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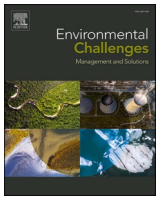

Mobilizing Evidence-based Knowledge for Sustainable Wetlands Co-management and Co-governance amidst increasing Anthropogenic and Environmental Stressors: Key Lessons from Mityana District, Uganda

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ABSTRACT

Wetlands (covering about 1.5–1.6 billion hectares globally), are critical biodiversity and livelihood hotspots. Wetlands further replenish the global economy with $47.4 trillion/year worth of ecosystem services. By jealously guarding wetlands, progress toward sustainable development goals, and livelihood welfare are possible. Unfortunately, despite the promulgation of wetland governance mechanisms, 35 percent of the global natural wetlands have been lost since the 1970s. This could be worse in undocumented or explored wetland zones situated in remote tropical regions. In this study, we bring to the fore insights from 286 documents sourced from Scopus and engagements from 105 citizens in Mityana, to (i) map wetlands (including the current vulnerabilities and threats), and (ii) co-develop a wetlands management action pathway that could create sustainable co-management possibilities and sustainable livelihood futures. Findings revealed that although research on wetlands has increased for the last 31 years, since 2021, it has plummeted. In Uganda, wetland research and scholarship is predominantly situated around the Lake Victoria region. Most research focuses on natural or biological sciences. Emerging policy themes and trending research topics are shifting from key wetland management paradigms. From a total of 105 sampled wetlands scattered across fourteen (14) sub-counties in the Mityana district, critical wetland issues were unraveled. Mityana is crossed by two wetland systems (Lake Wamala and River Mayanja dominated by permanent papyrus and seasonal swamps respectively. Wetlands offer unique livelihood, cultural assets/capitals, and ecological benefits (including cultural/aesthetics meaning). An unfathomable rate of degradation is evident. Anthropogenic factors are the predominant threat drivers, especially eucalyptus planting. The loss of culturally valuable wetlands has increased socio-cultural-ecological grief, such as around Lake Wamala. Micro-level management actions are increasing, albeit mainly around accessible permanent wetlands. Most riparian wetland sedentary populations expressed willingness and interest in the co-management and governance of community wetlands. More robust actions and pathways are needed to create avenues for community co-management. The co-developed the sustainable wetlands management action pathway (SWeMAP) provides seven (7) coherent steps, including critical social science insights that could aid sustainable wetlands governance and management across geographies. As wetlands in Uganda have been

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gazetted as critical to sustainable development, the urgent co-development and financing of micro-level wetland action plans, including situational inventories could help create avenues for sustainable wetlands management.

1. Introduction

Globally, wetlands (covering about 1.5–1.6 billion hectares), have historically been considered 'infinite.' There is also consensus that wetlands are unique ecosystems that avail a paucity of goods, services, and resources for several communities across geographies (Convention on Wetlands, 2021). Wetlands replenish the global economy with $47.4 trillion/year worth of ecosystem services (Canning et al., 2021; Kadoma et al., 2023). This implies that irrespective of the seasonality or permanency of wetlands, most wetlands act as intertidal zones between the land-aquatic (marine or freshwater) interface, from where they perform a paucity of tangible and intangible functions (Bunyangha et al., 2022; Kansiime et al., 2005). Additionally, as wetlands contain different ecosystems, they provide several goods and services that sustain/drive macro and micro-level socio-livelihoods and ecological systems (D. Were et al., 2020; Ssanyu et al., 2014; Maclean et al., 2003). When the comparative benefits of wetlands are factored into the sustainability realm (including sociocultural, economic, and environmental domains), the benefits are astounding (Mfitumukiza et al., 2024; Muwanika et al., 2023; D. Were et al., 2020; Kansiime et al., 2023; 2007; 2005). For instance, in the environmental sustainability domain, although wetlands occupy a paltry 5–8 percent of the planetary surface, they sink about 20–30 percent of the global soil carbon, thus ameliorating global temperatures (Matovu et al., 2024; Mfitumukiza et al., 2024; Convention on Wetlands, 2021; Obubu et al., 2021; Were et al., 2021; D. 2020; Ramsar Convention, 2018).

With the increasing concerns of global warming, mostly among vulnerable communities in the tropical regions, natural tropical wetlands alone (cover 30 percent of the planetary wetland zone), could provide a nature-based alternative to climate change mitigation and adaption (Matovu et al., 2024; B. 2019; D. Were et al., 2020; Lyytimäki and Pitkänen, 2020; Pedersen et al., 2019; Freduah et al., 2019; Kansiime et al., 2007). Multiplier benefits of wetlands goods and services are visible in most regions of the tropics. Here, sedentary communities rely on wetland goods, such as fish, and services (including aesthetics) for their socioeconomic welfare (Scott et al., 2024; Muwanika et al., 2023; Were et al., 2021; Matovu, 2021; Freduah et al., 2019; Kipkemboi et al., 2010; Paterson and Chapman, 2009). Recent studies, such as in Scandinavian countries have further correlated community welfare indicators (including better quality of life, happiness, and human well-being indicators) to wetlands health and sustainable management (Convention on Wetlands, 2021; Lyytimäki and Pitkänen, 2020; Pedersen et al., 2019). The emerging psychological and social-cultural benefits of wetland goods and services create a new opportunity for driving sustainable development goals (SDGs), such as SDG 2 (no hunger), SDG 5 (gender equality), SDG 6 (clean water and sanitation), SDG 10 (reduced inequalities), SDG 11 (sustainable communities and cities), and SDG 13 (climate action), and SDG 15 (life on land) among others (Sachs et al., 2024; WEF, 2023; UN, 2023; World Bank, 2022). The sustainability value of wetlands is partly because, although the overall value of wetland goods, services, and resources is largely unknown, an economic assessment of 63 million hectares of global wetlands revealed an annual valuation of 3.4 billion USD (Matovu et al., 2024). The just use of the monetary value of wetlands could thus be a conduit for the creation of better livelihood and ecological safety nets. And since most of the benefits could be reaped by vulnerable communities, such as in Asia (the annual value of wetlands is estimated at 1.8 billion USD), sustainable livelihood transformations could be reaped in the next few decades (Matovu et al., 2024; Brander and Schuyt, 2010).

To sustain the opportunities and benefits of wetlands, conventions/frameworks, such as the Ramsar Convention (effected in 1971), and the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) concept of "nature's contribution to people" (i.e., global wetland outlook reporting mechanism to track issues on critical wetland sites), have been developed. These mechanisms inter alia, create an economic basis for wetland governance (e.g., under the Dasgupta report), socioecological need for sustainable utilization, governance, and management (Convention on Wetlands, 2021; Lyytimäki and Pitkänen, 2020; Pedersen et al., 2019; Ramsar Convention, 2018). This has partly emerged out of the recent recognition of the sustainability contribution of wetlands, and the potential to create inclusive and effective wetland use and management measures (Convention on Wetlands, 2021; Kakuba and Kanyamurwa, 2021). However, despite these grandiose and commendable efforts, operationalizing 'sustainable management measures' in most geographies has remained complex and less achieved, with sickening ramifications (Matovu et al., 2024; Muwanika et al., 2023). Unsustainable practices and management of natural wetland zones, such as in the tropics have led to the plummeting of wetland cover by 35 percent since 1970 (Convention on Wetlands, 2021). With the COVID-19 pandemic shocks, first, creating novel transformative perspectives on how community health is related to nature (e.g., zoonotic diseases), and second, affecting the most vulnerable communities, mostly in semi-urban regions, concerns about unprecedented encroachment on riparian and semi-urban wetlands, that would have aided sustainability have proliferated (Convention on Wetlands, 2021). This creates an urgent need for transdisciplinary research and an opportunity for policymakers to resuscitate momentum toward wetland management, especially in tropical regions, such as Uganda (Matovu et al., 2024; Muwanika et al., Kansiime et al., 2023; Lawrence, 2023; Were et al., 2021; Convention on Wetlands, 2021). The next sub-section highlights the dynamics and status of wetlands in Uganda.

1.1. *Livelihood survival or sustaining wetlands: the wetlands use, governance, and management complexity in Uganda*

Wetlands have for a long time been considered vital to the beauty of Uganda (Pearl of Africa), as they avail innumerable biotic and abiotic resources, goods, and services (including provisioning, and regulating services) (Matovu et al., 2024; B. 2019; Gabiri et al., 2020; G. 2019). This recognition has been epitomized by, first, the drafting of a plethora of laws and regulations, and second, the creation of specific Ministries, Departments, and Agencies (MDAs) to monitor, and regulate the management of wetlands in Uganda (both at national, regional, and district levels) (GoU, 2021). According to the 1995 Constitution of the Republic of Uganda, the government holds wetlands in trust for the people. This puts the precincts of power to manage and govern wetlands in Uganda in the hands of the Central Government, specifically under the Ministry of Water and Environment (MWE) (G. GoU, 2019). Additionally, to ensure micro-level wetland governance and management, the 1997 Local Government Act devolved the power to manage wetlands to the district-level governments. In this case, a focal technical office (District Natural Resources Office-DNRO), including a district environmental officer, is tasked with the effective monitoring, supervision, and assessment of user practices (GoU, 2021). Departments, such as the Wetlands Management Department (WMD) (mandated to manage wetland resources and sustain their biophysical and socioeconomic values), and semi-autonomous agencies/authorities, such as the National Environment Management Authority (NEMA), have been set up under the NEMA Act, 2019. These are vested with a national responsibility of coordinating, monitoring, regulating, and supervising environmental/wetlands management in Uganda (GoU, 2021; NEMA, 2019). These legal mechanisms have been spiced up by the enacting of

other regulations, such as the National Environment Act, 2019; The National Environment (Environmental and Social Assessment) Regulations 2020; Wetlands Policy, 1995; The National Environment Statute, 1995; Land Act 1998 (amended 2010), among others (GoU, 2021; NEMA, 2019). Some of these acts are dotted with clear and punitive safety nets to guard against illicit wetland use. For instance, under Section 55 (Restrictions on the use of wetlands), Cap 6 of the National Environment Act, it is stated that '*A person who contravenes subsection (1) commits an offense and is liable on conviction to a fine not exceeding thirty thousand currency points or imprisonment not exceeding twelve years or both*' (NEMA, 2019). A transparent and digital environment licensing and management information system (ELMIS) at NEMA has also been set-up. ELMIS manages the issuance of wetland licenses, permits, and certificates and evaluates environmental and social impact assessments as well as environment audits and reports submitted through the NEMA system (https://eservices.nema.go.ug/). These mechanisms have been partly developed to tap the potential of environmental/wetlands resources and products (including food and non-food products) (D. GoU, 2020; NEMA, 2019; GoU, 2015). For instance, the value of fish and fish products harvested in wetlands in Uganda is estimated at around US$ 0.49 per person, and the value of fish spawning is estimated to be US$ 363,815 annually. Additionally, the value of grasslands used for cattle grazing is US$ 4.24 million, and the value of household water use is US$ 34,364 million annually (Turyahabwe et al., 2013; Wasswa et al., 2019). Sustaining these benefits could be key in driving Uganda's National Development Plan III (NDP III) and Vision 2040, which among others aim at boost socioeconomic transformation for all (GoU, 2020a).

1.2. Emerging and perpetual unsustainable wetland management paradox in Uganda

Unfortunately, the commendable safety nets envisioned in policy to promote sustainable wetland management are mostly incompatible with the unsustainable wetland losses in most regions of Uganda (Wasswa et al., 2019; Mbabazi et al., 2010). The reality is worse in most riparian wetland zones, notably in remote areas. In remote geographies, complex wetland dynamics have emerged and this has been worsened by the limited research for years in remote wetland zones (Matovu et al., 2024; B. 2019; Ssanyu et al., 2014). Most of these concerns are not new and have evolved over the years (GoU, 2015; G. 2019; D. 2020). Since the 1990s. unwarranted and sporadic encroachment and decline of wetlands have emerged under the guise of industrial growth, infrastructure development, and recently urban sprawl, mostly in urban and semi-urban zones with devastating consequences, such as around Kampala and its metropolitan areas (D. GoU, 2020; 2015; Wasswa et al., 2019). It is estimated that wetland cover in Uganda has receded from about 15.5 percent in 1994 to 13 percent in 2017; of which 4.1 percent is under increasing degradation (Matovu et al., 2024). According to the 2023 policy statement from the MWE, since 2000, stratospheric levels of wetland loss and degradation have been evident (Were et al. 2021; D. GoU, 2020). Wetland cover has reduced from 30,000 km^2 in 2000 to 22, 500 km^2 in 2023, representing a 25 percent loss over the last two decades (Matovu et al., 2024). Recent reports indicate that Uganda is losing on average 5000 hectares of wetlands per annum, and this might be higher, as data on wetlands loss in remote areas are not readily available (UNDP, 2024; UNEP and UNDP, 2016).

Additionally, most wetland governance policies are not well-known to the local communities, partly due to the constant revision of the statutes (UNEP and UNDP, 2016; Wasswa et al., 2019). Because of this, the community members are not aware of their rights and mandate in the management of the wetlands. This has led to improper use of resources and poor site management (Muwanika et al., Kansiime et al., 2023). Additionally, when enforcement is applied (as evidenced in the 2024 forceful evictions in Nakivubo wetlands), they are forceful and selective, targeting the most vulnerable and less powerful (Matovu et al., 2024; Were et al., 2021; D. 2020). This complicates sustainable wetlands management practices as geopolitical interests usurp proper enforcement and management mechanisms, such as on wetland land title ownership and resource use (Kakuba and Kanyamurwa, 2021; Bikangaga et al., 2007). Policy implementation gaps are further complicated by (i) limited comprehensive socio-ecological research in wetland zones and (ii) limited integration of local citizens' perspectives on how to use, govern, and collaboratively manage wetlands (Matovu et al., 2024; Were et al., 2021; D. 2020; Maclean et al., 2014; Ostrovskaya et al., 2013; 2003; Kipkemboi et al., 2010, 2002). Yet, recent studies in most wetland zones in Uganda have emphasized that addressing complex wetland governance and management requires equity and inclusive governance mechanisms (Matovu et al., 2024; B. 2019; UNDP, 2024; Muwanika et al., 2023; Kakuba and Kanyamurwa, 2021). However, based on the current trends dotted with limited financing of local government institutions (including the complex, incoherent regurgitating policy/governance regulations and legislations), the concentration of research around Lake Victoria, and the historical preference for natural scientific research in wetlands, this seems like a stratospheric undertaking in Uganda (Dalahmeh et al., 2018; Vermeiren et al., 2012; Oguttu et al., 2012; Van Dam et al., 2007; Kyambadde et al., 2004; Chapman et al., 2002; Schofield and Chapman, 1999; Rosenberger and Chapman, 1999; Chapman et al., 1996).

With the official gazetting of wetlands under the National Environment (Declaration of Wetlands) Notice, 2023, where all 8613 wetlands in Uganda are officially protected (recognized as critical ecosystems) (UNDP, 2024; UNEP and UNDP, 2016), we argue that this could be the rare, possibly once-in-a-lifetime opportunity for researchers and concerned citizens to present a knowledge and evidence-base to co-develop and unearth their perspectives on how collaborative governance and management of wetlands (that includes social science perspectives) could be done. To contribute to this, our research slightly diverges from the perpetual concerns in wetlands management and governance research in Uganda. We, first, use a novel literature review method to explore published literature on wetlands in Uganda and second, use participatory engagements/observations across semi-urban/remote wetland zones of Mityana to gain insights and perspectives on how sustainable governance of wetlands can be achieved, without compromising the benefits and needs of micro-level communities. Specifically, our research aimed at unraveling the following aspects,

a. Gaining an in-depth understanding of the literature on the nature and performance of research on wetlands, as well as the persistent/emerging themes and networks in wetlands sustainability/policy in Uganda
b. Exploring the main resources and benefits of wetlands to micro-level communities in Uganda by using a case study of wetlands in Mityana district
c. Examining the key systemic issues and concerns regarding wetlands resources, use, and governance mechanisms from a micro-level perspective of communities sedentary along wetland zones.
d. Co-designing a sustainable pathway that incorporates critical components that can drive sustainable wetlands research, governance, and management among vulnerable wetland zones and communities across geographies.

2. Material and methods used

A combination of two (2) methods was used in this study, including (i) systematic literature review (SLR) and (ii) participatory engagements with households/citizens sedentary along or near wetlands zones in Mityana district.

2.1. Systematic literature review (SLR)

A phased process was used to conduct a systematic literature review as guided by previous studies (Matovu, 2024; Lukambagire et al., 2024).

