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Editorial: Freshwater science in Africa

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Editorial on the Research Topic
Freshwater science in Africa

Introduction

Human activities and global climate change affect ecosystems, species, and human services and resources (Dudgeon et al., 2006; Reid et al., 2019). Freshwater ecosystems are the most fragile habitats, hosting roughly 7% of the world's biodiversity on 1% of land and 0.01% of water (Gleick, 1996; Reid et al., 2019). Human population growth exacerbates climate change, pollution, water abstraction, impoundment of streams and rivers, nutrient and organic matter loading, invasive species, wetland degradation and loss, and other stressors (Dudgeon et al., 2006; Vörösmarty et al., 2010; Cazzolla Gatti, 2016). Knowledge of freshwater ecosystem structure and function helps us understand how they react to different pressures. This knowledge guides freshwater ecosystem conservation, management, and decision-support tools.

Africa's diverse and large freshwater systems include iconic rivers that fostered the earliest civilisations, the Great Lakes that hold 25% of the world's unfrozen fresh water, and extensive wetlands, floodplains, and deltas that support unique species. Fisheries, irrigation, and livestock production from these freshwater ecosystems feed millions of people. Due to rapid population growth, land use change, urbanisation, energy consumption, and water harvesting are threatening freshwater ecosystems (UNEP-WCMC, 2016; Fouchy et al., 2019; Birk et al., 2020). Studies have expressed serious concerns about the continent's freshwater fauna and ecological processes (Darwall et al., 2005; Thieme et al., 2005; Sayer et al., 2018; Masese et al., 2021). Freshwater impacts are reducing the continent's ecological services and human welfare (IPBES, 2018). There is a growing need to investigate the condition of freshwater ecosystems to document their conservation status, and the threats they face, and to devise management and conservation measures.

This Research Topic explores Africa's freshwater science potential and distinct freshwater ecosystems and communities. This Research Topic brings together expert research on African freshwater science by African and non-African scientists to highlight the continent's contribution to the global freshwater community. Articles in

this Research Topic help galvanise and harmonize science and information exchange by strengthening the collaborative network of African freshwater scientists. It also leads future freshwater research in the continent and helps researchers develop alliances and explore African freshwater science breakthroughs. The main topics of importance covered by the articles in this Research Topic included.

- Freshwater physical, chemical, and biological characteristics, and human impact.
- Methods to analyse, monitor, conserve, and manage freshwater ecosystems.
- Biomonitoring indices or tools.
- Social/cultural participation in freshwater ecosystem studies, management, and policy.
- Invasive species and their effects
- Multiple stressors, interactions, and management.
- Socio-ecological science, governance, and policy.

Status of African freshwater ecosystems

Africa boosts renowned freshwater ecosystems, including iconic rivers such as the Nile, Niger, Orange, Tana and Zambezi, the African Great Lakes—Albert, Edward, Kivu, Malawi, Tanganyika, Turkana and Victoria, and extensive wetlands such as the Inner Niger Delta, the Okavango Delta, St. Lucia Estuary and the Sudd. Other important freshwater ecosystems in semi-arid and arid areas include the inland oases, wadis and chotts of North Africa. These freshwaters and linked terrestrial and marine ecosystems support a great diversity of plants and animals, and their productivity provides the natural resources essential to the survival of a significant part of the African rural population.

Africa is underdeveloped, but humans nevertheless affect freshwater environments. Many rivers are being dammed for hydropower and water supply (McClain, 2013; O'Brien et al., 2021). Many lakes are stressed by excessive water withdrawal, pollution, invasive species, overfishing, and biomass harvesting, while many wetlands have been reclaimed for forestry, grazing, and settlements (Dalu and Wasserman, 2022). These pressures have weakened freshwater habitats. Land use change and pollution have caused the biggest water quality decline (Jacobs et al., 2017; Fayiga et al., 2018; Wanderi et al.). Threats to indigenous species and their habitats (Weyl et al., 2020) and altered ecological processes such as organic matter processing, nutrient cycling, and ecosystem productivity (Masese et al., 2017; Fugère et al., 2018) have also been noted.

Addressing challenges facing freshwater ecosystems in Africa

Despite the vulnerability of African freshwater ecosystems to human activities, few studies have assessed their status and threats. Lack of data, budget constraints, and inadequate financial and technical capacity hinder research, conservation, and management (Achieng et al., 2023). Multiple stressors threaten freshwater ecosystems, requiring immediate, long-term, and holistic management and conservation methods. One way is using biological indicators to evaluate and monitor freshwater environments.

