



Strengthening Africa's Capacity for the Integrated Management of Lakes and Reservoir Basins

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Abstract

Drawing from over three decades of international experience, this policy review article advocates for establishing an African Centre to enhance Tanzania's and Africa's capacity to manage lake and reservoir basins comprehensively, highlighting their importance for water security, climate resilience, and ecosystem services. It differentiates between lentic (lakes and reservoirs) and lotic (rivers) waters. It discusses some of the world's largest lakes, including Nyasa, Tanganyika, and Victoria, which Tanzania shares with eight nations, and largest reservoirs (Kariba). Tanzania's lake storage capacity exceeds 9,100 km³, surpassing the combined storage of all 62,000 large dams worldwide. These lakes' estimated ecosystem services value is between \$18.7 billion and \$83 billion annually, with a natural asset value estimated at \$1.25 trillion to \$5.5 trillion. Current water policies, lake management programs, and GDP assessments overlook and undervalue these immense storage and valuable resources. Lake and reservoir basins are deteriorating and losing benefits rapidly. Improved lake and reservoir basin governance is urgently needed. This article shares best lake basin governance practices and calls on the Tanzanian and African governments to understand, recognize, and value lentic waters and strengthen African lake basin management capacities and practices to improve water security, climate resilience, and ecosystem services.

Keywords ·Lakes and reservoirs, water security, ecosystem services, climate resilience, lake basin governance, and the African Centre for Managing Lake and Reservoir Basins

1 Introduction

Globally, millions of natural lakes and engineered reservoirs comprise lentic or standing waters. Natural lakes contain approximately 91,000 cubic kilometres (km³) of freshwater, representing 87% of the world's readily accessible fresh surface water from 104,590 km³ (Shiklomanov, 1993). Approximately 62,000 large dam reservoirs registered with the International Commission on Large Dams (ICOLD) hold around 9,000 km³ of freshwater (ICOLD, 2023), or about

10% of the volume stored in natural lakes (Hirji & Duda, 2025).

Lakes and reservoirs provide essential freshwater storage for global water security, ecosystem services, and climate resilience (Hirji & Duda, 2025). However, these lentic waters differ significantly from rivers, lotic, or flowing waters. Lentic systems are more vulnerable to environmental changes, making effective management essential for ensuring the sustainability of freshwater resources for future generations.

Africa is witnessing significant population growth and urbanization, accompanied by the expansion of its economies. Ensuring water, energy, and food security remains a critical priority, while pursuing sustainable development goals continues to present persistent challenges. The continent is one of the most vulnerable regions to the impacts of climate change. Moreover, Africa is home to some of the world's largest freshwater lakes, most notably the three East African Great Lakes—Lake Nyasa, Lake Tanganyika, and Lake Victoria—and the world's largest reservoirs, such as Lake Kariba. These lentic bodies of water provide essential ecosystem services for the continent's water security and climate resilience.

Tanzania is a riparian nation that shares all three EAGLs and sixteen other transboundary lakes, rivers, and aquifers with its neighbouring countries. Over 77% of Tanzania's river and lake basins are part of shared systems with other nations (MOW, 2019a), with many of these natural resources marking national boundaries.

Four of Tanzania's nine hydrological basins—Lake Nyasa, Lake Rukwa, Lake Tanganyika, and Lake Victoria—are dominated by lentic water systems. In contrast, the other five basins—the Pangani River, Wami Ruvu, Internal Drainage, Rufiji, and Ruvuma—are characterized as lotic-dominated

systems (Figure 1).

The management of national and transboundary lakes has been slow and limited. In their 2025 review, Duda and Hirji discuss the institutional barriers that hinder the implementation of integrated approaches necessary for sustaining the benefits of lake and reservoir basins globally. Matemu and Mashauri (2022) examine the impact of the 1890 colonial (Anglo-German) treaty on transboundary water cooperation and conflict resolution in the Southern African region. They analyze how the treaty helped establish boundaries based on water bodies, such as rivers and lakes, which affects contemporary water resource management and can lead to conflicts.

Examples of transboundary water conflicts—discussed further in the paper—include disputes over the Lake Nyasa boundary between Tanzania and Malawi, as well as issues related to unregulated water abstraction from Lake Victoria in Uganda between 2004 and 2006, which led to rapid declines in water levels, resulting in significant socioeconomic impacts on the riparian nations.