2.1.1. Procedure for conducting the systematic literature review

First, an online search for literature on wetlands in Uganda was conducted. Since we intended to use a bibliometric method for analyzing data (Mim et al., 2024), we sought to use the Scopus digital database, one of the comprehensive repositories for scholarly and peer-reviewed literature (Lukambagire et al., 2024). To comprehensively obtain huge amounts of literature, we conducted three different searches using different search terms, as guided by studies conducted by Matovu et al. (2024a; 2024). The search terms used were: (i) TITLE-ABS-KEY (wetlands AND in AND Uganda), and with this, 273 documents were obtained; (ii) TITLE-ABS-KEY (lake AND Wamala AND in AND Uganda), and this gave 9 documents, and (iii) TITLE-ABS-KEY (river AND mayanja AND wetlands AND in AND Uganda), and this search query produced 4 articles. Customized search terms '*Lake Wamala*' and '*River Mayanja'* were specifically used, as previous studies and reports have indicated that Mityana district is crossed by two wetland systems (Lake Wamala and River Mayanja wetland systems). Thus, we thought that this would help us obtain specific literature on the targeted wetland areas of Mityana district (Matovu et al., 2024; B. 2019; GoU; 2015). In total, 286 documents were obtained at this stage without filters/screening. Second, the 286 sourced documents were selected and downloaded as Microsoft Excel CSV files. The three separate Microsoft Excel CSV files were then combined to create a single CSV file that was to be imported into R and used for bibliometric analysis (See Link: https://tinyurl.com/2s49c7uk).

2.1.2. Analysis of included documents

To analyze the 286 documents, we used the bibliometrics tool in the R software. Bibliometrics is a new digital tool that explicitly synthesizes huge datasets to obtain insights (quantitative and qualitative trends, performance indicators/metrics/complex networks) on a given research field or context (Mim et al., 2024). To succinctly gain insights into research on wetlands in Uganda (part of objective (a) in our study), we used a phased process in R.

First, we downloaded and installed R into our computer, This was followed by the installation of the bibliometrics tool to run and open a new dashboard to be used for generating results. Then, we imported the combined CSV file into the bibliometrics dashboard. With this, we were able to start our analyses. Ten (10) key analyses were conducted to obtain insight into the literature on wetlands. These were (a) an overview of the literature (capturing a summary of the literature (nature of sources extracted), main information, e.g., on annual scientific production, average citations per year, and Three-Field Plot (on authors, their affiliations, and the prominent keywords they use), (b) core sources (based on the Bradford's Law), (c) authors (most relevant, authors' production overtime and authors' local and author's impact (based on Lotka's law), (d) affiliations (most dominant/relevant and the production overtime), (e) countries (corresponding authors' countries, countries' scientific production and their production overtime, most cited countries), (f) documents (most cited local, most local referenced and references spectroscopy), (g) words (most frequent words, frequency over, trending topics, by using a tree map), (h) clustering, i.e., by coupling using cluster labelling of dominant authors' keywords, (i) conceptual structure, using the network approach (co-occurrence network, including thematic evolution, thematic map), and factorial approach (including factorial analysis), and (j) social structuring of the collaboration networks of leading authors and affiliations). The key analyses are indicated in Section 3.

2.2. Participatory engagement(s) and field data collection

To obtain evidence on wetlands and the micro-level dynamics amidst riparian wetlands, and sedentary communities, we conducted field data collection in Mityana district.

2.2.1. Overview of Mityana district

Geographically, Mityana district is situated in the Buganda region (synonymously called Central Uganda), 73 kms west of Kampala city (Matovu et al., 2024) (Fig. 1). Historically, the district was curved out of Mubende district on 1st July 2005, through an Act of the Parliament of Uganda (MDLG, 2024; UBOS, 2017). The district is bordered by the following districts: Kiboga, Kyankwanzi, Kasanda, Nakaseke, Wakiso, Mpigi, Gomba, and Mubende (UBOS, 2017). Administratively, Mityana district is comprised of four counties and seventeen (17) sub-counties/divisions/town councils: Busujju, Mityana municipality (Ttamu Division, Busimbi Division, and Central Division), Mityana North and Mityana South (Matovu et al., 2024; B. 2019; Matovu, 2021). Mityana district has a total land area of 14,597,85 hectares with 9.49 percent covered by water and wetlands. The rest of the land covered by tropical high forests, woodland, bushland, farmland, and built-up areas (MDLG, 2024). The topography consists of undulating hills and valleys that emerged due to down-warping. Most of Mityana's topographic zone falls under the pre-Cambrian granitic gneisses. Thus, Mityana falls under the greater Lake Victoria down-warped basin (Matovu et al., 2019). This partly accounts for the impeded drainage in the area dominated by down-warped lakes, such as Lake Wamala, and reversed rivers, such as Mayanja, with lush dombos or lacustrine wetlands (B. Matovu et al., 2019).

Demographically, in 2014, Mityana district had a population of 328,964 people (165,717 males and 163,247 females) (UBOS, 2017). This has been projected to have increased to 400,000, as of 2023 (MDLG, 2024). The district has 79,665 households, of which 82.4 percent are engaged in agriculture or livestock farming (UBOS, 2017). This is partly due to the favorable tropical climate with temperatures ranging from 17 °C to 29 °C (MDLG, 2024).

2.2.2. Procedure for collecting field data

Field data was collected in a phased and systematic manner for three (3) months from October 2021 to December 2021. A community participatory approach was used to collect data on wetlands from local citizens along wetland zones in 14 sub-counties (SC) or town councils (TC) in Busujju (Bbanda SC, Bbanda TC, Maanyi SC, Butayunja SC, Kakindu SC, Malangala SC), and Zigoti TC), Mityana North (Kikandwa SC, Bulera SC, and Kalangaalo SC), and Mityana South (Ssekanyonyi TC, Busunju TC, Namungo SC, and Ssekanyonyi SC) counties. The three divisions of Mityana Municipality (Ttamu, Busimbi, and Central) were not considered in this study as most parts of the municipality are not covered with major wetlands but have minor streams that lead to major wetlands, such as River Mayanja and Lake Wamala, such as in Busimbi Division (B. Matovu et al., 2019).

Before the collection of field data, initial planning was conducted. This involved, first, obtaining ethical clearance from the Mityana District Natural Resources Office (DNRO). From the DNRO, we were able to obtain the 2000 wetlands map of Mubende district. The DNRO's office also helped us liaise with the Mityana District Statistics Department, from where we obtained the list of micro-level focal persons or leaders with their contact details. Using the wetlands map, we identified riparian villages along the wetlands, mapped them, and identified the contact persons/focal leaders of the mapped villages/communities crossed by the wetlands. Second, we phone-called the focal village leaders to ensure their availability and alert them/schedule convenient engagement about the pending field data collection exercise. Through this, a targeted/contacted sample of 230 key informants agreed to participate/confirmed their availability. Second, we developed a questionnaire and observation schedule that were to be used to coherently ask or mark the identified wetland issues. The survey questionnaire developed had four main parts/questions: (i) identifying the main wetlands, wetland resources, and wetlands types in Mityana district (based on permanency or seasonality), (ii) identification of the main livelihood activities carried out (either along or within) wetland zones, (iii) identify the main changes to wetland cover and the main drivers of such

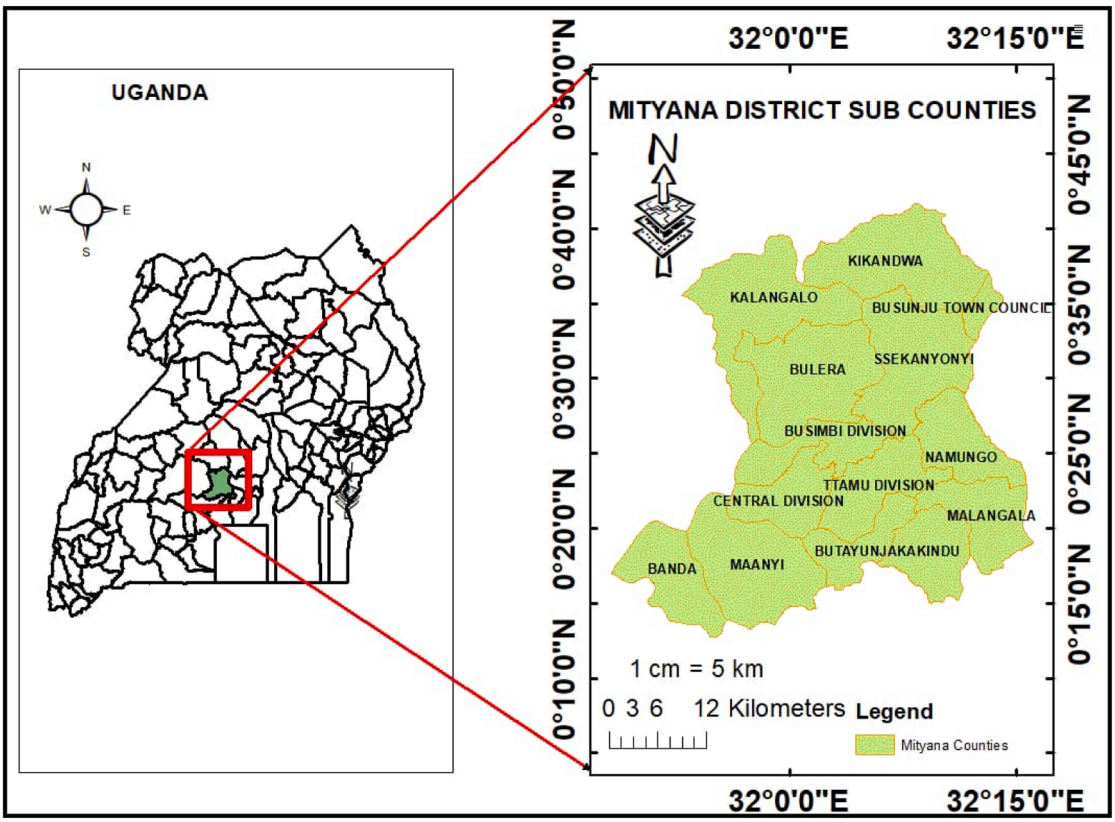

Fig. 1. Map of Mityana district showing the 17 administrative sub-counties/divisions (Authors' creation).

changes and (iv) gaining an understanding of the possible pathways for sustainable management of the wetland zones for better livelihoods and environmental management. To capture evidence-based observations and geo-reference the sampled wetland zones/areas, we obtained a phone camera and Garmin GPSMAP 64 device. This was used because some studies in participatory research emphasize that observation and field photography are some of the best qualitative tools for data collection in areas where interviews are not possible, or where evidence on physical features, such as wetlands is needed (Matovu et al., 2024; Neumann, 2014).

Third, to physically collect data, on reaching a targeted sub-county/wetland area, we used transect walks, within, across, or along a wetland, as guided by a previous study in South Africa (Lorenzo and Motau, 2014). The total distance covered to conduct data transect walks along wetlands or access participants was 100 kms. This was done because some wetlands were not along the road or could not be accessible without seeking permission to pass through the farms/gardens or privately owned property. During such scenarios, local participant(s) or focal persons helped us in reaching out/tracing the wetland. To interact with local participants, we sought consent from the local citizens and employed convenient sampling where citizens who were willing and able to be interviewed/interact, were asked questions or gave their narratives (Neumann, 2014). Out of the mapped 230 focal persons who had initially consented to participate, we were only able to reach 100 respondents. Thus, to obtain more information in the field and factual or historical data on wetlands, we employed snowballing and simple random sampling. This enabled us interact with citizens engaged in local wetland environment management groups, living along a given wetland or found conducting a given livelihood activity along a given wetland. Using this technique, we were able to interview/interact with more 50 citizens. Thus, a total of 150 participants were engaged for interviews. 70 percent of participants were male and 30 percent of respondents were female. The discrepancy in the gender dimension during the interview was because most of the people found and local village leaders were males and only females were accessed after consent or finding them in wetland zones. Information from respondents and observations during transect walks led to the identification and mapping of 105 permanent and seasonal wetlands. To further validate the findings and narratives from the interviews and field participant observations, two focus group discussions (FGDs) were conducted. The first FGD was conducted in Bimbye wetland in Kalangaalo SC with encroachers, to devise a sustainable management plan on controlled wetland destruction and restoration. A second FGD was conducted in Namutidde village in Bulera SC, mainly with landowners and elders to create awareness, aid capability building on wetlands, and co-ideate on a feasible wetland action plan or strategy. All information from the participant interactions was audio recorded on the phone.

2.2.3. *Analysis and synthesis of qualitative field data*

The information obtained from participants was analyzed in a step-by-step manner to generate key themes, as guided by a study conducted by Matovu et al. (2024a). First, all the transcripts were translated and transcribed from *Luganda* (a language used by citizens in Mityana) to English. Each of the translated information was noted down on a Microsoft Word document and separate folders for wetlands in each sub-county were created. For each of the sampled wetland zones/sub-county, a summary of the key information was recorded, based on the wetlands' situational profile (https://tinyurl.com/4c3vndxh). The profile among others included the specific wetland name, its geographical and physical location, altitude, wetland resources and uses, land tenure, jurisdiction, threats, and possible measures in place among others. This was meant to specifically address research components, (b, c, and part of d), as identified in *Section 1*. Details are given in *Section 3*.

3. Results

3.1. Summary of results

3.1.1. Summary of documents sourced

Table 1 gives the overall summary of results that were obtained from the literature and analyzed. Over the last thirty-one years (1993–2024), the annual growth of the rate of research has increased. Generally, limited literature/studies have been published on wetlands in Uganda. Only 280 documents have been published, and most literature is published by international authors (50 percent). A positive indicator is that the average number of citations for the published documents is relatively high (21.56). Most authors prefer publishing scholarly articles compared to other literature, such as conference papers.

3.1.2. Summary of the sampled wetlands and their location(s)

Table 2 gives a summary of the sampled wetlands, their location, and the wetland system that the wetlands belong to. 57 percent of the sampled wetlands were in Busujju County. This is partly because Busujju has one of the largest covers of wetlands, including Lake Wamala in Mityana (B. Matovu et al., 2019). A detailed breakdown of the sampled wetlands is given in this link: https://tinyurl.com/4c3vndxh

From the field, the sampled wetlands in Mityana are found along two wetland systems: the River Mayanja system (along the banks of River Mayanja), and the Lake Wamala system (leading to Lake Wamala). (*See* Fig. 2a).

Most observed wetlands around the Lake Wamala system were permanent (with surface water and dominated by lush papyrus wetland vegetation). This was confirmed by an engagement with a key informant in Bbanda SC near Kabasuma swamp/wetland. It was narrated that

> '*Since my childhood, most wetlands here such as Kabasuma and Mpongo have been covered by 'ebitoogo' (papyrus). Even the few which are drying up, such as Butayunja have spots of papyrus and water.*'

On the other hand, most wetlands along River Mayanja are seasonal (dominated by swamp grasses and marshes), such as Nesibye wetland near Kiryokya trading center in Kalangaalo SC, and Namigavu wetland near Busunju TC (Fig. 2b).

3.2. Results from the literature

3.2.1. Research trends (1993–2024)

In Fig. 3, an overview of the annual scientific production of research/documents in the field of wetlands is given. Since 1999, the research has been slightly increasing, peaking in 2021. However, from 2021, the scientific production of research has declined.

Table 1
Summary/overview of the sourced literature (Scopus/Biblioshiny).

Description	Result	Description	Result
Timespan	1993–2024 (31 years)	Keyword Plus (ID)	2147
Total documents analyzed	280	Author's keywords (DE)	899
Sources (articles, books, etc.)	163	Number of authors	771
Annual growth rate	5.95 percent (%)	Authors of single-authored documents	24
Document average age	10.8	Single-authored documents collaborations	26
Average citations/ document	21.56	Co-authors per document	4.15
References	11,942	International co-authorships	50 %
Article documents	238	Conference papers	17
Book chapters	16	Conference review	1
Review documents	5	Retracted & erratum documents	2

Table 2
Summary of the sampled wetlands and their location(s) (Source: Field data).

County	Sub-County (SC)/Town Council (TC)	Sampled wetlands	Wetland system(s)	Total/ Percentage (%)
Mityana South	Busunju TC	2	Mostly River Mayanja	20 (19 %)
	Namungo SC	8		
	Ssekanyonyi TC	5		
	Ssekanyonyi SC	5		
Mityana North	Bulera SC	8	River Mayanja and Lake Wamala	28 (27 %
	Kalangaalo SC	15		
	Kikandwa SC	5		
Busujju	Bbanda TC	8	Mostly Lake Wamala with few wetlands linked to the River Mayanja system	**57 (54 %)**
	Bbanda SC	5		
	Butayunja SC	5		
	Kakindu SC	8		
	Maanyi SC	22		
	Malangala SC	6		
	Zigoti TC	3		
Total	**14**	**105**	**2**	**105 (100 %)**

An additional concern is that the annual citations of works on wetlands in Uganda are not only low (averaging 4 citations per year) but have also sharply declined since 2019 (*Appendix 1*).

A further review of the nature of the works that the authors are publishing reveals that the focus is mainly on natural science research in wetlands. Based on the Three Field Plot of the eleven main authors, 11 main affiliation(s), and 11 keywords, it is evident that most research is done by researchers who are affiliated with institutions that are not from or in Uganda (Fig. 4). Only authors affiliated with Makerere University, Kyambogo, and the National Fisheries Resources Research Institute (NFRRI) have published some works. Additionally, in the discourse of wetlands management, and sustainability, from the keywords, it is evident that authors and institutions are mostly focusing on wetland research around the Lake Victoria region. Most keywords do not emphasize wetland management practices or sustainable governance.

