, with wetlands being sold, drained and built on undermining ecosystems.

INSTITUTIONAL AND GOVERNANCE FAILURES

A common theme in the literature is that institutional and governance failures drive environmental degradation around

Lake Chivero. Key issues include weak enforcement, infrastructure deficits and the political economy of pollution. Enforcement of environmental laws, such as Zimbabwe's "polluter pays" principle in section 57 of the Environmental Management Act, is rarely effective, industries seldom face financial penalties (Mbisva, 2025). The costs of treatment plants often exceed fines, encouraging pollution. Despite orders from 2021 to 2025, enforcement remains weak due to minor fines, limited resources and political indifference, especially in Harare. International efforts like Lake Chivero's Ramsar status have not led to enforcement or funding, leaving the area a symbolic "paper park".

Second, infrastructure deficits worsen environmental damage. Over 150 000 households lack formal sewage systems, relying on pit latrines, septic tanks, or discharging into drainage channels. Infrastructure designed for 200 000 now serves over 2.4 million, exceeding capacity (Matamanda, 2021). Rapid population growth without infrastructure investment, coupled with chronic underfunding of maintenance, leads to frequent failures. Studies from 1982 to 1997 emphasise pollution concerns and recommend wetland restoration and sewage upgrades, but political and economic hurdles hinder implementation.

The political economy of pollution sustains environmental degradation. Research shows enforcement is uneven, thus small-scale sand miners may be arrested, yet politically connected factories often avoid penalties. EMA lacks the backing needed to act against industrial polluters with political ties, revealing power structures where the poor are criminalised for survival, while the wealthy pollute with little consequence. As a parliamentary witness noted,

"We have the laws. We have the science. We have known what to do for 50 years. What we lack is the political will to enforce laws against

powerful interests, invest in infrastructure and prioritise public health over profits” (Mukamuri, 2026).

Consequently, developers and officials benefit, whereas the urban poor and middle class suffer environmental and health consequences.

CONSEQUENCES FOR HABITABILITY AND HUMAN WELL-BEING

The literature highlights how livelihood-driven degradation harms habitability and human wellbeing in Lake Chivero. The health impacts, especially on the urban poor, are severe. Microcystins from algae are carcinogenic, linked to liver damage, gastroenteritis and liver cancer after prolonged exposure. Microcystin-LR levels (19.9 µg/L) exceed WHO limits twenty-fold, risking those using untreated water (Nhapi *et al*, 2017). Cyanotoxins accumulate in fish, exposing consumers. Zimbabwe’s health system struggles to link illnesses to cyanotoxins, so no recorded deaths do not imply safety, but reflect data gaps. Economically, sport fishing and tourism collapse, causing job losses and water treatment costs increase by 64%, raising living expenses. Fishermen are criminalised as poachers and the urban poor face contaminated fish, polluted water and waterborne diseases.

As such, this review fills gaps in the literature by using an SES framework to examine multiple livelihood strategies, institutional failures and habitability outcomes in the Lake Chivero crisis. It addresses limited focus on rural livelihoods, social group impacts and feedback mechanisms, providing a comprehensive understanding of environmental degradation and its effects.

METHODOLOGY

The study reviews how livelihood activities relate to environmental impacts in Harare. A systematic review collects and analyses data on specific questions (Owens, 2021), following a protocol to ensure rigor and relevance (Fromm *et al.*,

2025). Using the PRISMA framework, it involves five stages: (1) setting inclusion criteria; (2) searching relevant databases; (3) screening and selecting studies; (4) extracting key data; and (5) synthesizing findings (Figure 1).