Water use conflicts are on the rise, pollution from both point and nonpoint sources is increasing, invasive species are proliferating, and lake ecosystems are rapidly degrading, losing their valuable benefits. Current water policies, integrated

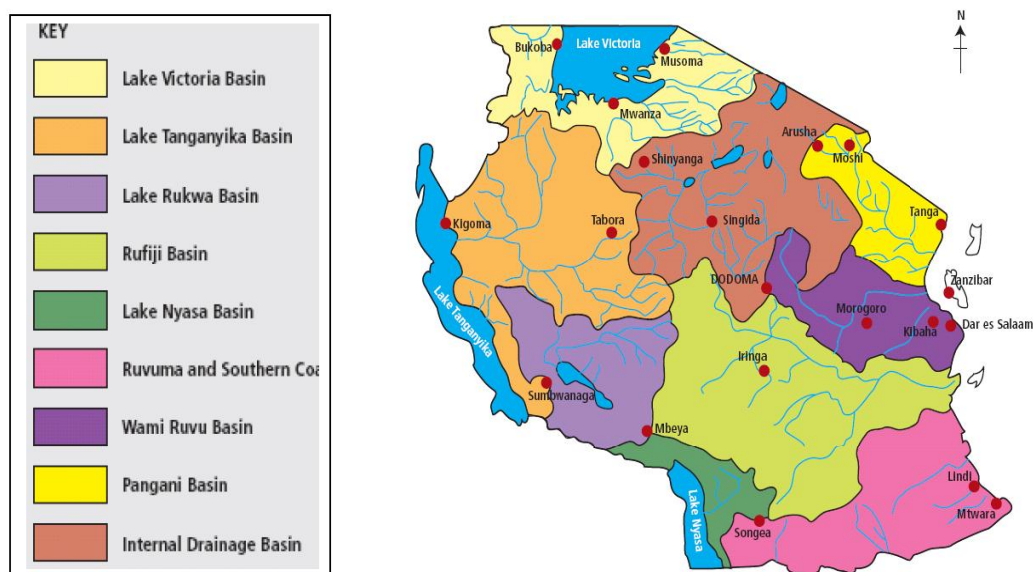


Figure 1: River basins and Lake Basins of Tanzania (Source: MOW, 2019)

water resource development plans, and Lake Basin management investments across Africa often fail to recognize and incorporate the unique characteristics of lentic water systems. They also inadequately acknowledge the ecological importance of freshwater lake ecosystems in planning and management decision-making processes. Instead, there is a predominant focus on developing river basins and building dams, with very few exceptions dedicated to the conservation and protection of lake ecosystems.

Tanzania is facing a rapid increase in water demand due to population growth and economic development. The updated National Water Policy (NAWAPO) anticipates total water demand will rise to 80.2 billion cubic meters (BCM) by 2035, up from 62 BCM in 2024. Domestic water needs will increase from approximately 1.9 BCM in 2025 to 2.5 BCM by 2035. Urban water supply coverage is around 92%, and rural access is about 83%. To address the uneven distribution of water, NAWAPO advocates for the creation of a national water supply grid to meet the increasing demand in both urban and rural areas.

In addition, significant investments in infrastructure projects—like the Magufuli Bridge, Lake Victoria port upgrades, the MV Mwanza Hapa Kazi Tu vessel, the East African Crude Oil Pipeline, and the Standard Gauge Railway—aim to boost regional trade and integration in the Great Lakes Region. However, rapid population growth and economic development may strain vulnerable lentic water systems unless effective management measures are put in place and implemented swiftly.

Karia, A., R. Hirji, and W. Senkondo (2025) have proposed an Integrated Lake Basin Management (ILBM) strategy for Tanzania to support NAWAPO. This strategy aims to create a reliable water supply system and enhance resilience to climate change. It includes developing governance policies, institutional arrangements, capacity building, community engagement, and financial planning, and will also focus on transboundary cooperation and addressing environmental and social issues.

President Dr. Samia Suluhu Hassan emphasized the crucial role of water in sustaining life, promoting well-being, and driving economic growth. She noted that access to clean water is vital for human development, food security, and environmental preservation. Effective management of water resources is essential for sustainable development (TANWIP, 2023). She reinforced this message, as well as the establishment of a National Water Grid System to interconnect water sources and infrastructure through interbasin transfers across Tanzania, during the World Water Day celebration at Mlimani City, when she launched the Tanzania National Water Policy 2002 Update 2025.

Under President Hassan's directive, it is essential to actively enhance management strategies for lentic ecosystems and lotic water systems. Such a strategy would entail elevating and improving knowledge and understanding of their intrinsic value, vulnerabilities, and best management practices. Additionally, it is crucial to develop the necessary capacity and strengthen the institutions responsible for managing the lake basin. Prioritizing the protection of these vital freshwater resources will significantly contribute to enhancing climate resilience.

Tanzania is a member of various regional intergovernmental organizations and cooperation partnerships, including the East African Community (EAC) and the Southern African Development Community (SADC). The EAC played a crucial role in establishing the Lake Victoria Basin Commission (LVBC) in 2003, which aims to promote the sustainable and equitable management of the Lake Victoria basin. Additionally, the Lake Tanganyika Authority (LTA) was established in December 2008 by the governments of Burundi, the Democratic Republic of the Congo, Tanzania, and Zambia to oversee the management of the Lake Tanganyika basin. However, there is currently no regional body coordinating the overall management and conservation efforts for Lake Nyasa.

Tanzania has a unique opportunity to enhance its regional leadership by advancing its national interests and fostering trade and cooperation. Its strategic

position as a riparian to Africa's three Great Lakes increases its potential influence. Furthermore, Tanzania's proactive management of transboundary waters has earned its respect in the region, showcasing its political maturity and commitment to peaceful coexistence.