3.2.2. Top authors' citations and articles' analysis

In Table 3, the prominent authors, their works, and the impact analysis of their works (based on citations and most impactful articles are given (*Also see Appendix. 2*). Commendable research was done by Chapman LJ in 1996 and this has garnered 1062 total citations (TCs). In this prominent and impactful piece titled '*Refugia for Endangered Fishes from an Introduced Predator in Lake Nabugabo, Uganda*' published in the *Conservation Biology journal*, Chapman et al. (1996) critically documented evidence-based findings on complex dynamics regarding the introduction of the predatory Nile perch in Lake Victoria and its negative impact on the disappearance and mass extinction of 16 Indigenous species around Lake Nabugabo and Lake Victoria wetlands.

With regards to the production trends of authors with over seven TC per year, the work in which Niwagaba CB was a co-author in 2018, titled '*Per- and polyfluoroalkyl substances (PFASs) in water, soil, and plants in wetlands and agricultural areas in Kampala, Uganda*' published in the Science of the Total Environment journal ranks first as has received a TCpY of 23.286. In this work led by Dalahmeh et al. (2018), increased pollution fluxes and concentrations of 26 per- and polyfluoroalkyl substances (PFASs) were examined in wastewater, surface water, soil, and crop plants (yam (*Dioscorea* spp.), maize (*Zea mays*) and sugarcane (*Saccharum officinarum*) in Nakivubo wetland and Lake Victoria in Kampala, Uganda. It was scientifically revealed that anthropogenic pollution is threatening Lake Nakivubo wetland biodiversity, and contaminating plants grown and eaten by sedentary communities along the wetland, such as sugarcane, yams, and maize

However, although these works highlighted in Table 3 are commendable when the works and citations of the prominent authors are factored into Lotka's law (analyses of the temporal productivity of authors in each academic or scientific field), authors' global and

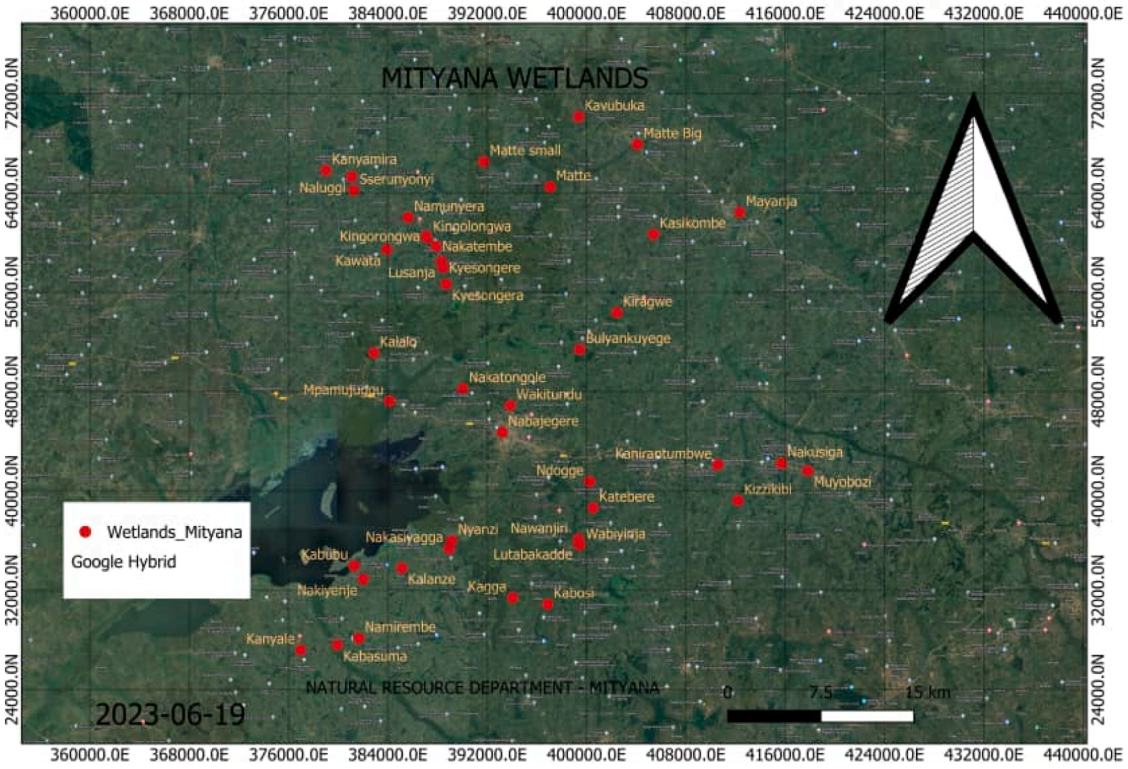

Fig. 2a. The location of the main sampled wetlands in Mityana (Created by authors using QGIS software).

Fig. 2b. Samples of seasonal and permanent wetlands in the sampled areas (Field Photos).

regional productivity and impact in the scholarly discourse on wetlands, wetlands research, and sustainability, has plummeted (See Fig. 5).

3.2.3. Dominant affiliations/institutions of prominent authors

In Fig. 6, a specific breakdown of the publication impact of the leading institutions where dominant authors publishing work in the field are situated is given. Makerere University in Uganda has been increasingly publishing research in this field, especially after 2002. Among the top ten institutions, only three are from Uganda. Makerere University has the greatest number of articles published by authors affiliated with it (238), Kyambogo University (35), and the National Fisheries Resources Research Institute (NAFIRRI) (13). The other seven (70 institutes are from other geographies (Also see *Appendix 3*).

3.2.4. Dominant journals/sources of published documents

In Table 4, the prominent journals that have published scholarly work on wetlands in Uganda, as published over time are indicated. A main concern is that for the past 28 years, the TC and NP of works published by dominant authors have been on a declining trend, from a high of 322 total citations in 2007 to 1 total citation in 2023!

Additionally, when the sources of the published documents are analyzed using Bradford's Law (zones sources/journals in order of their decreasing/increasing impact over time) (Fig. 7). Most of the sources cited by scholars/authors publishing works on wetland issues in Uganda have their impact ranking declining. Research on wetlands by some authors are not cited in top journals or indexed in reputable publishing houses, such as Elsevier, or Springer among others.

3.2.5. Research correspondence of authors and countries and the impact

Here, we indicate the corresponding authors' countries, countries' scientific production, and the comparative impact of the produced work with other countries or globally cited documents.

Fig. 3. Annual scientific production (Biblioshiny).

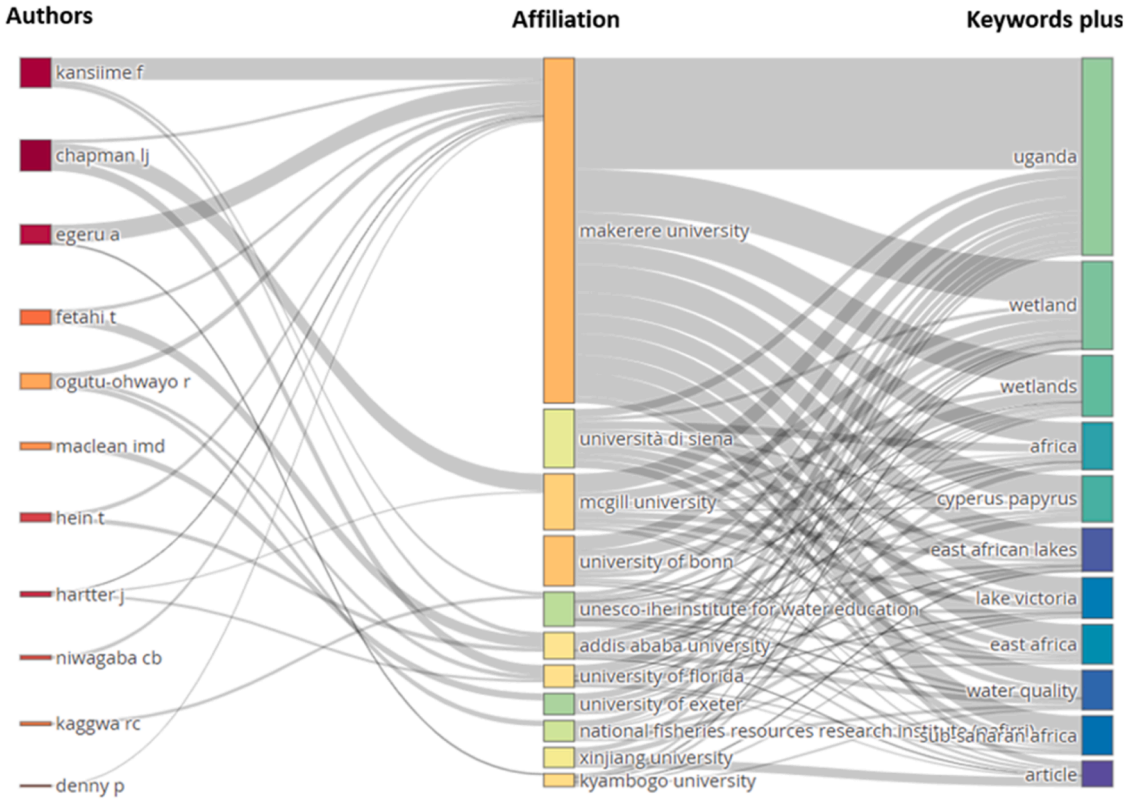

Fig. 4. Three-field plot of the leading researchers' affiliations and keywords (Biblioshiny).

In Fig. 8, it is indicated that authors from Uganda are the leading corresponding researchers. However, most of the Ugandan authors are publishing single-country publications (SCPs) and a few multi-country publications (MCPs). The limited focus on MCPs has led to a comparatively low impact on their works if compared to, for instance, Sweden and Switzerland.

Additionally, from the analysis of the social structure of the documents published as MCPs, there is a significant correlation between the number of citations and global impact. In other words, authors who have published works with other collaborating authors from other countries,

Table 3
Key authors, their publications, and citation matrices over time (Biblioshiny).

Top 10 authors' impact over the years							Production trends by authors with the most citations (exceeding 7 TCpY) over time					
Author	h_index	g_index	m_index	TC	NP	PY_start	Author	Year	Frequency	TC	TCpY	Top Impact article
Chapman LJ	18	28	0.621	1062	28	1996	Niwagaba CB	2018	1	163	23.286	https://doi.org/10.1016/j.scitotenv.2018.03.024
Kansiime F	15	27	0.577	760	29	1999	Hartter J	2010	3	185	12.333	https://doi.org/10.1080/08,941,920,903,360,372
Hartter J	8	8	0.5	376	8	2009	Kansiime F	2007	5	181	10.056	https://doi.org/10.1007/s11273–007–9047–5
Denny P	6	7	0.2	171	7	1995	Fetahi T	2021	4	39	9.75	https://doi.org/10.3390/cli9120179
Kaggwa RC	6	7	0.25	169	7	2001	Kansiime F	2004	2	201	9.571	https://doi.org/10.1016/j.watres.2003.10.008
MacLean IMD	6	7	0.273	92	7	2003	Niwagaba CB	2020	2	47	9.4	https://doi.org/10.1016/j.scitotenv.2019.136347
Niwagaba CB	6	8	0.545	357	8	2014	Chapman LJ	2002	2	199	8.652	https://doi.org/10.1016/S1095–6433(02)00,195–2
Ogutu-Ohwayo R	6	7	0.207	318	7	1996	Hartter J	2009	2	128	8	https://doi.org/10.1080/10,871,200,902,911,834
Chapman CA	5	6	0.172	434	6	1996	Chapman LJ	1996	3	228	7.862	https://doi.org/10.1046/j.1523–1739.1996.10020554.x
Fetahi T	5	7	1	66	7	2020	Kansiime F	2005	3	150	7.5	https://doi.org/10.1016/j.pce.2005.08.010

*h_index (Hirsch index): represents the author-level metric that tries to measure both the productivity and the citation impact of the publication of a given author(s) over time; g_index: represents the author(s) level metric based on the distribution of citations received by the author(s) publication(s) over time, i.e., G-index measures the cumulative citation performance for a given article; m_index: provides a more accurate measure of the author's impact, relative to other authors' impact factor, by adjusting the h-index for the time factor; TC: Total cited/citations of the author's given publication; TCpY: Total citations received by a given author's publication each year; PY_start: Publication year start (when the article/document was/is first published); NP: number of publications.

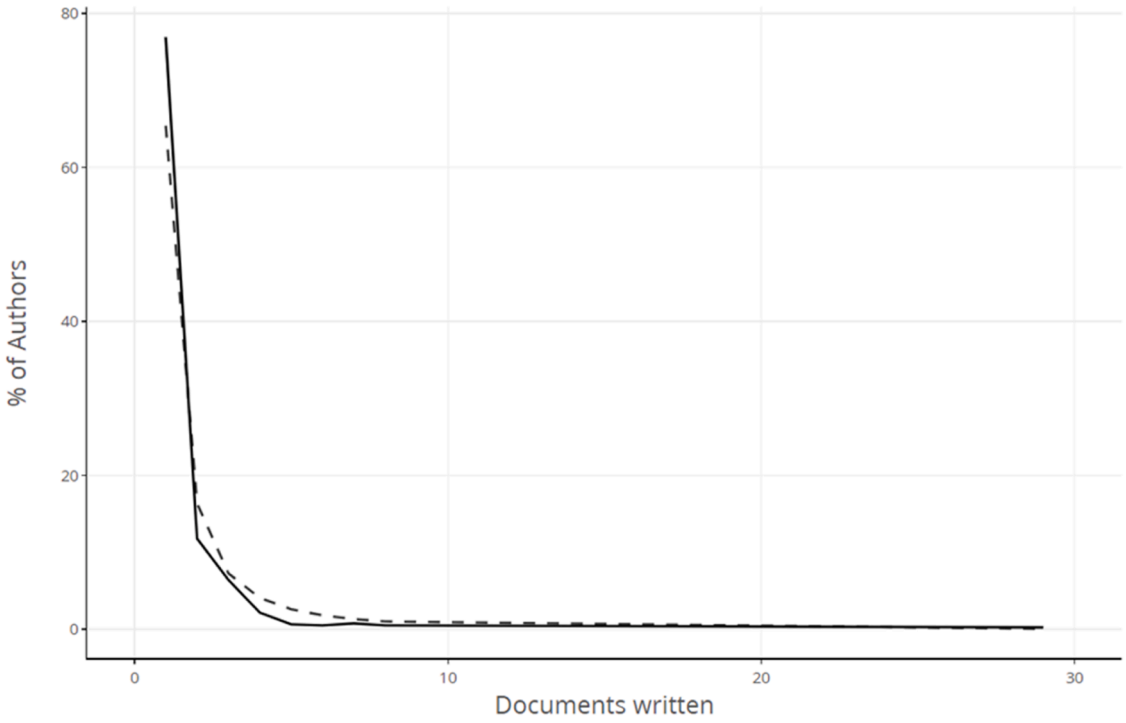

Fig. 5. Author's productivity based on Lotka's Law (Biblioshiny).

such as Chapman LJ, have better citation impact scores and ratios than authors with SCP, irrespective of the time when the publication was published (Table 5). For instance, the notable work of Chapman and Chapman (1996) titled 'Exotic *tree plantations and the regeneration of natural forests in Kibale National Park, Uganda*', focused on the use of a novel ecosystem (wetlands and forest) rehabilitation and management strategy for the rehabilitation of Indigenous tree communities, based on precautionary principles, has garnered 21 local citations (LC), 90 global citations (GC), and a high LC/GC impact ratio of 23.33 percent. On the other hand, however, the SCP of Mbabazi (2009) titled '*Rapid assessment of the fish biodiversity of the Mburo-Nakivali wetland systems and Opeta-Bisina wetland systems, Uganda'*, although it comprehensively brings out critical socio-ecological wetland dynamics, complex threats, and possible management strategies in western and eastern Uganda wetland zones, and published under NAFIRRI, has garnered a single citation.

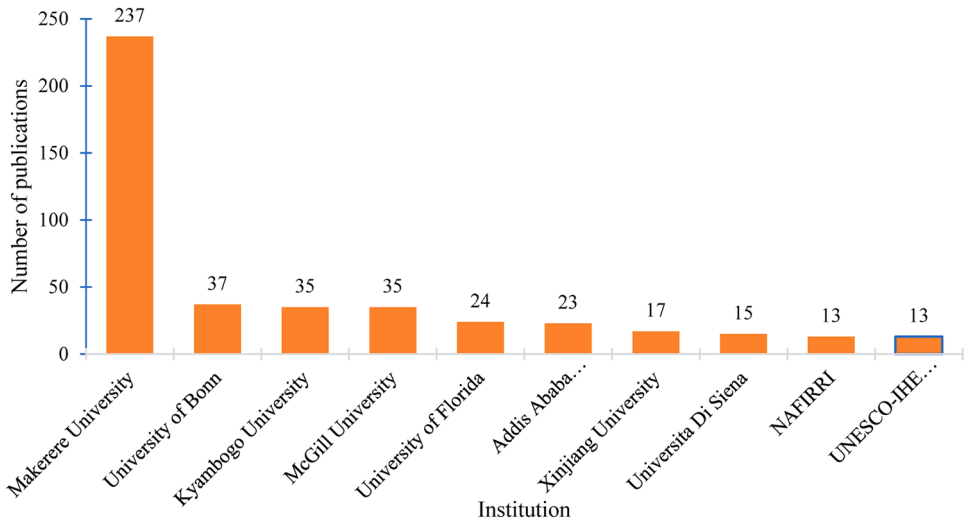

Fig. 6. Dominant institutions/affiliations of leading authors (Sourced from Biblioshiny and modified by authors).