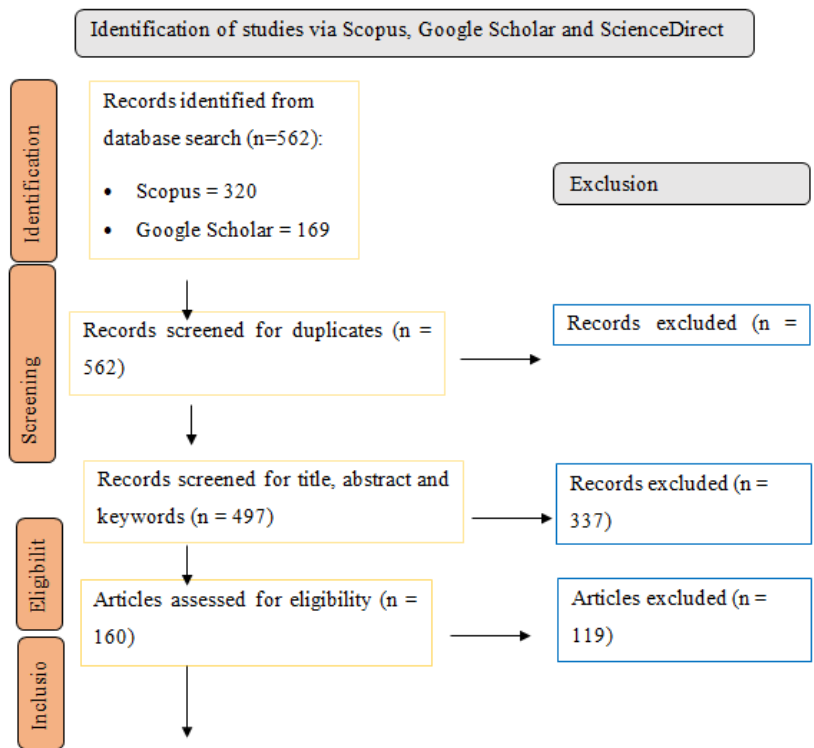


Figure 1: *PRISMA (2020) Flow of Information Across the Various Stages of a Systematic Review*

INCLUSION CRITERIA

To systematically assess how the Lake Chivero Catchment Area area is impacted by livelihood activities, the study established a set of inclusion criteria based on key themes such as the livelihood activities, degradation and inclusive governance. Recognising the importance of scholarly credibility, the review

considers solely peer-reviewed literature, including journal articles and book chapters, that directly relate to drivers of livelihoods, policy contexts, water and soil quality (critical zone components) and opportunities for environmental repair to create a habitable environment. To ensure consistency and quality, grey literature such as working papers, government reports and institutional publications, which often lack standardised peer review processes, were deliberately excluded. The focus was on literature from 2010 to 2025, a period marking a significant era for the Lake Chivero Catchment Area. During this time, the region's environmental and socioeconomic pressures converged, leading to a noticeable 'tipping point' characterised by rapid resource depletion, a sharp decline in biodiversity and the erosion of ecosystem services upon which the City of Harare depends.

LITERATURE SEARCH

Building upon the inclusion criteria previously established, the study executed a systematic literature review to synthesize peer reviewed evidence regarding the causal mechanisms of the 'polycrisis' within the Lake Chivero critical zone. This process prioritised the identification of scholarly works that analyse the intersection of ecological degradation, institutional volatility and socioeconomic stressors.

To guarantee both thematic depth and disciplinary breadth, the search strategy leveraged three prominent electronic databases: Scopus, Google Scholar and IEEE Xplore. This initial search yielded a total of 562 records, distributed as follows: Scopus (320), Google Scholar (169) and Web of Science (73). To refine the search and ensure thematic alignment, the following Boolean search string was applied:

("livelihood" OR "means of living") and ("environmental" OR "ecological") and ("degradation") and ("impacts" OR "effects") and ("habitability")

This string was created to identify literature that explicitly discusses institutional arrangements promoting inclusive environmental management systems in the Lake Chivero Catchment Area. The application of wildcard operators and logical connectors (AND/OR) facilitated a targeted and comprehensive search for relevant studies. The initial 562 records were imported into Rayyan, an AI-supported systematic review platform, where they were screened for relevance, duplicated and data was extracted following the study protocol. This multistage approach ensures a robust and thematically consistent evidence base for analysing livelihood activities and their environmental impacts across Southern Africa.

PAPER SCREENING AND SCREENING

To account for potential duplicates across multiple databases, first, 562 records were imported into Rayyan, an AI-driven systematic review tool. An initial check for duplicates found 65 redundant entries, which we excluded from further review. The remaining 497 records then underwent an initial screening based on title, abstract and keywords. Each was evaluated against the study inclusion criteria, focusing on geographical relevance, thematic connection to inclusive institutional arrangements and methodological rigor. During this phase, 337 papers were eliminated mainly because they did not address environmental degradation or its causes.

A second screening round involved a full-text review of the remaining 160 papers. Applying the same inclusion criteria, 119 papers were excluded, mostly because they were descriptive and did not meet the essential requirements for this review. The screening was done collaboratively by multiple reviewers and disagreements were resolved through discussion to maintain consistency and objectivity. In the end, 41 papers fulfilled all the inclusion criteria and were selected for detailed analysis. These studies form the empirical basis for understanding the

links between the causes of land degradation in the Lake Chivero Catchment Area.