This article's objective is to advocate for the establishment of an African Centre to enhance Tanzania's and Africa's ability to manage lake and reservoir basins in an integrated manner. The paper calls for advancing integrated lake basin management across Africa. It proposes establishing a regional centre to build ILBM capacity in Tanzania, given Tanzania's unique position as the only nation with riparian access to all three of the EAGLs.

2 Methodology

This article presents a structured policy review of thirty years of international experience promoting integrated water resources management (IWRM), primarily focusing on integrated lake basin management (ILBM). It summarizes the keynote address titled "Enhancing Climate Resilience: Developing Integrated Management Capacity for Lakes and Reservoir Basins in Africa," which was delivered at the Fourth International MAJI Scientific Conference, organized by the Water Institute of the Ministry in Dar es Salaam, Tanzania, on January 29, 2025. The conference's theme was "Water and Sanitation Solutions Amidst Climate Change".

The article provides an overview of lakes and reservoirs in Africa, particularly Tanzania, within their current context and global trends. It highlights the importance of these water bodies in storing resources and benefiting communities, economies, and ecosystems. The discussion emphasizes the value of freshwater lakes in Tanzania, addresses their decline, and presents best practices for integrated lake basin management. It concludes with recommendations to enhance management capacity for lake and reservoir basins across Africa, aiming to improve water security, ecosystem services, and climate resilience.

3 Policy Review Findings

3.1 The Growing Importance of Lakes and Reservoirs Amid Alarming Global Trend

Hirji and Duda (2025) discuss recent United Nations resolutions about lakes, the WMO report on lake and reservoir depletion, and the World Bank report on integrated storage management, elevating renewed global attention to the growing importance of lakes and reservoirs.

In 2022, the United Nations Environment Assembly adopted the Sustainable Lake Management (SLM) resolution to tackle water scarcity, environmental degradation, and climate change. It urges member states to address critical issues such as poor land use, agriculture and industry pollution, water over-extraction, and rising temperatures affecting lake ecosystems globally (UNEP, 2022).

Lakes and reservoirs are vital freshwater resources and biodiversity hotspots and face threats from human activities and climate change. The SLM resolution calls for a comprehensive, collaborative approach to protecting and managing these essential ecosystems. It encourages collection of essential data through improved research on lake ecosystems. It urges member states to strengthen the resilience and sustainability of lakes and reservoirs for future generations. This comprehensive approach is essential for protecting human well-being and the health of our planet.

In 2024, the United Nations Environment Programme (UNEP) established August 27 as World Lakes Day to raise awareness of lakes' crucial role in communities and the economy. The resolution emphasizes the threats to these water bodies and the need for sustainable management, as outlined in the UN Resolution on Sustainable Land Management (SLM).

The WMO's 2023 State of Global Water Resources Report highlights concerning trends: over 50% of catchments saw reduced river flows, and more than 60% of reservoirs had below-normal inflows in 2022 compared to the 1991-2020 average.

Climate change exacerbates these issues, underscoring the need for improved monitoring, data sharing, and cross-border collaboration to manage water resources and address the extremes of flooding and drought (WMO, 2023).

On February 3, 2023, a World Bank blog titled "Water Storage is at the Heart of Climate Change Adaptation" highlighted the critical role of water storage solutions in addressing climate change. The report emphasizes the need for investment in natural and artificial water storage systems to help communities manage water scarcity and mitigate the effects of extreme weather events (Burke et al., 2023).

These resolutions and reports highlight the necessary policy shifts to incorporate innovative water management strategies and promote international cooperation, ensuring equitable access to essential water resources in an increasingly unpredictable climate.

3.2 Lakes and Reservoirs are Vital Stores of Freshwater

Globally, liquid fresh surface water totals around 104,590 cubic kilometres (km^3), lakes store 91,000 km^3 , wetlands about 11,470 km^3 , and rivers approximately 2,120 km^3 (Shiklomanov, 1993). About 87% of accessible freshwater is found in natural lakes, highlighting their vital role in ecological stability, water regulation, and community resources.

Artificial reservoirs, including around 62,000 ICOLD-registered large dams, are vital in boosting global freshwater storage by capturing about 9,000 km^3 of water (ICOLD, 2023). While they represent less than 10% of the total storage capacity of freshwater lakes, they are crucial for water management, especially in areas facing droughts or water scarcity (Hirji & Duda, 2025).

Africa has some of the largest freshwater lakes, including the East African Great Lakes (EAGL): Tanganyika, Nyasa, and Victoria. Other notable lakes are Albert, Baringo, Chala, Edward, Fundudzi, Jipe, Kivu, Maweru, Naivasha, and Tana in Eastern and

Southern Africa, along with Lake Bosumtwi in Ghana and Lake Chad in Central Africa.

Lakes Tanganyika, Nyasa, and Victoria—hold 18,900 km^3 , 7,720 km^3 , and 2,760 km^3 of freshwater, respectively (ILEC, 2005), totalling 29,380 km^3 or 28% of the world's accessible freshwater (Hirji & Duda, 2025).