Table 4
Dominant sources/journals publishing scholarly documents and their impact (1995–2023) (Source: Biblioshiny).

Source	h_index	g_index	m_index	TC	NP	PY_start
Hydrobiologia	5	5	0.167	150	5	1995
Biological Conservation	5	5	0.172	262	5	1996
African Journal of Ecology	7	10	0.241	112	12	1996
Water Science & Technology	5	5	0.192	209	5	1999
Ecology of Freshwater Fish	6	6	0.231	150	6	1999
Environmental Biology of Fishes	4	4	0.154	91	4	1999
Physics & Chemistry of the Earth	8	9	0.400	296	9	2005
Wetlands Ecology & Management	10	15	0.556	**322**	15	2007
Environmental Science & Policy	4	4	0.250	243	4	2009
Land-Use Policy	3	3	0.200	87	3	2010
Science of the Total Environment	6	7	0.600	280	7	2015
Environmental Monitoring & Assessment	3	3	0.300	97	3	2015
Egyptian Journal of Remote Sensing & Space Science	1	1	0.250	21	1	2021
Environmental Processes	1	1	0.250	20	1	2021
Environmental Challenges	1	1	0.250	12	1	2021
Hydrology	2	3	0.500	11	3	2021
Environmental Management	1	1	0.333	9	1	2022
Environmental Systems Research	1	1	0.333	9	1	2022
Preventive Veterinary Medicine	1	2	0.333	5	2	2022
Urban Planning	1	1	0.500	1	1	2023

3.3. Scientific mapping and network analysis of trends, themes, and complex structures

In this section, we highlight three main results/aspects (i) keyword analysis (using a tree map), (ii) clustering of the major keywords and word themes (using cluster labeling of the authors' keywords), (iii) conceptual structuring (based on the network approach and factorial approach).

3.3.1. Most trending keywords

The Tree Map highlighted in Fig. 9 highlights the most trending keywords in research and scientific networks. It is evident that 224 documents specifically focus on Uganda and 8 percent of the research by authors and scientific discourses focus on wetlands.

3.3.2. Clustering of the trending themes and keywords

To cluster the trending themes and keywords, we utilized the cluster labels of the main keywords plus used by the authors. From this, two main clusters were generated based on the impact/frequency of the keywords (Fig. 10).

From the blue cluster, it is evident that wetlands are given priority as a main buzzword in research. However, it seems that most authors have a geographical focus on Kampala wetlands and specific wetland vegetation, such as *Cyperus papyrus*. Critical issues, such as land use change have a low frequency of <50.

3.3.3. Conceptual structuring

Here, we aimed at mapping and visualizing the level of impact of the key concepts and trending themes in research, to understand if they are aligned with the regional and global discourses in wetland management and sustainability research.

In Figs. 11 and 12, a network approach based on co-occurrence network mapping of keyword plus, and keywords to identify the density/relevance/influence of the main themes. Thematic mapping revealed that although research on wetlands has increased, most of the themes targeted by researchers have limited relevance and development impact, with regards to sustainable policies and research on wetlands. Wetlands in Uganda are still basic themes with relatively low levels of relevance or declining development degree. An increasing niche research theme of relevance is on floodplains.

When an in-depth synthesis was conducted to identify how this complex indicator has evolved, researchers and policies have been sustainability assessments and policies are limited. Conservation management and livelihood along wetlands as key themes have only evolved recently between the years 2008–2011 and 2017–2020 (Fig. 12). Most themes are aligned with wetland scientific research themes, such as species diversity (2008–2016).

In Figs. 13, 14, and 15, a critical analysis of the conceptual structure of the domination of the themes, keywords, and terms is given. A factorial analysis using the multi-dimensional scaling of keyword Plus

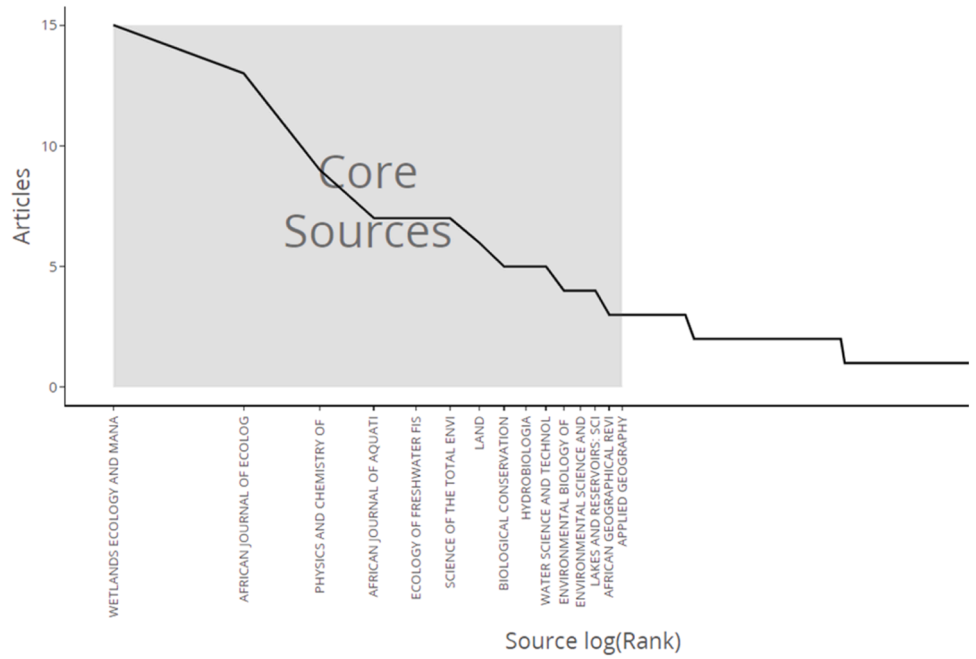

Fig. 7. Zoning/ranking of the core sources based on the Bradford's Law (Biblioshiny).

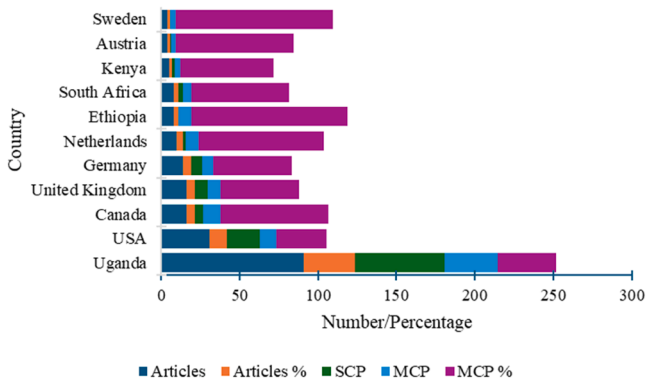

Fig. 8. Country collaboration and impact (Sourced from Biblioshiny and modified by the authors).

sourced literature reveals that most of the concepts in research are associated with 'perception and controlled studies', such as on remote sensing, and central region. Most research themes have still less explored or dived deeper into critical or principal components of wetland sustainability or management, such as social equity dimensions, collaborative wetlands governance dimensions/frameworks, decision-making, community perspectives, and narratives. Additionally, based on the degree of centrality and coherence on the topic dendrogram, it is evident that the research themes and topics mostly have a higher degree of dissimilarity, as they are located far away from each other (de-clustered/not congested).

3.4. Key results from the field/community participatory engagements

In this section, a qualitative description and field visualization of the main aspects relating to wetlands in the 14 sampled sub-counties is given.

3.4.1. Livelihood activities from wetland resources and around the sampled wetlands

Table 6 highlights the dominant livelihood activities (either within or along the wetland), the resources where such livelihoods are derived, and the livelihood contributions to the communities. Within the wetlands, fifteen activities were reported and along wetland zones, eight dominant activities were reported.

According to the participants and based on participant field observations, wetlands provide a paucity of tangible and intangible benefits to both rural and urban citizens. A key informant in the Lusalira fish landing site reported that

> '*We depend on Lake Wamala and the wetlands of Lusalira for fish and water. Most of the water here is also used to irrigate our crops, such as bananas during some periods of water scarcity*.'

Commendable socioeconomic benefits were also reported by riparian communities, such as around Lubajja and Kimuli wetlands, along Lake Wamala. One fisherman in Lubajja reported that

> '*My livelihood depends on the fish that spawns in these wetlands and goes to the lake. During good seasons, I can earn over 300,000 Uganda Shillings (about 80 USD) per day. I have reinvested this income to start a small business, buy a motorcycle, build a house, and take my children to school*.'

Some of these benefits are reaped by citizens sedentary along the wetlands, well as others cut across to other residents in neighboring districts, such as Mubende, Kassanda, Kiboga, Mpigi, and Wakiso. For instance, during a transect walk along the River Kitenga wetland in Malangala sub-county, some respondents reported that

> '*River Kitenga wetlands are the main source of natural water to several agrarian communities in Mityana such as in Butayunja, Kambuzi, Nawanjiri, Lubira, Mbuye, and the neighboring villages of Gomba, including Nsabwe and Mpenja*.'

Some of the values are administrative, such as the provision of natural boundaries and markings for easy district demarcation. For instance, during a stakeholder engagement session in Bimbye Wetland in Kalangaalo SC, citizens reported that

> '*Bimbye River has wetlands that reach up to Lake Wamala. From its source to the mouth, Bimbye is a natural boundary to Mityana, Kassanda, and Kiboga districts*.'

Table 5
Impact of authors' works based on the SCP/MCP trends (Source: Biblioshiny).

Author(s)	Year	Journal	DOI Link	LC	GC	LC/GC ratio (%)	NLC	NGC
Kyambadde J	2004	Water Resources	https://doi.org/10.1016/j.watres.2003.10.008	11	197	5.58	4.05	5.65
Vermeiren K	2012	Landscape & Urban Planning	https://doi.org/10.1016/j.landurbplan.2012.03.006	8	181	4.42	5.00	3.82
Chapman LJ	2002	Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology	https://doi.org/10.1016/S1095–6433(02)00,195–2	11	174	6.32	1.74	2.34
Fuller RM	1998	Biological Conservation	https://doi.org/10.1016/S0006–3207(98)00,005–6	4	113	3.54	1.33	1.56
Chapman LJ	1996	Conservation Biology	https://doi.org/10.1046/j.1523–1739.1996.10020554.x	22	101	21.78	1.32	1.33
Chapman LJ	1996	Biological Conservation	https://doi.org/10.1016/S0006–3207(96)00,030–4	21	90	23.33	1.26	1.18
Hartter J	2009	Landscape Ecology	https://doi.org/10.1007/s10980–009–9339–7	9	82	10.98	3.72	2.29
Hartter J	2010	Land Use Policy	https://doi.org/10.1016/j.landusepol.2009.11.001	9	55	16.36	5.06	2.06
Schofield PJ	1999	Environmental Biology of Fishes	https://doi.org/10.1023/A:1,007,544,017,989	14	42	33.33	2.90	0.88
Chapman LJ	2003	Conservation Biology	https://doi.org/10.1046/j.1523–1739.2003.01519.x	11	42	26.19	4.28	2.31
Schofield PJ	2000	African Zoology	https://doi.org/10.1016/j.scitotenv.2018.06.087	9	39	23.08	1.80	1.83
Rosenberger AE	1999	Ecology of Freshwater Fish	https://doi.org/10.1111/j.1600–0633.1999.tb00049.x	8	37	21.62	1.66	0.78
Kansiime F	2005	Physics & Chemistry of the Earth	https://doi.org/10.1016/j.pce.2005.08.010	4	35	11.43	1.50	0.70
Paterson JA	2009	Ecology of Freshwater Fish	https://doi.org/10.1111/j.1600–0633.2009.00355.x	8	29	27.59	3.31	0.81
Kansiime F	2007	Wetlands Ecology & Management	https://doi.org/10.1007/s11273–007–9054–6	8	27	29.63	2.24	0.53
Kipkemboi J	2002	African Journal of Aquatic Science	https://doi.org/10.2989/16,085,914.2002.9626570	8	24	33.33	1.26	0.32
Bikangaga S	2007	Wetlands Ecology & Management	https://doi.org/10.1007/s11273–007–9049–3	8	24	33.33	2.24	0.47
Gabiri G	2019	Science of the Total Environment	https://doi.org/10.1016/j.scitotenv.2018.10.430	3	23	13.04	7.20	1.68
Mbabazi J	2010	African J. of Agricultural Research	http://www.academicjournals.org/AJAR	7	14	50.00	3.94	0.52
Kayandeke EJ	2018	Science of the Total Environment	https://doi.org/10.1016/j.scitotenv.2018.06.087	9	10	90.00	5.82	0.34
Matovu B	2019	International Journal of Public and Environmental Health	https://doi.org/10.15739/irjpeh.19.021	6	5	35.00	4.98	0.50
Matovu B	2024	Discover Environment	https://doi.org/10.1007/s44274–024–00,041–5	1	1	0.02	1.23	0.23

*NLC—Normalized Local Citations; NGC- Normalized Global Citations.

During the transect walks across and along wetland zones, some critical important values, including aesthetic and cultural values were observed and narrated. For instance, in Businju TC, a respondent working at the River Mayanja cultural site narrated that

'*Mayanja wetland here has both Kato and Wasswa (Buganda traditional names of twins), and we attach huge cultural importance to this river, as it services a valuable contribution to Buganda kingdom. So, we are protecting this site and many local tourists come here.*'

Similar cultural importance is attached to Lake Wamala wetlands, especially around Nakyegalika near Lubajja fish landing site in Maanyi sub-county. Lake Wamala's origin is related to a historical Buganda legend.Residents narrated that

'*The origins of Lake Wamala are related to a historical Buganda traditional folklore and legend. It is at Nakyegalika caves that this Wamala is and was birthed. So, we are guarding Nakyegalika site from encroachment.*'

Prominent values were observed and reported around Nakatongoli wetland which serves as a boundary between Busimbi Division (Mityana Municipality) and a part of Bulera SC. It was narrated that

'*The clean and piped water that serves Mityana municipality is sourced from Mpamujjugu and Nakatongoli. Here at Nakatongoli, the water is collected, cleaned, and purified by the National Water and Sewage Corporation (NWSC), before being distributed to customers. It has helped many residents with access to clean water.*'

3.3.2. Emerging/Persistent (un) sustainable wetland stressors, causes, and possible remedial measures

Although wetlands serve several purposes, participants and field observations revealed a nexus of eight (8) threats of which six were considered more critical, because of increased human-induced activities (Table 7). To help understand the causal-effect relationship of the different drivers of threats, in Table 7, each threat driver is qualified and quantified. Additionally, based on participant observations during the transect walks, the level of severity is highlighted. For instance, high severity means that the threat has completely degraded the wetland, and low severity implies that the threat has not yet had a detrimental negative impact on wetland(s) resources and functions.