DATA EXTRACTION

Aligned with the goals of this systematic review, the research performed a structured data extraction from the final set of 41 peer-reviewed studies using Rayyan. A custom extraction template was created to gather information across five key areas: (i) authorship and geographic scope, (ii) thematic focus, (iii) methodological approach, (iv) scenario details and (v) key modelling assumptions.

This review systematically evaluates the environmental health of Lake Chivero, highlighting the socio-environmental factors contributing to its pollution and land degradation. It extends beyond diagnosis by examining crisis involvement within the Lake Chivero Catchment Area and exploring opportunities for inclusive governance to support ecological restoration and habitat resilience. To meet these objectives, a detailed and structured data extraction process was conducted, analysing 101 peer-reviewed studies. The data collection utilised Rayyanguided by a specialised template focusing on five key dimensions: (1) authorship and geographic scope to assess regional research representation and fairness; (2) thematic focus to identify research areas like pollution, biodiversity loss, economic influences and governance strategies; (3) methodological approaches to understand evidence collection methods, including participatory research, spatial analysis and modelling; (4) scenario analysis to review how future projections and stakeholder-driven pathways are incorporated into planning; and (5) key assumptions behind modelling efforts to evaluate their robustness, validity and applicability. This comprehensive framework enabled a thorough synthesis of evolving knowledge systems and methodologies, providing a strong foundation for evidence-based interventions focused on

land diagnosis, ecological repair and sustainable habitat management.

FINDINGS

Debates across Africa suggest that local livelihood activities contribute to environmental degradation (Gashu and Muchie, 2018). Adams (2009) argues that sustainable development literature links environmental degradation to population growth and rising poverty. Studies also show that natural resources are an inexpensive alternative for poor rural households to generate income from natural products (Shackleton, 1998; Twine *et al.*, 2003). Consequently, in Sub-Saharan Africa, land degradation is widespread. Peprah (2014) notes many African countries rely on land for livelihoods, highlighting the connection between livelihoods and environmental degradation. Land is vital in Africa, providing food, water, fuel and basic needs (Gashu and Muchie, 2018). Most research on anthropogenic causes of climate change and environmental damage has focused on reducing greenhouse gas (GHG) emissions by large industries and other machines (De Moraes Sá *et al.*, 2017; Gustavsson *et al.*, 2017). These are by far the biggest contributors to environmental damage. However, resource utilisation by locals for the purpose of securing livelihoods also contributes to environmental degradation.

SEDIMENTATION AND RESERVOIR CAPACITY LOSS

An analysis of long-term data on Lake Chivero's physical decline reveals a consistent pattern of increasing sediment build-up, primarily caused by land-use activities in the catchment. Sedimentation research presented at the EGU General Assembly 2026 (Mukamuri, 2026) shows that, since its construction in 1952, the reservoir has lost approximately 49.13 million cubic metres of capacity (about 18%). This corresponds to an average yearly capacity reduction of around 792 357 cubic metres, with current sedimentation rates at

352.31 cubic metres annually per square kilometre of catchment area. The data suggest a remaining useful life of approximately 106.63 years, raising concerns about a potential '2050 Doomsday Scenario' if trends continue (Mukamuri, 2026). Sediment analysis indicates high levels of mud (54%), sand (24%) and silt (22%), pointing to persistent erosion that current land management practices fail to control effectively (Tendaupenyu, 2017). Overall, these trends demonstrate how land management decisions such as expanding agriculture without erosion controls, urban development lacking sediment retention and wetland degradation have collectively accelerated reservoir infilling, now at roughly three times the rate predicted by 1970s studies. This highlights the tragedy of the commons, where small individual actions result in substantial collective damage.

NUTRIENT LOADING AND EUTROPHICATION

The nutrient data show rapid degradation at Lake Chivero, shifting from mesotrophic to hypereutrophic in under 20 years. Nhapi *et al.* (2004) report nitrogen and phosphorus loads increased from 524 tonnes in 2000 to 940 tonnes in 2012, over 1,000% in 12 years, surpassing population growth, which increased 2.5 times, indicating systemic failures. Wastewater treatment plants contribute 50-56% of dry-season flow in the lake's main tributaries, with treated and untreated sewage dominating low-flow periods. The lake's mean total phosphorus (77 mg/L) and nitrogen (21 mg/L) greatly exceed hypereutrophic thresholds, promoting algal blooms (Tendaupenyu and Magadza, 2017, Mbisva, 2025). The Vollenweider Model suggests that phosphorus must be reduced to 10 tonnes/year to achieve oligotrophic status, a 90% reduction from current non-point sources, which is unlikely, given land use (Tendaupenyu and Magadza, 2017). Experts propose a more realistic goal of 75 tonnes/year, similar to the 1970s. Currently, point sources contribute 634 tonnes annually

and non-point sources contribute 493 tonnes annually, meaning that even removing point sources would leave the lake eutrophic. Between 2000 and 2012, nutrient levels surpassed the lake's buffering capacity, causing internal phosphorus loading from sediments, perpetuating eutrophic conditions despite pollution controls, a phenomenon called "legacy phosphorus".