Lake Kariba, shared by Zambia and Zimbabwe, is the world's largest freshwater reservoir with a capacity of 185 km^3 . Other notable artificial lakes include Nasser in Egypt (145 km^3), Volta in Ghana (132 km^3), the Grand Ethiopian Renaissance Dam (GERD) (74 km^3), Cahora Bassa in Mozambique (63 km^3), and Julius Nyerere in Tanzania (34 km^3).

Tanzania has substantial freshwater in its many lakes. Table 1 lists 33 lakes from the Tanzania Water Resources Atlas (MOW, 2019) in nine basins and their sizes. These include large and small transboundary lakes, soda lakes, and the Nyumba ya Mungu reservoir. Transboundary lakes include the total area shared among all riparian nations.

The two nations dispute the Lake Nyasa/Malawi/Niassa border between Malawi and Tanzania. Malawi claims Tanzania has no share of the lake, allocating about 70% to itself and 30% to Mozambique (Scenario 1). Conversely, Tanzania argues it shares half of the lake area above the border with Mozambique, suggesting a distribution of around 20% for itself, 50% for Malawi, and 30% for Mozambique (Scenario 2).

Table 2 displays the total area and water volume of the three EAGL and estimates for Tanzania, excluding smaller freshwater lakes from Table 1. It assumes the lake volume is proportional to the area for illustrative purposes. Estimating areas and volumes for Lakes Tanganyika and Victoria is straightforward due to their well-defined boundaries. For Lake Nyasa, there are estimates of two scenarios.

Table 3 shows the storage volume of Tanzania's 777 existing dams, including the Julius Nyerere Dam, across nine basins. It includes dams planned or under-construction.

Table 1: Major Lakes in Tanzania (Source: MOW, 2019)

No	Lake Name	Basin	Area (km ²)	No	Lake Name	Basin	Area (km ²)
1	Balangida Lelu	ID	43.4	18	Victoria	LV	67,500
2	Balangida	ID	36.0	19	Jipe	Pangani	9.2
3	Babati	ID	5.6	20	NYM	Pangani	100.4
4	Singida	ID	39.1	21	Chala	Pangani	3.9
5	Burungi	ID	348.1	22	Mahogona	Rufiji	312.5
6	Manyara	ID	348.5	23	Uba	Rufiji	3.0
7	Natron	ID	756.3	24	Ruwe	Rufiji	9.5
8	Eyasi	ID	1163	25	Umwe	Rufiji	2.0
9	Amboseli	ID	5.4	26	Tagalala	Rufiji	2.5
10	Nyasa	LN	29,450	27	Nzerkera	Rufiji	4.2
11	Rukwa	LR	5,983	28	Mzizima	Rufiji	1.2
12	Lweio	LV	18.1	29	Zumbi	Rufiji	7.4
13	Rwakajunju	LV	32.7	30	Weme	Rufiji	2.6
14	Nyamawale	LV	2.8	31	Ilu	Rufiji	4.2
15	Rushwa	LV	11.7	32	Lugongwe	Rufiji	3.3
16	Ikimba	LV	40.7	33	Tanganyika	LT	33,127
17	Bungi	LV	210.7				

Table 2: Conservative Estimate of Lake Storage Capacity in Tanzania

Lake	Area	% of area	Volume	Estimated storage
Victoria	68,800 km ²	Tanzania (49%) – 33,712 km ² Uganda (45%) – 30,960 km ² Kenya (6%) – 4,128 km ²	2,760 km ³	Tanzania—1,352 km ³ Uganda—1,242 km ³ Kenya—165.6 km ³
Tanganyika	32,600 km ²	Tanzania (41%) – 13,366 km ² DRC (45%) – 14,670 km ² Burundi (8%) – 2,608 km ² Zambia (6%) – 1,956 km ²	18,880 km ³	Tanzania—7,741 km ³ DRC—8,496 km ³ Burundi—1,510 km ³ Zambia—1,153 km ³
Nyasa	29,500 km ²	Malawi (70%) – 20,650 km ² to (50%) – 14,750 km ² Mozambique (30%) Tanzania (Scenario 1 - 0%) – 0 km ² to (Scenario 2 20%) – 5,900 km ²	7,775 km ³	Malawi— 3,888 km ³ to 5,443 km ³ Mozambique— 2,333 km ³ Tanzania—0 km ³ (Scenario 1) o 1,555 km ³ (Scenario 2)
Tanzania		47,078 km ² – 52,978 km ²		9,093 km ³ – 10,648 km ³

Table 3: Estimated Reservoir Storage Capacity in Tanzania (Source: MOW, 2019)

Basin	Existing dams & reservoirs	Total Storage Volume (MCM)	Dams planned or under construction
Internal Drainage	119	119.2	88
Lake Rukwa	4	-	8
Lae Nyasa	5	1.1	15
Pangani	156	1191.6	16
Lake Victoria	154	85.61	36
Rufiji	38	37,935.1	50
Wami/Ruvu	167	52.5	24
Ruvuma and SC	75	21.7	14
Lake Tanganyika	59	15	28
Tanzania	777	39.4 km ³	279

A comparison of freshwater storage in Tanzania's lakes and reservoirs shows that:

- i. Freshwater storage in Tanzania's portion of the EAGL is estimated between 9,083 km³ (scenario 1) and 10,648 km³ (scenario 2).
- ii. The total storage in Tanzania's 777 reservoirs is 39.4 km³, including the Julius Nyerere Reservoir (34 km³).
- iii. Tanzania's lakes hold 230 to 266 times more water than all its dams.