A surge in unsustainable human activities in wetland and threshold zones was increasingly reported to be a result of mainly eucalyptus tree planting and harvesting (39 percent), and this has increasingly threatened the provision of wetland resources. Participants gave insightful accounts of the causation of the increasing threats. In Maanyi and Bbanda SC, for instance, participants attributed the degradation of wetlands to the less clear or insecure tenure of most residents sedentary along wetlands. One key informant around Musamya Wetland reported that

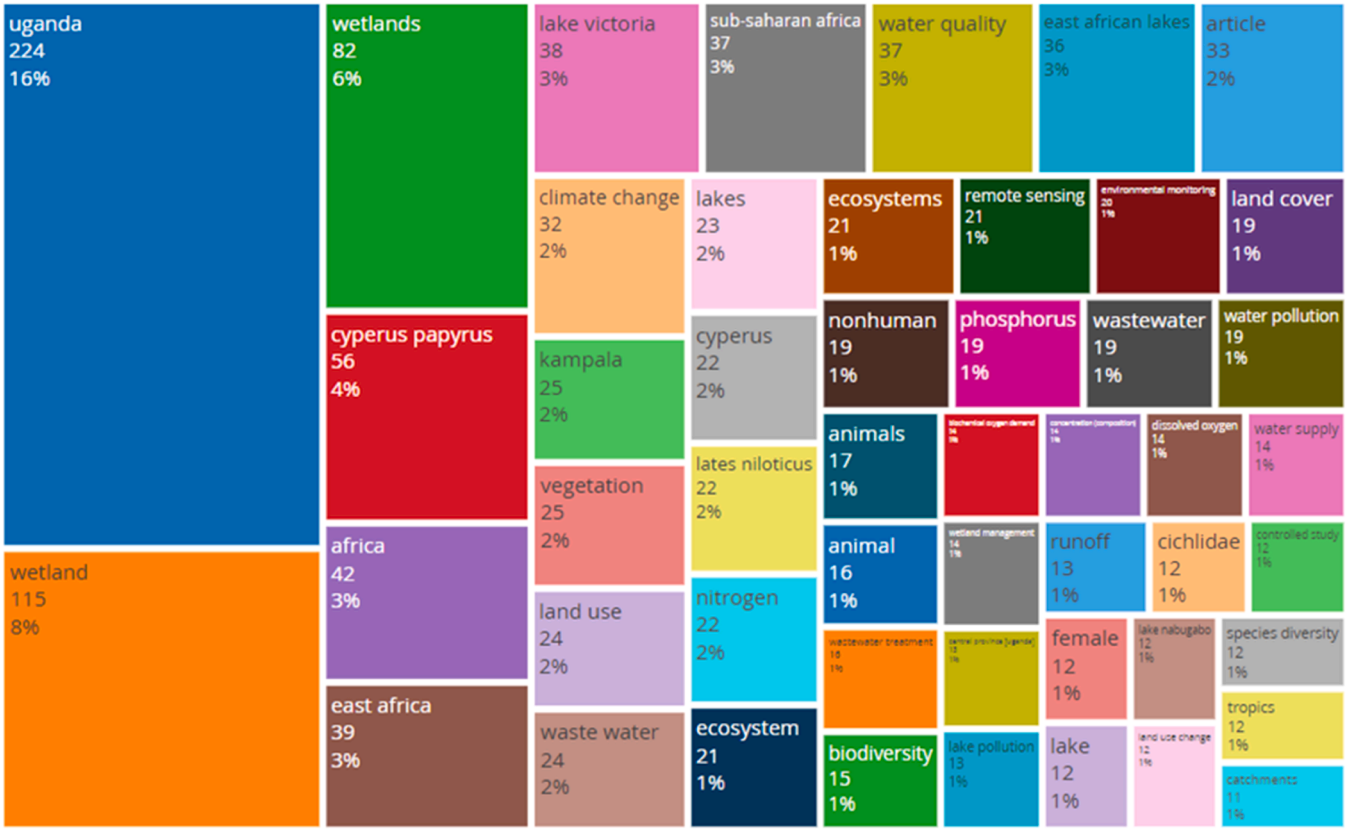

Fig. 9. Tree-Map showing the most trending keywords in research and scientific reporting (Biblioshiny).

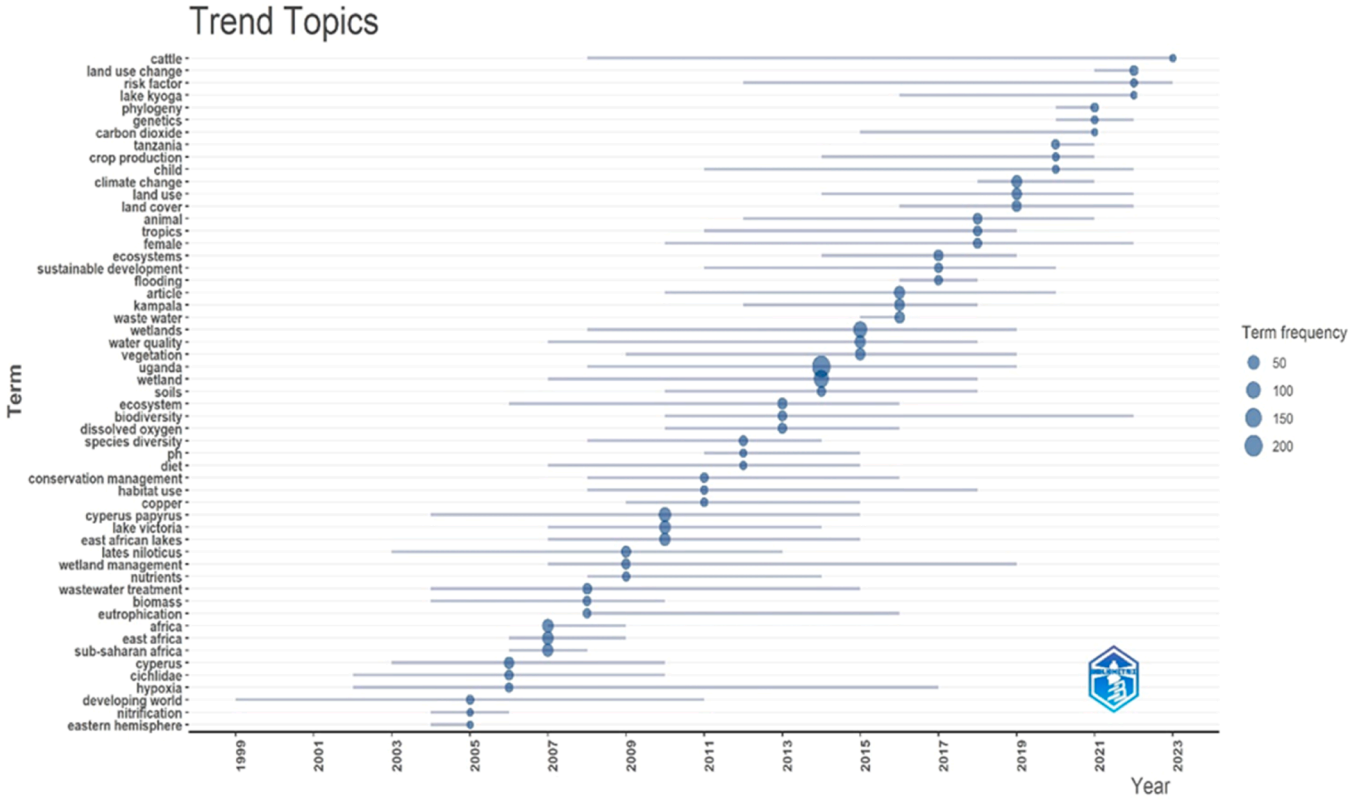

Fig. 10. Cluster labeling of the trending keywords, terms, and topics (Biblioshiny).

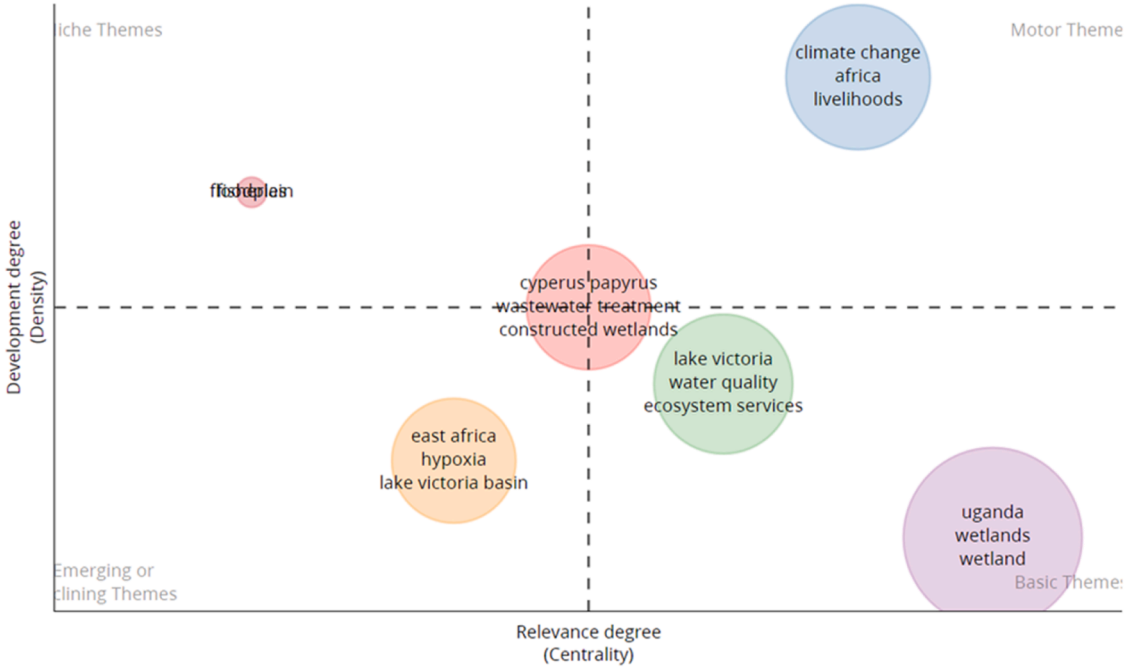

Fig. 11. Thematic mapping of keywords, terms, and topics (Biblioshiny).

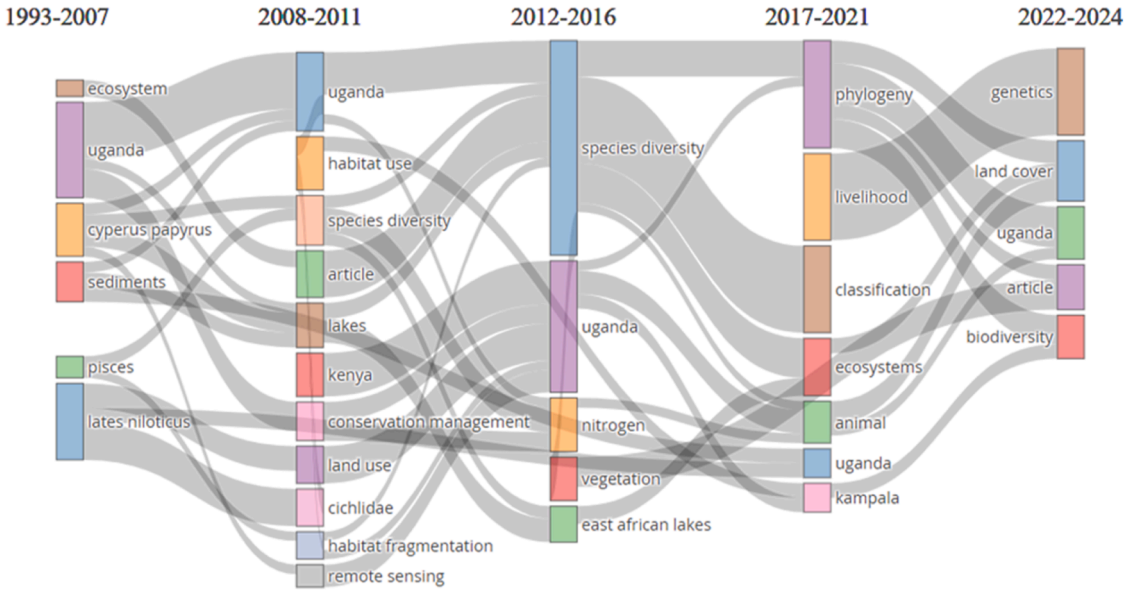

Fig. 12. Thematic evolution of the trending and dominant keywords, terms, and themes (Biblioshiny).

'*Due to the lack of secure tenure, some land squatters have decided to clear wetlands that they consider 'free' to get some land for farming. I also think that most of us don't know the meaning of the wetland or the limit of the blue page on our land titles and we just encroach on the wetland because our land extends up to there….if we can get guidance on that, I think we can stop using land near the wetland.*'

Regarding the damage and threats caused by increased eucalyptus tree planting, especially within the wetland zones, some respondents in Ssekanyonyi SC and Ssekanyonyi TC narrated that,

'*When we plant eucalyptus, such as the South African variety that grows fast, it drains out most of the water in the soil. It is very bad for us who depend on the growing of seasonal crops, such as maize that need water, but we have nothing to do as such plantations are planted by rich and powerful people. We hope the government can help us on this.*'

In some agricultural communities that reside along wetlands such as Bimbye in Kalangaalo SC, participants during the stakeholder engagement reported that

'*Most of the crops that are being planted in Bimbye take a lot of water. Additionally, some farmers are increasingly channeling the water to their small plots and this has affected the natural flow and supply of water to nearby communities. Through the interactions with the District Natural Resource Office (DNRO), we are going to stop this and focus on the regeneration of the wetland.*'

Increasing cases of pollution were also reported around the crucial permanent wetlands, mostly around the Lake Wamala system. For

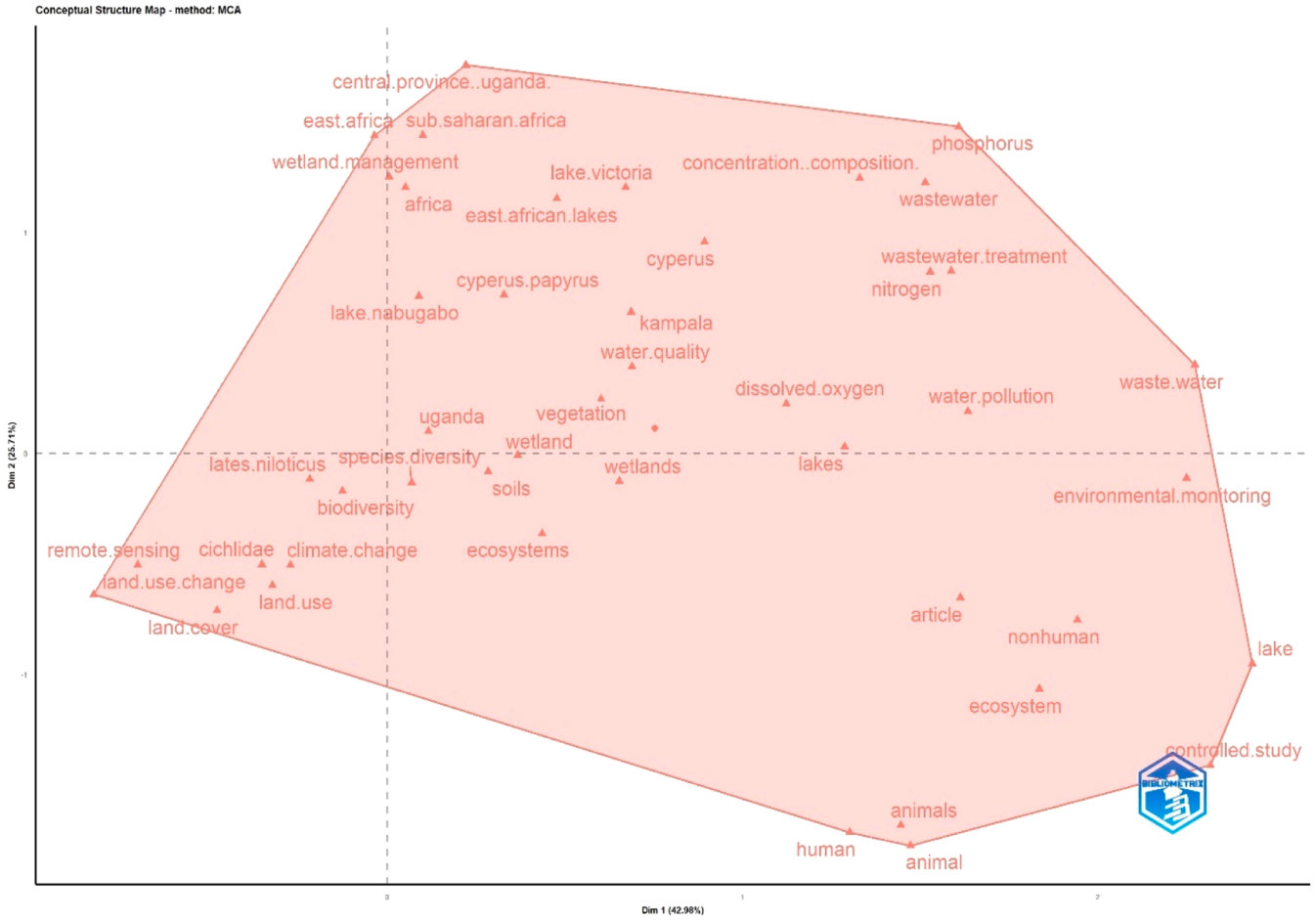

Fig. 13. Factorial analysis of the trending and dominant keywords, terms, and themes (Biblioshiny).

instance, around Nabajegere wetland in parts of Miseebe and Jungwe in Bulera SC, participants reported that

'*Some chemicals used in the nearby tea plantations make the water in Nabajegere look bad and I think this is not good for the water we collect from the wetland.*'

In parts of Busunju TC and emerging trading centers near wetlands, increasing evidence of landfilling in seasonal swamps, such as Sebobbo was observed and reported. Some respondents in Namulamba B village reported that

'*Before, here in Busunju no one was living in wetland zones, but because of the population increase after making this a Town Council, many people have come to work. We cannot also afford expensive accommodation and plots of land. The land dealers give us small plots here for better prices.*'

Additionally, a participant in Bbanda SC reported an increasing concern of climate change that is affecting wetland resources, harvested by local communities and their farmlands. A smallholder farmer in Nkokonjeru village near Kabasuma wetland reported that

'*It is true Kabasuma naturally burns during some times. But these days, it occurs more frequently. Last month, my garden of casava got burnt and the papyrus I used to collect to make papyrus mats or crafts has been reduced due to the fires… I think it is because of much sunshine and heat.*'

During the interactions and field observations, commendable micro-level-based wetland management practices were reported and observed, albeit most of them are in areas dominated by permanent wetlands or swamps (Fig. 16). In most of the management measures, key informants reported that they focus on limiting damage or restricting access to some of the critical wetlands, such as Nakatongoli, that serve Mityana residents with water. During the transect walks, for instance, traces of stone marks were planted by officials from the Mityana District Local Government and the Wetlands Management Division (WMD). Stone markings are mainly labeled with '*Tokirizibwa kusanyaawo lutobazi luno*' translated as 'you are not allowed to destroy/degrade this wetland' were observed near River Mayanja wetland in Busunju TC, Nabajegere in Bulera SC, and Buyobozi wetland in Namungo SC among others.