INDUSTRIAL AND AGRICULTURAL LIVELIHOOD CONTRIBUTIONS

While sewage has received most research and policy attention, industrial and agricultural livelihoods significantly contribute to Lake Chivero's nutrient budget and must be included in any comprehensive analysis. The Manyame River, draining Chitungwiza and industrial areas, is now the largest source of nutrients and water flow, surpassing Marimba and Mukuvisi Rivers (Nhapi *et al.*, 2004; ILEC Database, nd). Elevated nutrient levels in the Willowvale River result from sewer overflows, effluent from Ingwe Pasture Irrigation Farm and a neighbouring dairy farm, indicating direct agricultural contributions to the lake without treatment (Nhapi *et al.*, 2004). The Manyame Catchment shows "lower dissolved oxygen saturation" due to urban pollution, industrial discharge and organic loads, reflecting diffuse pollution from rural livelihoods, not just urban sanitation (Mbisva, *et al.*, 2025). Chemically intensive agriculture, land speculation and wetland conversion for development worsen environmental stress, with wetlands being sold to developers who drain and build on them, undermining local ecosystems (Kariati, 2025). These findings highlight substantial nutrient loads that are unregulated by wastewater treatment or enforcement.

Long-term livelihood-driven degradation at Lake Chivero impacts human health, primarily affecting the urban poor. Professor Hilda Matarira explains that,

“Microcystins from blue-green algae are carcinogenic and linked to liver damage, gastroenteritis and liver cancer with prolonged exposure” (cited in Kariati, 2025).

The microcystin-LR level (19.9 µg/L) exceeds WHO guidelines by 20-fold, exposing those who drink untreated water. This exposure also occurs through fish consumption, as cyanotoxins bioaccumulate in tissues such as the liver and viscera. In addition, the economic effects of environmental degradation threaten overall habitability. The collapse of sport fishing and recreational tourism has eliminated livelihoods for many families. Increased water treatment costs, driven by a 64% reduction in filter run times, are passed to consumers, raising living expenses across Harare. Socially, livelihoods have been criminalised, fishermen who once operated legally are now labelled poachers by decree, despite lacking alternative income sources. This creates a group of “environmental criminals” simply trying to support their families after their legal livelihoods were banned without compensation or alternatives (Mbisva, 2025). The distributional impact is especially regressive, with the urban poor in informal settlements without sewage connections both primary contributors and the main victims.

GOVERNANCE FAILURES AND THE PERSISTENCE OF DEGRADATION

The review highlights ongoing governance failures that enable livelihood-driven degradation despite the availability of scientific evidence and solutions. A legal framework, including the Environmental Management Act which designates EMA as the enforcement authority, exists, but enforcement from 2021 to 2025 has been weak due to small fines, limited resources and political indifference, particularly in Harare (Kariati, 2025). Pollution issues, especially sewage, have been recognised since 1982 and 1997, with recommendations for wetland restoration and improvements to sewage infrastructure. Nevertheless, these measures remain largely unimplemented, due mainly to

political and economic barriers, rather than technical challenges. International protections, such as Lake Chivero's Ramsar status have not led to enforcement or investment, reducing the area to a "paper park" (*ibid.*). The political economy favours vested interests, with politically-connected developers evading enforcement, city funds for sewer upgrades insufficient and the national government prioritising other sectors. Consequently, benefits accrue mainly to developers and officials, while the urban poor and middle class face environmental and health impacts. A parliamentary witness stated,

"We have the laws. We have the science. We have known what to do for 50 years. What we lack is the political will to enforce laws against powerful interests, invest in infrastructure and prioritise public health over profits" (Kariati, 2025).