- iv. Tanzania's estimated 64 million population is 0.78% of the global population; its lakes store 8.7% to 10.1% of the world's freshwater supply.
- v. Tanzania's lake storage exceeds the combined storage of all 62,000 large dams globally
- vii. Wastewater Assimilation: Lakes are also often used as receiving bodies for wastewater. Major urban centres and towns often discharge partially treated or untreated wastewater into Lake Victoria, including Kisumu, Entebbe, Bukoba, Mwanza, and Musoma.

3.3 Lakes and Reservoirs Provide Vast Socioeconomic and Ecological Benefits

Natural lakes and constructed reservoirs are vital for ensuring a reliable global water supply and providing essential ecosystem services, especially in climate change (Hirji & Duda, 2025). They offer numerous benefits, including:

- i. Water Supply: Lakes and reservoirs provide crucial water for urban supply (for Bujumbura, Bukoba, Kalimeji, Kigoma, Kisumu, Musoma, Mwanza, and Entebbe), hundreds of villages and communities, agriculture, livestock, mining (in Kahama and Shinyanga), and industries.
- ii. Electricity Generation: Many lakes and reservoirs, such as Lake Victoria, Lake Nyasa, and the Grand Ethiopian Renaissance, Cabora Bassa, Kariba, Volta, and Julius Nyerere dams generate hydroelectric power, contributing to renewable energy and reducing fossil fuel dependence.
- iii. Support for Fisheries, Navigation and Recreation: These bodies of water support commercial and subsistence fisheries, facilitate transportation and trade, and offer recreational activities, enhancing community well-being.
- iv. Biodiversity Habitats: Lakes are crucial ecosystems that support diverse plant, bird, and animal life and contribute to ecological balance. Lake Nyasa is the most biodiverse lake in the world.
- v. Aquifer Recharge: They help maintain groundwater levels, ensuring long-term water security.
- vi. Flood Control and Drought Mitigation: Lakes manage water flow, helping to control floods and providing water during droughts.

In summary, lakes and reservoirs are invaluable natural resources that support sustainable development, environmental preservation, and regional trade.

3.4 The Global, Regional and Local Value of Freshwater Lake Ecosystem Services

A recent study estimated that the global value of ecosystem services from freshwater lakes ranges from USD 1.3 trillion to USD 5.1 trillion annually (Li & Tsigaris, 2024). This value is estimated by multiplying the average price per hectare per year, roughly USD 15,618 (Costanza et al., 2014), by the total area of lake ecosystems, which varies between approximately 200 million ha (Costanza et al., 2014) and 326 million ha (Messenger et al., 2016). These services include water purification, habitat provision, flood control, and recreational opportunities.

Freshwater lakes' net asset value worldwide is between USD 87 trillion and USD 340 trillion (Li & Tsigaris, 2024), highlighting their significant contributions to livelihoods, the economy, and ecological balance.

The total area of the three EAGLs—Nyasa, Tanganyika, and Victoria—is approximately 134,100 square kilometres (ILEC, 2005), equating to 13.4 million hectares. The value of ecosystem services from these lakes ranges from USD 53 billion to USD 210 billion annually, emphasizing their critical role in supporting local communities through water supply, energy generation, flood and drought mitigation, navigation, trade, fishing, tourism, and ecological benefits.

Their asset value of the EAGLs is between USD 3.4 trillion and USD 13.98 trillion (Li & Tsigaris, 2024), highlighting the significant wealth of freshwater lake resources.

Tanzania has approximately 61,500 square kilometres (6.15 million hectares) of its area covered by water, including lakes and wetlands (MOW, 2019).

For the Tanzanian portion of the three EAGL, two scenarios are estimated:

- Scenario 1 (excluding Lake Nyasa) covers about 47,078 square kilometres (4.7 million hectares), with ecosystem service values ranging from USD 18.7 billion to USD 73.5 billion annually.

- Scenario 2 (including a portion of Lake Nyasa) covers approximately 52,978 square kilometres (5.3 million hectares), with values between USD 21 billion to USD 83 billion per year.

These lakes provide essential services such as water supply, energy generation, flood mitigation, navigation, fishing, and tourism. The estimated asset values are:

- Scenario 1: USD 1.25 trillion to USD 4.9 trillion.

- Scenario 2: USD 1.4 trillion to USD 5.5 trillion.

National decision-makers must recognize the value of these lakes in water policies and economic planning to ensure sustainable management and conservation for future generations.

3.5 Characteristics of Lakes Versus Rivers and their Management Implications

Understanding the distinct characteristics of lakes and rivers is essential for sustainable management and climate resilience. Lakes and reservoirs are lentic or standing waters, stratification and sediment composition impact nutrient cycling and biodiversity. In contrast, rivers are lotic, or moving waters that reshape landscapes and affect sediment transport and aquatic habitats.