Additionally, wetland support initiatives both from the government through the Ministry of Water and Environment (MWE) and partners, such as the Lake Victoria Environment Management Programme II (LVEMP II), were observed around wetlands of the Lake Wamala system for instance along Nakatongoli wetland.

For instance, during an engagement with a key stakeholder, it was reported that

'*With the support of the World Bank and through the Wetlands Inspection Division (WID), the demarcation and mapping of wetlands along the Lake Wamala system have commenced, such as along Mpamujugu and Nakatongoli wetlands. We intend to map the entire wetland systems to help the community know the outermost limits of the wetlands.*'

Additionally, during the community engagements with citizens sedentary along wetlands, such as Bimbye, notable strategies were reported. One stakeholder mentioned that

'*NEMA (National Environment Management Authority) monitoring team has visited here and alerted us on the dangers of wetland encroachment.*'

A participant (private mailo landowner) in Namutidde revealed that,

Fig. 14. Visualization of the main values of wetlands and wetland resources (Field photos).

Fig. 15. Some of the observed human-environmental stressors to wetlands (Field photo).

'*Constant engagements and capacity-building meetings with local communities near wetlands can help increase knowledge of the existing laws, regulations, and policies on wetland use and management. Before this training by the Mityana District Natural Resources Office, we did not know the three key aspects used to define a wetland* (nature of soils, vegetation, and drainage). *Most of us were also unaware of the meaning of blue page on our land titles.*'

Table 6
Dominant wetland resources and their value (Source: Field data).

Land use benefits within the wetland	Frequency of responses	Percentage	Value in surrounding wetland zone	Frequency of responses	Percentage
Crop cultivation	**28**	**28**	Eucalyptus farming	**39**	**39**
Livestock/animal grazing	**13**	**13**	Grazing	**16**	**16**
Brick making	**13**	**13**	Trading	**15**	**15**
Sand excavation	**7**	**7**	Crop farming (including plantation tea farming	**11**	**11**
Conservation of wetlands and their cultural sites	**6**	**6**	Forestry (tree nurseries and wetland forest protection)	**7**	**7**
Fishing	**6**	**6**	Settlement	**6**	**6**
Fish farming	**1**	**1**	Brick making	**5**	**5**
Papyrus harvesting	**3**	**3**	Quarrying	**2**	**2**
Hunting	**1**	**1**			
Arts and crafts	**2**	**2**			
Eucalyptus farming	**7**	**7**			
Forestry	**2**	**2**			
Washing bay	**5**	**5**			
Water collection	**6**	**6**			
Settlement	**1**	**1**			
Total	**103**			**102**	

One of the users of wetland resources near Lusanja wetland in Bulera SC revealed that

'*I think if we the local community and leaders work in harmony with the local government and NEMA, we can be able to manage the wetlands without any problem. Most problem is the local people are evicted and yet we hear and watch news of some other people encroaching on wetlands in urban centers without being chased away. I think this is where the problem lies.*'

Another notable measure to boost the value of relevance was reported by fisherfolk around Kalyankoko fish landing site in Maanyi, along Lake Wamala. It was revealed that

'*We can promote the benefit of this wetland by promoting eco-tourism and beautifying the beach with trees. Around here, we have unique offshore islands, such as Kiraza, Baggwe, and Zigwe with unique bird species that come during some seasons. These can attract tourists and make us be leaders in managing these wetlands*.'

During the local stakeholder engagements in Kalangaalo SC (in Bimbye) and Bulera SC (in Namutidde), a critical recommendation by highlighted and emphasized as key in driving the sustainable use and management of wetlands. Participants narrated that

'*Through the district natural resource office and environmental offices, such as from NEMA, we agree that to enforce laws on the governance of wetlands and collaboratively manage our wetlands, we must create an inventory that can help us create village, parish, sub-county, county, and district wetland action plans. Such plans can be used by the district to plan for us and maybe get also support from the government or some other environmental groups or organizations*.'

4. Discussion

A systematic discussion of the results highlighted in *Section 3* is given here.

4.1. Discussion of literature review findings

From the bibliometric analysis, critical insights that are worth unraveling were revealed. First, a positive trajectory in research on wetlands is evident through the increased production of scholarly works, over the years. This is indicated in Table 1 and Fig. 3, where for instance, the average citation of research on wetlands stands at a respectable 21.56 percent. On the other hand, however, when a comprehensive analysis of the emerging/novel wetlands sustainability lens is factored into the nature and impact of the research on wetlands and networks therein, concerns abound. First, the impact and research performance of insightful research has plummeted over the years. This is evident in formerly impactful works, such as the notable findings of Chapman et al. (2002; 1996), in studies on '*physiological refugia: swamps, hypoxia tolerance and maintenance of fish diversity in the Lake Victoria region*' and '*refugia for endangered fishes from an introduced predator in Lake Nabugabo*' respectively. This is partly because, leading fisheries research institutions in Uganda, such as NAFIRRI are either shifting to other wetland systems, such as Mburo-Nakivali wetland systems and Opeta-Bisina wetland systems, or addressing current pressing and urgent concerns regarding eutrophication around Lake Victoria (Mbabazi et al., 2009, 2010; Kipkemboi et al., 2010; 2002). The plummeting impact of research is critically indicated in the research reference spectroscopy, the declining impact measure of the journals where most dominant researchers published their works, and the current dominance of researchers whose works were published several decades ago (See Appendices 4, 5, 6, 7).

More worrying concerns are prevalent if we dive into the research focus of dominant researchers and the geographical spread. A synthesis of the 280 sourced documents reveals that about 90 percent of the research either focuses on pure natural sciences, and wetlands biology or is situated around the Lake Victoria region. Most dominant authors over the years have focused on using mathematical or scientific models to quantify wetland threats (Kansiime et al., 2023; 2007; 2005; Chapman and Chapman, 1996; Chapman et al., 2002; 1996; Dalahmeh et al., 2020; 2018; Gabiri et al., 2020; G. 2019; Bikangaga et al., 2007). Although this doesn't discredit the immense and insightful revelations in their studies, such as on the impact of eutrophication on fish resources in Lake Victoria (Kipkemboi et al., 2010; 2002). However, when factored into the emerging sustainability narratives and research on wetlands management, gaps related to co-development of sustainable pathways and incorporating in social science narratives are prevalent (Matovu et al., 2024a; Were et al., 2021; D. 2020; Bunyangha et al., 2022). Worst of all, some studies that have shifted focus from natural science and the Lake Victoria region, to incorporate local citizens' perspectives on co-management in remote and upcountry wetlands, have gained less visibility, citation impact, and interest (Matovu et al., 2024; B. 2019; Bunyangha et al., 2022; Gosling et al., 2017; Hartter, 2010; 2009; Hartter and Southworth, 2009). For instance, evidence-based research by B. Matovu et al. (2019) around the vulnerable riparian communities around Lake Wamala, although open access and explicitly breakdown the emerging threats to wetlands, has for the past five years garnered a paltry five citations. Additional concerns are related to the limited collaboration among researchers and institutions, such as on multi or cross-country research on wetlands management and governance. Where researchers collaborate, the collaboration is intra-institutional

Table 7
Main wetland threats, causes, level of impact, and possible governance measures (Source: Field data).

Nature of Threat	Percentage of threat	Level of severity	Dominant cause (s)	Possible mitigation measure/ intervention
Eucalyptus growing and cutting	39 %	High	Scarcity of land, lack of local management laws, ignorance, need for quick profits, nature of land tenure to *bibanja* or leaseholders, lack of clear reporting mechanisms for encroachers, urbanization, and the need for eucalyptus products, poverty, increased brick making, issuance of licenses, limited local supervision, fear among poor people to report the rich	Environmental education, land-use planning, hard laws on wetland eucalyptus farming, demarcation and mapping of wetland boundaries, stopping the issuance of licenses to eucalyptus farming in wetlands, issuance of sustainable short-term user permits or revoking of permits, imprisonment, community sensitization on the dangers of eucalyptus farming in wetlands, the extension of wetland management programs and campaigns to involve cultural, religious, and school leaders, using local radio stations to train people on the dangers of eucalyptus in wetlands, zoning of functional and protected wetlands
Unplanned farming/ land-use practices (Human)	21 %	High	Poverty, increasing population, lack of local land-use plans, ignorance, increased settlement and urban growth, increased demand for food	Provision of alternative sources of income, promotion of ecotourism, development of wetland action plans at village, parish, sub-county & district levels, mapping of wetland zones, training and emphasis on fish farming, partnership with the Buganda cultural and tourism leadership in conservation
Increased settlement in wetland zones (Human)	20 %	Moderate	Increasing population, poverty, complex land tenure, perception of wetlands as free land, high land prices, dubious landlords, increasing urbanization, ignorance	Seasonal restoration, phased resettlement, revision of local land management practices, by-laws, education and training, mapping of wetlands boundaries, using local media talk shows, restricted settlement in wetlands, creation of alternative social housing schemes, partnership with the Buganda cultural and Tourism leadership in conservation
De-vegetation due to human activities, such as bush burning (Human)	6 %	High	Farming, seasonal fishing, eucalyptus growing, cattle rearing, ignorance, seasonal charcoal burning, urban developments, road construction, tea growing	Tree Planting and reforestation, planting trees along wetland boundaries, seasonal restoration through local engagement, ecotourism, seasonal restoration, setting up local management teams, planting trees along the wetland boundaries, training on organic farming and home gardening
Brickmaking and sand mining (Human)	3 %	Moderate	Poverty, lack of alternative jobs, complex land tenure, uncontrolled encroachment, limited supervision, and monitoring, lack of local environmental focal persons at village levels, eucalyptus growing adjacent to permanent wetlands	Creation of wetland action plans, land-use planning, restoration and covering of pits, seasonal harvesting/ mining, licensing of users, collaborative agreements, by-laws with *bibanja* and private landlords, restricted activities, micro-level wetland management and action plans, formation/ election of village environmental focal persons, partnerships in conservation

(*continued on next page*)

Table 7 (*continued*)

Nature of Threat	Percentage of threat	Level of severity	Dominant cause (s)	Possible mitigation measure/ intervention
				management and grants support
Pollution and dumping (Human)	5 %	Moderate	Use of agricultural chemicals, Release of engine oils, Illicit dumping of waste by local people, channeling, increased large farming/ grazing in wetlands, use of agricultural chemicals by estates	Training in proper fishing methods and sustainable utilization of resources, sensitization, eco-tourism to create alternative income, by-laws, replanting and restoration, controlling tress-passing, environmental education and training, training on proper or modern farming methods, fencing of critical wetland zones, water purification and treatment, wetland zoning, setting up of special waste management/ dumping sites near settlement zones, issuance of sustainable short-term user permits or revoking of permits.
Climate change effects (Natural)	5 %	Moderate	Release of toxic air from factories, cutting of natural wetlands and forests, eucalyptus farming, increased deforestation, encroachment in wetland forests, bush burning, sand extraction, brick making, increased wetland natural fires,	Reforestation, agroforestry, climate change mitigation, and adaptation planning, supporting women-led environmental groups, growing organic and environmentally friendly crops, hard laws on encroachment, new local wetland management agreements and plans
Wild pests and animals (Natural)	2 %	Low	Encroachment on neighboring forests, cutting down of wildlife habitats, increased flooding of banks, sand and brick making, bush burning, sugarcane growing	Reporting to the district environmental office, relocation of people, reduced encroachment, environmental plans, setting up local level environmental teams, training local communities on management/

Table 7 (*continued*)

Nature of Threat	Percentage of threat	Level of severity	Dominant cause (s)	Possible mitigation measure/ intervention
				harmonious co-existence with nature, wetland zoning

(See *Appendix 7*). Where collaborations are international and inter-institutional, perpetual focus on wetlands biology or natural sciences around Lake Victoria have persisted, or issues regarding document access (closed access). For instance, the works of van Dam et al. (2007) between Makerere University and UNESCO-IHE Institute for Water Education researchers and the recent research collaboration by researchers from the University of Bonn and Makerere University, among others (Gabiri et al., 2020).

4.2. Discussion of field findings

Field findings unearthed intricate micro-level dynamics in and around semi-urban, less accessible, and remote wetland zones of Mityana. Most of the narratives are largely unexplored and might be emblematic of the systemic vulnerabilities affecting most vulnerable tropical wetlands, across geographies. From the engagements with local communities, it was revealed that most parts of Mityana are crossed by two wetland systems (River Mayanja and Lake Wamala), and these are critically interrelated/connected to the Lake Victoria broad catchment zone. This finding is corroborated by recent studies and reports that revealed the interconnection between most tropical wetlands in central Uganda (Matovu et al., 2024; B. 2019; G. GoU, 2019; 2015; G. Gabiri et al., 2019). Additionally, wetlands serve innumerable functions, some of which are invisible. A synthesis of some of the notable works, such as by Bunyangha et al. (2022) around the River Mpologoma wetlands catchment zone, and Dalahmeh et al. (2020) around Nakivubo wetlands near Lake Victoria, attests to this. In their study among sedentary communities in districts of Kibuku, Butaleja, and Namutumba, Bunyangha et al. (2022) explicitly demonstrated the relevance of preserving wetland values by using discrete choice experiments (DCEs), based on micro-level citizens' preferred attributes in informing sustainable actions for wetland co-management. The valuable nature of wetlands is explicitly reinforced in international and regional descriptions of what wetlands entail. Accordingly, wetlands are defined as critical biodiversity hotspots, that are broadly distinguishable based on the unique (i) drainage, (ii) edaphic (soil), and (iii) flora and fauna in comparison to the surrounding environment (Matovu et al., 2024; B. 2019; Muwanika et al., 2023; Kayendeke et al., 2018). For instance, in some regions, wetlands contain papyrus vegetation, and other plants or soils adapted to water (irrespective of the altitude), including grasslands, swamps, marsh, bogs, papyrus, grassy fens, and fertile floodplains (Kakuba and Kanyamurwa, 2021; Maclean et al., 2014; Kipkemboi et al., 2010; 2002). Additionally, the wetlands, irrespective of their permanency or seasonality, avail myriad abiotic and biotic resources that sustain rural livelihoods and economies. Similar findings have been revealed in most of the riparian wetland zones, such as in the River Mpologoma catchment area (extending up to Lake Kyoga wetland system) (Were et al., 2021; D. 2020; Gabiri et al., 2020; G. 2019; Bunyangha et al., 2022; Gosling et al., 2017; Olupot, 2016). For instance, it is estimated that about 82.4 percent of most agrarian communities in Mityana rely on the direct benefits of wetland water resources and indirect environmental benefits for their livelihood (MDLG, 2024; UBOS, 2017). Myriad studies have revealed similar or related benefits, especially around locally and nationally protected wetland sanctuaries and zones, such as Bigodi around Kibale National Park (Hartter et al., 2010; 2009). Additionally, as wetland vegetation, such as

Fig. 16. Some of the observed measures to minimize/control wetlands loss (Field Photo).

papyrus helps mitigate and control floods, they reduce the cost of flood control by US$ 1.7 billion for flood. Some studies have comprehensively estimated that the non-use indirect values of wetlands, such as water recharge and regulation are in the region of US$ 7.1 million. Aside from the most reported tangible benefits of wetlands, a critical facet availed by wetlands in Mityana related to social/aesthetic preservation, of historical and cultural sites, such as along River Mayanja and Nakyegalika caves in Lubajja in Maanyi SC. By aligning wetland uses to cultural assets and goods, possibilities of ushering in crucial socio-cultural tipping points for livelihood welfare, health, and sustainability are possible (Convention on Wetlands, 2021; Freuder et al., 2019; Ramsar Convention, 2018).

Of concern, however, is the increasing threat of degradation to permanent wetlands that are not easily accessible or are in remote areas, for instance, in Kikandwa and Kalangaalo SCs. Correlations on the nature of causal-effect drivers (mostly human drivers) of wetland degradation have been reported in several studies. Around Nakivubo wetlands, for instance, emerging wetland concerns, are prominently due to the proliferation of anthropogenic-induced pollution of water resources that choke biodiversity in Lake Victoria (Dalhmeh et al., 2020). Similar profound concerns regarding the unabated pollution and unsustainable human drivers of wetland degradation around Lake Victoria (including in threshold agricultural and metropolitan urban zones) have also been resoundingly reported in several studies over the years (Wasswa et al., 2019; Dalahmeh et al., 2018; Vermeiren et al., 2012; Mbabazi et al., 2010; Oguttu et al., 2008). Astonishing evidence-based ramifications of human-induced threats have also been reported around Lake Nabugabo wetlands, where exotic invasive species (Nile Perch) led to indigenous species losses never seen before (Matovu et al., 2024; Chapman et al., 2002; 1996). It is estimated that about 16–18 indigenous fish species have become extinct in the riparian wetlands of Lake Victoria, partly due to the planting of exotic trees and the introduction of invasive species (Chapman and Chapman, 1996; Chapman et al., 2002; 1996). In some wetlands, such as around the Lake Kyoga catchment, it is estimated that by 2040, about 647.64 sq. km of wetlands will be lost and converted to agricultural land (due to the multiplicity of users) (Olupot, 2016)!