While efforts have been made to develop ecological indices and other models to assess and monitor the status of inland waters in Africa (Dallas, 2021; Masese et al., 2021; Plisnier et al., 2022), most studies have focused on land use change (e.g., agriculture and urbanisation), industrial discharges, and organic pollution (Masese et al., 2021). Wanderi et al. examined the combined effects of land use change, flow variation, and of organic matter and nutrients by large mammalian herbivores on an Afromontane-savanna Mara River in Kenya to understand how other stressors affect aquatic ecosystems. Dusabe et al. used macroinvertebrates as bioindicators to assess river impacts from dams. Damming rivers for hydropower development in Africa is expanding to meet electricity demands (O'Brien et al., 2021), but little is known about the effects on river flows and biodiversity. To bridge this knowledge gap, Muvundja et al. examined the hydrological regime and water quality of the Ruzizi River. Masese et al. assessed the ecological condition of Afrotropical rivers using the transboundary Mara River, Kenya and Tanzania, as a case study to improve macroinvertebrate-based indices.

Understanding species phylogeny, occurrence, and distribution is crucial to understanding African biodiversity and its threats. Human disease causing vectors must be controlled by knowing their occurrence and distribution. Tabo et al. used a machine learning algorithm and random forest to estimate the distribution of gastropods *Biomphalaria* and *Bulinus*, intermediate hosts of *Schistosoma mansoni* and *S. haematobium*, to help manage Schistosomiasis in western Uganda's crater lakes. Tumwebaze et al. examined pan-African *Bulinus* species from varied habitats across different altitudinal ranges, particularly on the highlands, to determine how contemporary climate and historical geological causes affect species distributions and evolutionary processes. Another biodiversity study by Sands et al. examined the phylogeography of the freshwater limpet genus *Burnupia* in the southern African Highlands to assess its diversity, endemicity, and colonisation date.

Exotic species also threaten African freshwater environments. Many African lakes, rivers, and wetlands have introduced fish. Introduced species have been extensively studied in lakes like Lake Victoria (Taabu-Munyaho et al., 2016), but few studies have examined their effects on rivers and wetlands. Trout are among the most widely introduced fishes, including in African highland streams and rivers (Crawford and Muir, 2008; Weyl et al., 2017). Maimela et al. examined food web interactions between fish communities in invaded and uninvaded river reaches in the upper Blyde River catchment, South Africa, to understand how the exotic *Oncorhynchus mykiss* affects indigenous fish species.

Finally, inland freshwater environments serve millions of Africans through fishing. Overfishing, alien species invasion, pollution, eutrophication, and climate change threaten fisheries resources. Several steps should be taken to maximise the benefits of declining catch fisheries. Nyamweya et al. examined how product diversification, value addition, and sustainable fisheries may maximise Lake Victoria's benefits. This study shows that minimizing post-harvest losses of the silver cyprinid

Rastrineobola argentea will boost revenue and yield higher-quality fish for human consumption. Biowaste (frames, skin, and fish mouth) might triple Nile perch revenues, too. If fishing targeted maximum sustainable yield (MSY), long-term Nile perch and Dagaa landings might increase. In addition, tourism, recreation, and fish cage culture investments can strengthen Lake Victoria's blue economy.

Way forward

This special Topic highlights biodiversity research and human impacts on African freshwater ecosystems. Although many measures are needed, we highlight three areas that should be considered to address the myriad pressures affecting African freshwater ecosystems.

i) Hydropower and excessive water abstractions imperil many freshwater habitats. Environmental flows and integrated water resources management should influence stream and river development plans (Arthington et al., 2018; Dirwai et al., 2021; Meran et al., 2021).
ii) Water-borne diseases continue to be a growing challenge in the African continent. To contribute to the control and/or eradication of water-borne diseases, it is critical to understand the factors influencing the occurrence and distribution of hosts and vectors. Similarly, studies that assess the occurrence and distribution of vectors and hosts of waterborne diseases should be examined to inform management and control measures.
iii) The complex mix of various stressors operating on rivers requires multidisciplinary collaborations to create cost-effective monitoring techniques. Existing indices should be evaluated for performance and improved using indigenous taxa. While developing these tools, emphasis should be placed on stakeholder participation and community engagement.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Conflict of interest

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