Four Special Characteristics of Lakes:

- i. *Natural Storage*: Lakes hold about 91,000 km³ of water worldwide, far exceeding the storage capacity of all 62,000 large dams, which is less than 9,000 km³. In Tanzania, lake storage surpasses 9,000 km³, while 777 dams store around 40 km³.

- ii. *Rivers*, which flow in one direction, lakes mix their waters, sharing resources and challenges among all users.

- iii. *Long Retention Time*: Lakes have longer retention times than rivers, with Lakes Nyasa, Tanganyika, and Victoria averaging 114, 440, and 23 years, respectively. This stability helps buffer against floods and droughts, but means lakes respond slowly to management.

- iv. *Complex Response Dynamics*: Lake behaviours can be complex and unpredictable, as their responses to various factors are not always linear.

These differences lead to varying management needs. Lakes often require strategies to monitor water quality and control eutrophication, exacerbated by nutrient runoff. River management focuses on flood risk mitigation, maintaining flow regimes, and supporting fish migration. Enhancing the resilience of these ecosystems becomes crucial as climate change progresses. Targeted conservation and adaptive management strategies can support ecological health and community well-being. Recognizing the unique features of lakes and rivers allows for better planning and sustainable use amidst environmental changes.

The interplay of four key characteristics in lake ecosystems significantly influences lake management practices:

- i. *Holistic Stakeholder Engagement*: Lake-related issues often affect various ecological and community aspects, necessitating the involvement of diverse stakeholders, including local communities, government agencies, and environmental organizations. Collaborative strategies lead to sustainable solutions.

- ii. *Long-Term Commitment to Solutions*: Problems within lake systems can develop slowly over time, requiring sustained efforts and resources. To effect lasting improvements, stakeholders must be prepared to invest in ongoing monitoring and maintenance.

- iii. *Complex Cause-and-Effect Relationships*: The link between lake problems and their causes is often

complex. Rigorous scientific inquiry and interdisciplinary approaches are essential for identifying root causes and designing effective interventions.

iv. *Awareness Gaps Among Water Managers*: Many water managers may not fully grasp the interconnectedness of ecological health and water quality. Educational initiatives can help bridge this knowledge gap, enhancing decision-making.

v. *Refinement of Integrated Water Resources Management (IWRM)*: To effectively manage lake ecosystems, IWRM should be adapted to Integrated Lake Basin Management (ILBM), which addresses lakes' unique features and promotes better coordination across land and water uses.

Understanding these dynamics enables stakeholders to navigate the complexities of lake management and foster resilient aquatic environments.

3.6 Lakes and Reservoir Basins are Rapidly Deteriorating both Globally and Locally

Over-extraction of water for agriculture, industry, and domestic use pressures ecosystems, leading to lower water levels and habitat loss. Pollution from runoff, industries, and sewage degrades water quality and harms aquatic life.

Poor land use, such as urban expansion and deforestation, increases erosion and sedimentation, disrupting natural water flow. Invasive species also threaten native biodiversity by outcompeting them.

Climate change significantly impacts freshwater systems, leading to increased droughts and floods. It threatens clean drinking water, fisheries, and biodiversity. Sustainable management and conservation are crucial for safeguarding lentic waters globally.

Technological advances enhance environmental analysis through tools like global databases, Geographic Information Systems, remote sensing, and satellite imagery. Resources such as the International Lake Environment Committee's World Lake Database, the World Wildlife Fund's Global

Lakes and Wetlands Database, and a lake water quality database (Naderian, 2024) offer valuable data on lakes and their ecological importance.

Examples of Global Level Analysis

Filazzola et al. (2020) analyse the effects of global environmental changes on chlorophyll levels and water chemistry in 11,959 lakes across 72 countries. Their study highlights the complex relationship between climate factors and freshwater ecosystem health, providing valuable insights for conservation and policy.

Small lakes are significant contributors to greenhouse gas emissions. Pi et al. (2022) mapped 3.4 million lakes from 1984 to 2019, revealing that these lakes, covering only 15% of the surface area, account for approximately 25% of global CO₂ emissions and 37% of methane (CH₄) emissions, highlighting their role in climate change.

Thousands of drying lakes threaten water supplies for over 150 million people. A study by Weyhenmeyer et al. (2024) found that about 115,000 lakes are rapidly drying up, jeopardizing those who rely on them for drinking and agriculture. This trend poses significant ecological and socio-economic risks, highlighting the need to address its causes.

A study by Yao et al. (2023) of 1,972 lakes and reservoirs from 1992 to 2020 found that 53% experienced declining water levels, mainly due to rising temperatures (36%) and water usage (20%). Additionally, sedimentation from soil erosion accounted for 67% of reservoir declines, diminishing the benefits of newly built dams.

Sedimentation is a significant global issue, with over 40,000 large reservoirs in 150 countries facing a 13% to 19% loss in storage capacity. This loss could reach 26% by 2050, impacting water supply, irrigation, power generation, and flood control (Perara et al., 2022). Since the 1950s, sedimentation rates have tripled due to rapid population growth and land use changes like urbanization and deforestation (Baud et al., 2021).