Several studies have confirmed that, as wetland zones and resources are increasingly being used by multiple users, with varying extraction levels, such as water and sand, threat levels have proliferated (Matovu et al., 2024; B. 2019; Were et al., 2021; D. 2020; Kakuba and Kanyamurwa, 2021; Ostrovskaya et al., 2013; Kyambadde et al., 2004). This is worsened by the increasing variations in the tropical climate, dotted with increasing temperatures, and droughts (Bunyangha et al., 2023; Gabiri et al., 2020). Devastating impacts of droughts (due to climate change) have been reported in a studies conducted in tropical inland wetland catchment zones, where increasing flash rains have led to flooding and eutrophication (Gabiri et al., 2020). Additionally, as some studies related the outbreak of human zoonotic viruses to human contact with wild animals (some of which are sedentary in wetlands), this has been used as a conduit to destroy some wetlands (Convention on Wetlands, 2021; B. Matovu et al., 2019). The perpetuation of mainly anthropogenic threats to wetland loss has popped up an opportunity cost/loss estimated US$ 4.63 million per annum. Amidst the increasing debilitating threats, riparian and vulnerable communities relying on wetlands for their livelihood are normally sidelined, leading to socio-ecological and economic grief (including social/community identity crises) (Scott et al., 2024; Matovu et al., 2024a). For instance, recent studies have revealed that most communities have inadequate safety nets, such as user licenses to access/use wetland resources, are hardly involved in decision-making, and are regarded as wetland encroaches, thus increasing opposition to established management policies and illegal encroachment (Matovu et al., 2024; B. 2019; G. GoU, 2019; 2015). As the unabated destruction and deterioration of wetlands has proliferated, intricate unsustainable human threats/practices have morphed from mere wetland encroachment to a complex network (including key stakeholders wetlands capture), and this has been confirmed in urban wetland zones of Jinja, Kampala, Wakiso, and Iganga (Matovu et al., 2024; Bunyangha et al., 2022).

Most of these networks have been reportedly involved in ‘elite capture’ of wetlands, such as in Lwera in Uganda, wetland grabbing, and

unabated securing of land titles in wetlands by the rich, powerful, and influential stakeholders (Convention on Wetlands, 2021; Matovu et al., 2024; Wasswa et al., 2019; Ssanyu et al., 2014; Ostrovskaya et al., 2013). Although local institutions (including cultural institutions) are trying to use traditional and indigenous knowledge pathways for conservation, fragmented governance, and management styles are prevalent. In some cases, established 'hard laws' and strategies have created a systemic risk of limiting access to livelihood resources extracted from wetlands and other socioeconomic injustices, such as the destruction of livelihood capitals, and loss of community identity. The perpetuation of these injustices, first, exposes the vulnerable rural populations sedentary along wetlands to social costs and loss of cultural assets, and second, to limited access to economic livelihood productive zones, such as fishing sites (Bunyangha et al., 2022; Mbabazi et al., 2010; Mbabazi, 2009; Hartter et al., 2010; 2009; Bikangaga et al., 2007; Maclean et al., 2014; 2007). Amidst this complexity, perpetual issues have remained concerning the creation of sustainable avenues for governance, as some policies and mechanisms on wetland management are largely sidelining vulnerable communities (Were et al., 2021; D. 2020; Bunyangha et al., 2022; Hartter et al., 2010). And yet, research and policies that comprehensively underscore/guide knowledge on the cumulative impacts and risks of wetland losses, such as on aesthetics and livelihoods are largely understood and limited (Matovu et al., 2024a; Scott et al., 2024; Lawrence et al., 2023; Freduah et al., 2019). This complex policy divide is evident in current national-level environmental assessment frameworks and reports (UNDP, 2024; Muwanika et al., 2023; UNEP and UNDP, 2016; Turyahabwe et al., 2013). Most often, the regulations are not only complex but, in some cases, contradict or overarch, creating enforcement deficiencies or limited implementation of sustainable policies and regulations (Mfitumukiza et al., 2024; Matovu et al., 2024; B. 2019; D. Were et al., 2020; Wasswa et al., 2019; Mbabazi, 2009). This creates a need for new approaches to sustainable wetlands management coiled around inclusivity, equity, and community engagements, to create novel transformative perspectives (Were et al., 2021; D. 2020; Convention on Wetlands, 2021; Wasswa et al., 2019).

5. Invigorating a road towards sustainable and evidence-based wetlands co-management and co-governance through the sustainable wetlands management action pathway (SWeMAP)

According to the 2021 Global Outlook Report, as wetlands have sporadically receded, critical and urgent measures are needed more than before to mitigate the causes of the degradation and avert future damages (Convention on Wetlands, 2021). From the global fora, policymakers agree that the key issues to curtail unfathomable wetland losses need to hinge on a typology of critical measures: urgent redress to climate change, reverting unsustainable global ecological crises (including the sporadic biodiversity loss), and charting inclusive, sustainable, and transformative societal actions that scale down anthropogenic-induced damages (Convention on Wetlands, 2021; Ramsar Convention, 2018; Matovu et al., 2024a). To contribute towards the burgeoning research and policy enthusiasm towards this, we have amalgamated key insights to develop a novel pathway called the '*sustainable wetlands management action pathway (SWeMAP)*.' The developed SWeMAP has seven coherent and interrelated steps (Fig. 17). For each step, key descriptions and highlights are given that inform on what needs to be done, by whom, for whom, and the purpose it serves towards sustainable wetlands management. To bring to the fore the micro-level and regional relevance of the SWeMAP, we have crucially borrowed, expounded, and contextualized key insights from the complex systems perspectives, sustainability dimensions, and factors in context-based/evidence-based realities. Most importantly, the insights could be resoundingly situated in impact-based studies and policy interventions for transformative change among vulnerable and complex

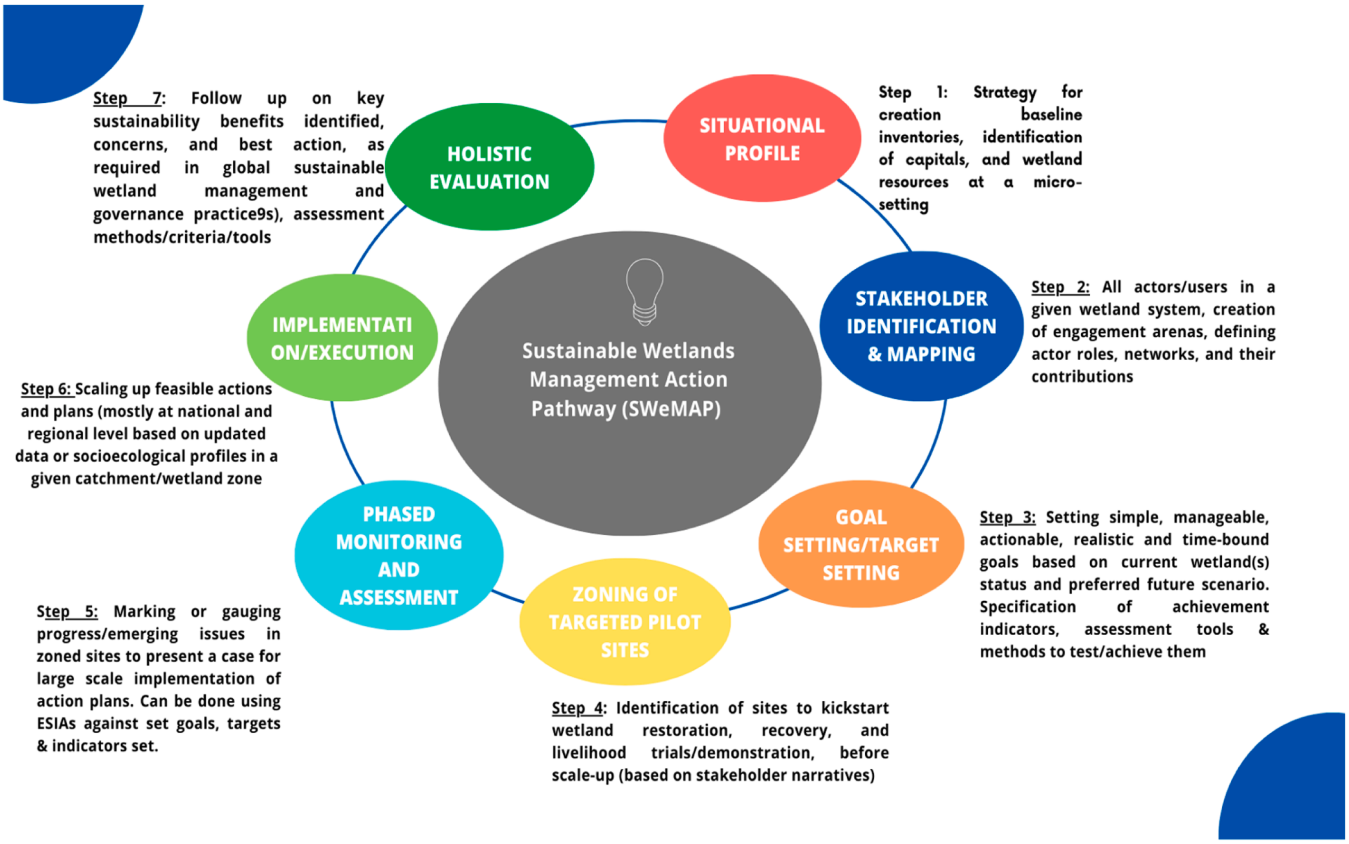

Fig. 17. Novel development/contribution: the SWeMAP (Authors' creation).

natural resource settings (Matovu et al., 2024a; Lukambagire et al., 2024; Lawrence et al., 2024).

5.1. Relevance of the SWeMAP and contribution to policy and scholarship in the sustainable wetland management discourse

To reaffirm the global commitment(s) on wetlands management and governance, on 30th August 2021, the United Nations General Assembly (UNGA) passed a resolution that designated 2nd February per annum, as World Wetlands Day. Through this, progress indicators towards situating wetlands at the core of sustainable development and livelihood equity are to be emphasized (Convention on Wetlands, 2021). In some jurisdictions, such as Sweden and Finland, progress and a focus on sustainable indicators (both in policy, practice, and research), have gained traction with tangible livelihood benefits (Lyytimäki and Pitkänen, 2020; Pedersen et al., 2019). However, in most tropical and vulnerable wetland regions, as observed in the current micro-level system dynamics in Uganda, such progressive efforts seem far-fetched from achieving sustainability targets. A positive transformative opportunity has surfaced with the recent gazetting of wetlands as critical to national development in Uganda (UNDP, 2024). This could create a critical building block to inform sustainability research and pathways for wetlands use, management, and governance have been birthed (UNDP, 2024). The key components highlighted in the SWeMAP could be the missing link to bridging the perpetual concerns of wetlands management. Subsequent paragraphs dissect this deeper and show how the SWeMAP avails a kickstarting foundation for this.

In step one of the SWeMAP (situational profiling), we argue that since research has revealed that through the creation of micro-level safeguards, possibilities of charting sustainable and proper mechanisms for harnessing wetland resources are invigorated, the baseline step should be the creation of situational profiles of both vulnerable communities and vulnerable wetlands, across geographies (Convention on Wetlands, 2021; Matovu et al., 2024; B. 2019). Studies in vulnerable catchment zones have revealed that through community engagements aimed at unearthing visible and invisible drivers of wetland losses/management, equity dimensions, and socioeconomic livelihood tipping points are birthed (Winkelmann et al., 2022; Voyer et al., 2021; M. 2020). To sustain short-term and medium-term transformative actions, the silver lining should be the identification of feasible actions and micro-level shifts. These need to cascade toward the broader recognition that wetland biodiversity loss and micro-level livelihood sustainability are inextricably linked and can seldom be achieved through stepped-up collaborative action to reverse the unprecedented loss of nature (Matovu et al., 2024; Were et al., 2021; D. 2020; Wasswa et al., 2019). The creation of causal links between biodiversity and livelihoods is a novel arena that is well documented in the system thinking approach and logical models for transformative change (but less explored in most vulnerable wetland zones) (Matovu et al., 2024a; 2024b). Since driving sustainability transformations in complex systems is a phased process, studies have recommended that the baseline engagement arena should be the profiling of the critical wetland resources and livelihood capitals, that are intrinsically embedded in the socioeconomic and cultural fabric of a given society (Lawrence et al., 2023; Freduah et al., 2019; Convention on Wetlands, 2021). The relationship between increased livelihood capital and better sustainability and resilience to shocks has been well-documented in several regional and global studies (Matovu et al., 2024; Lukambagire et al., 2024; Winkelman et al., 2022; Freduah et al., 2019).

According to Freduah et al. (2019), seven livelihood capitals could be key, especially in creating baseline inventories. These include cultural capital (including values, traditions, and attitudes towards wetlands by a given local community), human capital (including skills and know-how to derive a livelihood from wetland resources), natural capital (ecological assets and endowments of a given wetland), social capital (based on shared visions, values, trust, respect among users of a given wetland resource), political capital (diving into informal and formal power-relations in decision-making and influence of actors and institutions in use/management of wetland resources), financial capital (includes available monetary and non-monetary resources/benefits such as carbon credits, donations, and grants obtained or available to interest users in wetland management), and built capital (consisting of support infrastructure linking other capitals or providing development/livelihood benefits derived from the wetlands, such as water) (Freuder et al., 2019; Yan et al., 2022; Canning et al., 2021). The benefits of profiling wetland capitals include helping build adaptive capacity to human-environmental stressors (Freduah et al., 2019), incentivizing large-scale wetland efforts based on common user asset trusts (Canning et al., 2021), and creating novel eco-credit accounting repositories, and information banks that could aid progress toward the goal of No Net Loss (NNL) of ecosystem services (Yan et al., 2022; Convention on Wetlands, 2021; UN, 2023; Ramsar Convention, 2018).

Stakeholder identification and mapping (step 2 of the SWeMAP): As wetland zones are a theatre of diverse interests among different users (often competing with unsustainable repercussions), a critical follow-up phase could be the crisp identification and mapping of stakeholders, depending on the targeted region or wetland zone. To (co)create new engagement arenas for stakeholders, an explicit focus on a schematic illustration of all users, their roles, level of engagement, and benefits towards a given sustainability target is crucial (Lukambagire et al., 2024). This perspective is hinged on the stakeholder mapping and engagement theories and logic models of actor networks in complex systems (Lukambagire et al., 2024; Matovu et al., 2024; 2024a). To increase avenues for capacity building and trust, all users and stakeholders, including cultural leaders, religious leaders, direct users of wetland resources, policymakers and technical persons, learning institutions, and civil society organizations need to be involved in the process (Yan et al., 2022; Were et al., 2021; D. 2020). When micro-level and top-level stakeholders are involved, more scientific and social science knowledge (including legends, riddles, and folklore), about complex and innate wetland socioecological systems and their intrinsic values are obtained (Matovu et al., 2024a; B. 2019). Further benefits could include the promotion of better transparent communication (between local leadership and community users), and the ability to build social capital for securing resources needed for driving wetland restoration, enhancing adaptative capacity, and mitigation to shocks (Convention on Wetlands, 2021; Freduah et al., 2019). In Uganda for instance, micro-level stakeholder engagements across five agro-ecological zones (AGEZs), such as around the Lake Victoria catchment area led to the identification of four critical local capacity needs to drive resilience to environmental shocks due to climate change (Mfitumukiza et al., 2024). These included awareness building, training of riparian communities' nature-based options, increased evidence-based research, and techno-capacity building. Similar or related success stories have been reported around Naigombwe wetland in Iganga and in the River Mpologoma catchment among paddy rice farmers experiencing pollution fluxes (Were et al., 2021; D. 2020; Ssanyu et al., 2014).

Most often, inclusive stakeholder engagements naturally lead to the birth of feasible goals/priorities/visions that drive sustainability across the socioeconomic, ecological, and psychological dimensions (Matovu et al., 2024a; Lukambagire et al., 2024). In complex natural resource settings, and vulnerable areas with data gaps, emphasis needs to be placed on creating simple to understand, manageable, and time-bound goals (Canning et al., 2021). Such coherent but comprehensible goals are critical in building replicable actions, reducing exorbitant costs for conducting technical socioecological feasibility studies, and mobilizing capital to respond to most shocks in situ (Freduah et al., 2019). In the Pacific regions, for instance, the benefits of curating and crafting inclusive and collaborative goals on wetlands/ecosystem management have been realized. These have included the creation of special provisions for critically vulnerable persons, micro-level generation of

evidence on the level of impact, threat drivers, and the creation of moral grounds for accelerated functionality/implementation of adaptation actions (Voyer et al., 2021; M. 2020). Such tipping points can aid the creation of micro-level mechanisms and plans for building indicator metrics and tools necessary for co-management and co-governance (Matovu et al., 2024; Winkelmann et al., 2022; Canning et al., 2021; Freduah et al., 2019).