DISCUSSION

This review reveals a contradiction in Lake Chivero: economic activities supporting Harare's poor harm the city's water source. It discusses these findings with literature, theories and policy implications, focusing on four themes: (1) how livelihood activities cause environmental damage; (2) institutional shortcomings; (3) impacts on living conditions and wellbeing; and (4) needed governance and strategies. The study shows that four main livelihood activities, sand mining, brick-moulding, urban farming and industrial work, cause environmental harm through different but related processes. These results reflect common patterns in sub-Saharan Africa, where poverty, economic hardship and weak governance lead households to exploit natural resources in ways that damage ecosystems. The Lake Chivero case is unique due to the extent and severity of damage, with nutrient levels increasing eleven-fold from 2000 to 2012 (Kariati, 2025). This rise far exceeds the 2.5-fold population increase in the same period, suggesting that degradation is not due solely to population growth, but also stems from systemic failures in infrastructure, governance and

institutional capacity. The results indicate institutional failures mediate between livelihood activities and environmental degradation, with key issues, including weak enforcement, infrastructure deficits and the political economy of pollution. These support Ostrom's framework which posits that institutional arrangements influence resource access, use and conservation. Ostrom states that effective institutions establish rules, monitoring and enforcement for sustainability, while weak ones lack these, leading to degradation. The weak enforcement around Lake Chivero, with seven environmental protection orders issued from 2021 to 2025 without consequences, validates Ostrom's concept of failure. The infrastructure deficits around Lake Chivero reveal a mismatch in social-ecological systems, in which human and ecological scales misalign, leading to overload. The infrastructure for a population of 200 000 now serves 2.4 million without proper expansion or maintenance. This is not just technical, but a governance failure: pollution issues from 1982 and 1997 remain unaddressed due to political and economic barriers. The political economy of pollution shows selective enforcement, targeting poor households while protecting industrial polluters. This reflects environmental justice theories, where marginalised communities suffer environmental harms due to lack of political power. In Lake Chivero, the urban poor contribute to waste and face contaminated water and illnesses, illustrating environmental injustice common in the Global South and U.S. industrial pollution.

The findings reveal that livelihood-driven degradation in Lake Chivero affects habitability and well-being, with severe health risks. It highlights economic impacts such as the collapse of sport fishing and recreational tourism, along with higher water treatment expenses, which align with ecosystem service valuation frameworks. The loss of sport fishing threatens the livelihoods of many families, while a 64% decrease in filter run

times at water treatment facilities increases costs passed on to consumers. These impacts mirror globally observed patterns in lake ecosystems, where eutrophication diminishes recreational appeal, raises treatment costs and threatens livelihoods linked to healthy ecosystems. The distributional effects are notably regressive, with the urban poor disproportionately suffering from pollution and adaptation costs, a trend well documented in environmental justice research. The findings highlight the social impacts, such as criminalising livelihoods and stigmatising poor households, which support existing theories on the social aspects of environmental governance. The findings carry important implications for governance and intervention strategies in the Lake Chivero Catchment Area. They confirm that effective interventions must target multiple leverage points simultaneously, such as rebuilding infrastructure, enhancing enforcement, providing alternative livelihoods and restoring ecological functions. Given the complexity of the Lake Chivero crisis, including various livelihood activities, institutional failures and feedback loops, single-focus, piecemeal interventions will not suffice. This aligns with established frameworks for tackling social-ecological system failures, which highlight the importance of integrated approaches that simultaneously address several system dimensions.

The findings also affirm the importance of providing alternative livelihoods, as activities like sand mining and brick-moulding often occur due to a lack of options. Offering formal jobs, skills training and micro-enterprise support is essential to reduce reliance on harmful activities. This aligns with sustainable livelihoods frameworks, which state that environmental sustainability depends on addressing both economic and social causes of degradation. Therefore, lake restoration must emphasise slow, integrated strategies to tackle external nutrient sources and internal phosphorus stores, acknowledging that recovery from eutrophication is gradual.

CONCLUSION

The case of Lake Chivero demonstrates the perilous intersection between livelihood strategies, institutional failure and ecological decline. What started as rational household coping strategies, such as urban agriculture, sand mining, brick-moulding and informal waste disposal, have together caused the lake to become hypereutrophic, decreasing its depth, capacity and biodiversity. The evidence indicates that this degradation is not due merely to individual negligence, but results from systemic failure, outdated infrastructure, weak environmental law enforcement and poor governance have prioritised short-term survival over long-term sustainability. The SES Framework shows how feedback loops, involving pollution, sedimentation and nutrient loading, worsen degradation, threatening Lake Chivero's habitability. Without intervention, the '2050 Doomsday Scenario' warns it could become unusable in a century. A comprehensive strategy is needed, including reforming waste management, enforcing the polluter-pays principle, providing alternative livelihoods and restoring wetlands. Sustainable governance should combine community needs with ecological resilience to protect livelihoods without harming systems. The crisis at Lake Chivero reflects broader issues in the Global South, where poverty and weak institutions accelerate environmental decline. Addressing these is crucial for Zimbabwe's water security, public health and achieving SDGs to keep the area habitable.

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