Analysis Examples from Eastern and Southern Africa

Accelerated siltation of Lake Bassotu, Tanzania, threatens its viability. On December 22, 2024, Christosy Lalika from WaterAid highlighted concerns about the lake, which supports over 5,000 people in the Hanang District, in a LinkedIn post. Analysis of Landsat 8 imagery from 2015 to 2024 shows the lake's surface area increased from 11.34 km² to 14 km², but its depth is decreasing due to rising siltation.

With over 50% of the surrounding land cultivated, significant soil erosion and sedimentation are occurring, degrading water quality and harming local livelihoods dependent on fishing. Experts warn that without intervention, Lake Bassotu could face severe ecological degradation and may disappear within 15 years. Sustainable land management and collaboration among the community, local authorities, and environmental organizations are crucial for preserving this vital resource.

Sedimentation and climate change complicate water management. Water managers must tackle the growing population's needs and environmental degradation. Addressing sedimentation is crucial for sustainable water resources for future generations.

Toxic algal blooms in Winam Gulf pose risks to wildlife, livestock, and humans. A study by Lauren N. Hart and colleagues, titled "Metagenomics reveals spatial variation in cyanobacterial composition, function, and biosynthetic potential in the Winam Gulf, Lake Victoria, Kenya," published in *Applied and Environmental Microbiology* (2025), examines cyanobacterial populations that rapidly multiply and produce harmful toxins.

A toxic algal bloom linked to climate change may have killed 350 elephants in Botswana. Rising water temperatures and agricultural runoff are creating conditions for harmful blooms that threaten wildlife and ecosystems. Experts warn that such incidents could increase, emphasizing the urgent need for environmental protection.

The return of invasive water hyacinth to Lake Victoria is impacting local communities and livelihoods. Covering about 1,000 hectares, this aggressive weed thrives on nutrient-rich waters from agricultural runoff and pollution, affecting areas like Nyakach and Kendu Bay. Its dense mats hinder fishermen's access to fishing grounds and outcompete native plants, leading to declining fish populations. Managing its spread is challenging, necessitating sustainable practices and biological control methods. Collaborative efforts are essential to restore ecological balance and protect livelihoods. (Elizabeth Ojina & George Odiwuor, *The Nation*, January 18, 2024).

Unregulated outflows from Lake Victoria threaten local livelihoods, the economy, and national security. Concerns emerged from declining water levels between 2004 and 2006, impacting stakeholders reliant on the lake's resources (Bosuben et al., 2022). Fishing communities, agriculture, and transportation faced significant repercussions (Mugabe & Kisambira, 2006).

The Ugandan government contemplated shutting down the Jinja Dam, risking energy generation and water supply (Olupot, 2006), while transporters worried about increased logistical costs (Oywa, 2006). Low water levels also raised alarms about potential agricultural shortfalls and economic instability (Reynolds, 2005).

The Global Reservoir and Lake Monitor Project and the United Nations Environment Programme (2005) stressed the necessity for effective monitoring systems to manage Lake Victoria's resources and protect the ecosystems and livelihoods dependent on it. Immediate action is vital to prevent broader security issues in the region.

Advanced technology can aid in timely and accurate data analysis

The USDA's G-REALM system is a cutting-edge tool for tracking lake and reservoir levels in near real time, essential for water resource management. Its

sophisticated sensors monitor water level changes, helping to understand hydrological patterns and assess climate change impacts.

Data from G-REALM is essential for researchers and water resource managers, enabling informed decisions on sustainability and conservation. It helps develop strategies for adapting to environmental changes and enhances community resilience. By monitoring water level fluctuations, G-REALM supports sustainable water management and provides insights into essential water bodies like Lakes Nyasa, Rukwa, Tanganyika, Victoria, and the Mtera and Nyumba ya Mungu Reservoirs.

4 The Opportunity

This section highlights how the MOW can improve Integrated Lake Basin Management (ILBM) by leveraging existing knowledge and minimizing duplication. Insights from the World Bank, UNEP, and ILEC provide valuable lessons and guidelines for sustainable water resource management.

Early Global Initiatives in Lake and Reservoir Management

The World Bank adopted integrated water resources management to balance environmental, economic, and social objectives in its Water Resources Management Policy (World Bank, 1993). While considering conservation, Dinar et al. (1995) provided a framework for equitable water use among agriculture, industry, and recreation. Ayres et al. (1996) highlighted effective management practices for policymakers to support ecosystems and communities. Mee (2003) stressed the need for adaptive management and stakeholder engagement in freshwater ecosystem resilience, specifically addressing lake and reservoir management in the last three publications.

From 1989 to 1998, the United Nations Environment Programme (UNEP) and the International Lake Environment Committee (ILEC) created nine volumes of Lake Management Guidelines to tackle pollution, biodiversity loss, and resource sustainability, promoting best practices for

environmental health and community well-being (Hirji & Duda, 2025).

Early World Bank, UNEP, and ILEC initiatives laid the groundwork for later integrated water resource management efforts.

A Multiagency Global Initiative on Integrated Lake Basin Management

The report "Managing Lakes and Their Basins for Sustainable Use" (ILEC, 2005), funded by the Global Environment Facility (GEF) and supported by ILEC, LakeNet, and the World Bank, emerged from a Cooperative Program involving nine agencies and 288 experts across 41 countries from 2000 to 2005. It included workshops in Vermont, Manila, and Nairobi, analysing 28 lake basin management cases, and offers practical lessons and strategies for sustainable use and ecosystem health.

The report "Lessons for Managing Lake Basins for Sustainable Use" (World Bank, 2005) analyses water resource challenges in river and lake basins, emphasizing policy frameworks and institutional responses to threats like pollution and ecosystem degradation. It also improves management practices based on GEF's international waters monitoring indicators.

Leveraging Existing Knowledge for Effective Water Resource Management

Leveraging relevant, accessible knowledge without reinventing the wheel can help advance IWRM and ILBM. A prime example is the fourteen World Bank Water Resources and Environment Technical Notes, created by experts over the past two decades. These notes, listed below and easily accessible online, provide valuable policy insights and sustainable and integrated water management guidelines.

I Environmental Flow Assessment series

- Technical Note C1 discusses environmental flow assessment and management principles and methodologies (Brown & King, 2003).

- Technical Note C2 highlights case studies demonstrating the effectiveness of environmental flow assessments in various contexts (King & Brown, 2003).
- Technical Note C3 focuses on assessing and managing flood flows, addressing ecological significance, and mitigation strategies (Acreman, 2003).

II Water Quality Management series

- Technical Note D1 outlines assessment methods and protective measures for safe water quality (Radstake & Tuinhof, 2003).
- Technical Note D2 highlights modern wastewater treatment techniques and best practices (Wolff, 2003).
- Technical Note D3 addresses nonpoint source pollution challenges and management strategies (Wolff, 2003).

III Irrigation and Drainage series

- Technical Note E1 covers planning and sustainable development of irrigation systems to boost agricultural productivity and conserve water (Ouchs & Plusquellec, 2003).
- Technical Note E2 addresses rehabilitating existing systems for better efficiency and water management (Wolff, 2003).

IV Water Conservation series

- Technical Note F1 discusses strategies for water conservation in urban areas (Versteeg & Tolboom, 2003).
- Technical Note F2 explores water efficiency techniques in irrigation (Ouchs & Plusquellec, 2003).
- Technical Note F3 outlines the benefits of treated wastewater reuse (Van Gool, 2003).

V Waterbody Management series

- Technical Note G1 focuses on lake management strategies, highlighting their ecological and recreational significance (Mee, 2003).

- Technical Note G2 emphasizes wetland importance and management techniques to boost biodiversity and water quality (De Shutter, 2003).
- Technical Note G3 covers aquatic plant management to maintain ecological balance and prevent disruptive overgrowth (Vermaat, 2003).

5 Recommended Actions

Four recommended actions for developing integrated management capacity for African lakes and reservoirs aim to combat the degradation of lentic waters. These actions align with the UN Resolution on SLM, respond to President Suluhu's human development call, and support NAWAPO's priorities and GOT initiatives on Lakes Tanganyika and Victoria.

I. *Adopt Best Practices in Integrated Lake Basin Management*: Holistic management of lakes and their basins requires considering the connections between land, water, and ecosystems. Engaging local communities and stakeholders is essential for developing guidelines that promote environmental sustainability and community welfare. Effective governance structures must empower all parties involved, while refining Integrated Water Resources Management to address the unique characteristics of lentic waters critical for ILBM.

II. *Submit a Bid to host the World Lakes Conference in Tanzania in 2027*: Hosting this conference would position Tanzania as a leader in African lake basin management and conservation. It would attract researchers, policymakers, and conservationists, fostering knowledge exchange and innovative solutions for our unique environmental challenges. This event would promote partnerships and international collaboration on critical issues affecting lake ecosystems, such as pollution, invasive species, and climate change.

III. *Celebrate World Lakes Day on August 27 Each Year*: Organize annual events to raise awareness about lake ecosystems and their challenges. Engage the community through educational programs and activities, incorporating local customs to foster a

sense of ownership and stewardship for preserving our lakes.

IV. *Establish a Centre in Tanzania to Enhance Africa's Capacity for Integrated Lake Basin Management*: Create in phases a dedicated center to serve as a hub for research, training, and capacity building in Integrated Lake Basin Management across Africa. The initial phase could include a program within the Water Institute to enhance skills in limnology and aquatic sciences, eventually expanding into a comprehensive program for national and transboundary management of Africa's rivers, lakes, and aquifers.

Over time, the centre can collaborate with local, regional, and international institutions to develop and share knowledge and experience and offer customized training programs for government officials, NGOs, and community leaders to equip participants with the skills needed for effective lake basin management. The centre can also promote joint research initiatives that address Africa's unique ecological and socio-economic challenges, fostering innovative solutions for issues related to lake basins. Enhancing Africa's capacity to manage lakes and reservoir basins would improve the continent's water security, ecosystem services, and climate resilience.

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