Goal setting (step 3): While setting goals and targets for achieving better livelihood and ecological outcomes, during the goal-setting process, a focus should not only be coiled around creating hard and inconsistent goals (Were et al., 2021; D. 2020; Mbabazi et al., 2010). Rather, an explicit emphasis on identifying and cementing goals that assess the impact at micro scales, and assess policy frugality, coherence, application, and coordination among users and at all levels need to be emphasized (Convention on Wetlands, 2021; Winkelmann et al., 2022; Voyer et al., 2021). The benefits of coherent and time-bound actionable goal-setting mechanisms have been reported to be key in creating feasible national or regional sustainable development goals indicators, and targets, such as in Timor-Leste (M. Voyer et al., 2020). To encompass and encourage the inclusion of non-economic sustainability goals, emphasis on creating voluntary agreements and commitments in propelling sustainable actions geared towards equity (including women) and environmental justice, such as in small-scale fisheries among riparian communities is critical (Scott et al., 2024; Convention on Wetlands, 2021; Voyer et al., 2021). Under the Wetlands Strategic Plan (WSP) commitments, micro-level commitments can aid in the wetland's ecological character through the identification of point sources that degrade or pollute wetlands (Convention on Wetlands, 2021; Ramsar Convention, 2018). This is partly because there has been a gap in research in tracing and tracking unsustainable drivers of pollution in most remote wetlands (Mfitumukiza et al., 2024; Were et al., 2021; D. 2020). As most wetlands have been reported to be moderately degraded in Mityana, we argue that improving micro-level commitments can further help improve the understanding and characterization of the drivers and interactions of wetlands and biodiversity losses in each inland wetland catchment zone(s) (Mfitumukiza et al., 2024; Muwanika et al., 2023; Bunyangha et al., 2022).

Furthermore, a systematic understanding of the interdependency or nature of human-environmental interactions in each zone can help in the zoning of a targeted site for either restoration, conservation, or sustainable extraction of a given wetland resource (Muwanika et al., 2023) (*step 4 of the SWeMAP*). In most studies, it is recommended that the zoning needs to be based on the hydrological, environmental, or demographic dynamics of a given wetland or catchment zone (Were et al., 2021; D. 2020). With the increasing technological advances, such as in geographic information system (GIS)-supported visualization and scenario-modeling techniques, an avenue for site-specific mapping of a given wetland zone and riparian communities (including the activities they do), is possible (Gabiri et al., 2020; G. 2019; Sebadduka, 2014). To avoid trade-offs regarding the use of technologies among less tech-savvy riparian wetland communities in some regions, and incompatible ambition gaps' such as scenario modeling of targeted zones, social science knowledge can be used to identify and create zones, such as along traditionally known biodiversity hotspots in each wetland (Matovu et al., 2024; 2024a; Freduah et al., 2019). By using the knowledge of local citizens in zoning critical wetland spaces, stand-alone authoritative quantitative indicators are minimized (Lawrence, 2023). This creates an avenue for the amplification of local citizens' contextual knowledge and voices needed to guide micro-level narratives and mechanisms. Such mechanisms can include the development of micro-level wetland action plans, collaborative wetland restoration, and monitoring (Matovu et al., 2024; Kakuba and Kanyamurwa, 2021). To aid the co-creation of management zones that are replicable and scalable, emphasis can be on using the globally renowned wetland management guidelines and benchmarks, such as the Ramsar guidelines on the "wise use of wetlands'', guidelines for assessment, monitoring, and management of animal disease in wetlands; and national level environment and impact assessment guidelines (Convention on Wetlands, 2021; Ramsar Convention, 2018; Ostrovskaya et al., 2013; GoU, 2015).

Step 5 of the SWeMAP: The increased implementation of wetland co-management or co-governance zones propels in a critical component of short-term monitoring and assessment of progress based on targeted indicators, targets, and defined goals (Matovu et al., 2024a; 2024; Kakuba and Kanyamurwa, 2021). As national and regional priorities change concerning wetland management and regulations, a critical driving force to assess wetland governance or management progress can include regular updating of inventories and conducting of environmental impact assessments (EIA) or environment and social impact assessments (ESIA) (G. GoU, 2019; NEMA, 2019). To enhance collaborative engagements, ESIAs can be done within the realm of the strategic implementation process, which considers the strategic implications of social and ethical issues in each zone or region (Kakuba and Kanyamurwa, 2021). This can help in the generation of critical recommendations and identification of emerging concerns (such as climate and non-climate change stressors), that could be factored into a large-scale implementation plans or projects (Lukambagire et al., 2024; Were et al., 2021; Freduah et al., 2019). To further enhance complementary actions and synergies for learning, crucial assessment tools, and methods can be used based on a given spatial-temporal dimension (Were et al., 2021; Muwanika et al., 2023); Hartter et al., 2009). Among micro-level vulnerable zones and contexts, a blended epistemological approach that scours out the perspectives on the expanded concept of eco-Ubuntu in the use of common-user wetland resources could be tapped (Muwanika et al., 2023). Socioecological assessment tools could also be piloted/tried, such as the discrete experimental tool, to qualitatively and quantitatively investigate the attitudes of micro-level citizens towards wetlands, governance mechanisms, and the resources therein (Bunyangha et al., 2022; Hartter et al., 2009). Under the emerging momentum for sustainable wetlands governance and management, as espoused under the Global Wetlands Outlook report, some of the robust regional-level assessment tools urgently needed have been developed. These include the eco-credit accounting method for wetland mitigation banking (Yan et al., 2022); payment for ecosystem service (PES) tools and schemes to build socioeconomic evidence-based investment portfolios and common asset trusts (CATs) for wetlands across landscapes (Canning et al., 2021), the 2018 land degradation and restoration assessment tools developed by the IBPES, and the European Union (EU) developed 2020 mapping and assessment of ecosystems and their services tool/method among others (Convention on Wetlands, 2021).

The creation of strong foundations for micro and regional-level assessment of wetlands management and governance measures propels a possible dimension for multi-level implementation of the propped-up ideas and strategies for sustainable co-governance and co-management (*step 6 of the SWeMAP*). With the assessments, updated inventories developed overtime could be replenished with tangible and intangible data on situational profiles, stakeholder matrices, achievable and actionable goals, assessment tools, and baseline findings (Matovu et al., 2024; 2024a; Kakuba and Kanyamurwa, 2021). At national levels, such as in Uganda, priority for scale-up and implementation could be situated around the four key targets envisioned under the National Environment (Declaration of Wetlands) Notice, 2023 (UNDP, 2024). These include (a) developing a detailed information inventory for each wetland (including the specific names, locations, maps, boundaries, and total area coverage for each wetland), (b) protecting all the wetlands in Uganda and recognizing the wetlands as critical ecosystems that are vulnerable and unsustainable activities, such as pollution and encroachment being prohibited, (c) increasing the contribution of wetlands to climate change resilience and community benefits (including the setting up of transparent safety nets, enforcement of protection measures and awareness, and (d) offering legal backing for the sustainable management and wise use of wetlands from micro, regional,

and national levels. These could be commendable building blocks towards sustainable wetlands co-management and co-governance in Uganda and in tropical regions. This is because previous studies have recommended the application or development of holistic and comprehensive measures, such as micro-level situational profiles and wetland inventories, encompassing village, parish, sub-county, county, and district wetland action plans (Matovu et al., 2024), capacity development and awareness (Kakuba and Kanyamurwa, 2021; Bunyangha et al., 2022; Hartter et al., 2009).

By developing coherent wetland profiles and sustainability safeguards (institutional, socio-cultural, and economic), possibilities for aligning national reports to the Convention of Wetland guidelines as derived from the evidence-based national wetland inventories (NWIs) are possible (Scott et al., 2024; Convention on Wetlands, 2021). This further helps in the localizing of SDGs and can form benchmarks for tracking SDG indicators and targets. Some of the critical SDGs indicators and targets that can be rowed in this path include SDG indicator 6.6.1 on the water-related ecosystem (un)sustainable markers over time and SDG indicator 10.1.1–4 (reduced inequalities of all forms), for which the Convention on Wetlands is the co-custodian with UNEP (United Nations Environment Programme) (Convention on Wetlands, 2021; Ramsar Convention, 2018). At national and regional levels, the streamlining of implementation plans with coherent sustainability and SDG monitoring or tracking mechanisms is an emerging cue for securing funding for sustainable projects (Matovu et al., 2024a). Through the Green Climate Fund (GCF), micro-level and national-level project financing is increasingly being entangled with an explicit focus on building equity and sustainable transformations for vulnerable communities and threatened ecosystems, such as wetlands (Matovu et al., 2024a; Convention on Wetlands, 2021; Canning, 2021).

This could be leveraged in Uganda to attract project funding to revitalize fragile ecosystems and support vulnerable communities in riparian zones (Kakuba and Kanyamurwa, 2021; Bunyangha et al., 2022; Hartter et al., 2009). Promising indicators have already been unearthed through the recent project on 'Building Resilient Communities, Wetland Ecosystems, and Associated Catchments in Uganda.' Under this project, riparian communities have been empowered (including women) in securing alternative livelihood and income-generating activities, while concurrently enhancing the technical capacity of micro-level natural resource departments, and other line institutions under the Ministry of Water and Environment (MWE) (UNDP, 2024). An additional focus under the implementation plan could be the restoration of critically encroached wetlands (Kakuba and Kanyamurwa, 2021). Through this, funding for comprehensive management of wetland catchment zones can be secured (UNDP, 2024). For instance, through funding under the GCF in Uganda, over 47,000 hectares of degraded wetlands and catchments have been restored, and mapping of wetland boundaries is being done under the WMD, such as around Lake Wamala wetlands (UNDP, 2024; Matovu et al., 2024; ESA, n.d.). This can help improve hydrological monitoring, regulate the water flow, and ameriolate the risk/-vulnerability of riparian communities to shocks, such as climate change-induced flooding (Gabiri et al., 2020; G. 2019; Were et al., 2021; D. 2020). By tapping into the domain of collaborative implementation of wetland management and project governance, possibilities of creating better livelihood outcomes are ripe (Voyer et al., 2021; M. 2020; Freduah et al., 2019). For instance, in Uganda, collaborative implementation of wetlands management practices have helped benefit and support 13, 1000 households in sustainable agronomic practices, alternative livelihoods on the use of wetlands, and capacity-building/generation of micro-level paths to access climate information (in local languages) (UNDP, 2024). This could be a conduit for increasing community livelihoods, wetlands management knowledge, and environmental resilience to shocks (Freduah et al., 2019). Additional benefits can include strengthening institutional evidence to support wetlands management (via the mapping and documentation of the state of wetlands reports), and developing legal safety nets (including by-laws) for the protection, management, and governance of wetlands (Matovu et al., 2024; B. 2019; Muwanika et al., 2023; Convention on Wetlands, 2021; Kakuba and Kanyamurwa, 2021).

Step 7 of the SWeMAP: As the feasibility and sustainability of the implemented wetland actions, programs, and management mechanisms must be tracked over time, the component of holistic evaluations becomes key (Ramsar Convention, 2018). Across jurisdictions, and based on shreds of evidence generated over time, there is no specific evaluation method or tool that can fit all scenarios (Kakuba and Kanyamurwa, 2021). Rather, an explicit emphasis has been laid on the promotion of coherent and synergetic evaluation mechanisms that factor in emerging changes (both environmental and human), in each system (Matovu et al., 2024a; 2024; Lukambagire et al., 2024; Oguttu et al., 2008). According to the 2021 Global Wetlands Outlook report, the development of holistic evaluation mechanisms could be key to developing a comprehensive wetland ecological character (the wetland ecological character is the combination of the ecosystem components, processes, and benefits/ services that characterize the wetland at a given point in time) (Convention on Wetlands, 2021). Such profiles explicitly help situate, suit, or align national, regional wetlands management guidelines to global wetland management or governance targets (Convention on Wetlands; 2021; Ramsar Convention, 2018). In vulnerable tropical wetland zones, >30 globally recommended evaluation assessment tools, guidelines, and methods have been developed using this synergetic approach (Convention on Wetlands, 2021; Muwanika et al., 2023; Kakuba and Kanyamurwa, 2021). These include the 2021 Unearthing Investors Action on Biodiversity (under the jurisdiction of Credit Suisse), the 2021 Economic Case for Nature assessment guidelines (under the jurisdiction of the World Bank), the 2021 G20 Environmental communique; 2021 Atlas of Rangelands (under the jurisdiction of the ILRI), Local Biodiversity Outlook assessment guidelines (under the jurisdiction of the FPP), Global Risks Assessment Reports and 2021 Nature, Biodiversity, and Health assessment guidelines (under the jurisdiction of the World Health Organization) among others (Convention on Wetlands, 2021; WEF, 2023; World Bank, 2022; Ramsar Convention, 2018; Fischer et al., 2021). As most of the developed evaluations confluence in global and regional (Africa) policy agenda, they are novel drivers for creating foundational and ambitious wetland restoration efforts (Fischer et al., 2021; Convention on Wetlands, 2021). This is becuase most of these evaluation mechanisms are cobwebbed and envisioned under the UN Decade on Ecosystem Restoration (2021–2030), and the reinforced Africa's Agenda 2030 and Agenda 2063. With the amalgamation and alignment of critical evaluation mechanisms, new insights that could aid wetland recovery and livelihood resilience to multiple crises and effective delivery of sustainable, resilient, and innovative (nature-based) solutions can be streamlined (Fischer et al., 2021; AU, 2024; Sachs et al., 2024; UN, 2023; World Bank, 2022).

6. Conclusions

Our study unravels valuable insights from literature and riparian wetland communities and zones in Mityana that could be key in mobilizing evidence-based knowledge needed for transitioning towards sustainable wetlands management. First, insights from the literature highlight critical research and policy issues that are worth exploring. Research on wetlands has increased and this could present an opportunity to understand the complex dynamics of wetlands ecosystems, services, and management opportunities among others. However, some concerns regarding the nature of the research conducted are prevalent. For instance, in Uganda, most research is either centered around the Lake Victoria region or researchers are comparatively interested in wetlands natural/biological research. Recently, plummeting trends in scientific research on wetlands in Uganda are evident in the literature. This could limit the identification of current vulnerability trends and viable themes for sustainable policy co-creation and formulation on wetlands. The narrow focus on a few wetlands themes and trending

topics for sustainable wetlands management could limit the generation of diverse and critical perspectives from local citizens on key narratives and inventories. A duopoly of ramifications for this unsustainable research façade are (i) reduced fervor for collaborative policies on co-governance and co-management of wetlands resources and (ii) limited policy coherence on sustainable ecosystem use and management, as targeted under the global sustainability pathways, such as the UN Decade on Ecosystem Restoration (2021–2030), Africa's Agenda 2063 on sustainable development and equity transformation in the use of ecosystem resources, goods, and services.

Additionally, micro-level citizens' engagements and participant observations along wetland zones in Mityana district highlighted a nexus of findings that are mostly uncovered in vulnerable wetlands zones of Uganda. Significant correlations are revealed in terms of wetland endowments across the sampled zones. Wetlands (irrespective of the type), have a paucity of resources that are critical to local communities' livelihoods. In Mityana, the valuable socio-cultural and environmental contributions of wetlands superimpose the generally highlighted economic values in national policy. In some communities, such as around Lake Wamala in Maanyi, wetlands form a critical part of social identity and a historical common, that is locally cherished. Although some of the narratives given by residents seem 'mythical', such as on the motherly origins of Lake Wamala and River Mayanja wetland systems, they reveal critical and intricate structural social identities and community drivers for interest in wetlands management and governance. These urgently must be incorporated into policy and research discourses, if community interest in wetlands co-governance is to be achieved. A common trend, however, is the sporadically increasing vulnerability façade of wetlands and riparian communities is evident in Mityana. Critical wetlands and their resources are increasingly lost due to anthropogenic drivers. The commonest threat driver is eucalyptus tree planting, and this is worsened by the complex land tenure system. Riparian zones with absentee landlords or mailo landowners are experiencing unwarranted encroachment. Although this might not be emblematic of the complex land-wetland zone threats and systemic risk drivers, the land management issue seems to be an underlying driver of wetlands degradation, especially in remote wetlands of Mityana. Most of these concerns are scattered across the, less accessible wetlands or wetlands that cannot easily be monitored. In areas with wetlands that have a unique cultural value, a critical trade-off has emerged involving socioecological and cultural grief. Riparian communities are increasingly wary of losing their cultural identity and unique heritage that has been preserved for centuries. Although riparian communities demonstrate a willingness to drive wetland management practices, elite capture of wetlands is an emerging threat, especially where riparian zones have land squatters. In permanent wetland zones, institutional-led management practices are evident, but financial impediments to scaling up the co-governance practices have led to lucklustre implementation progress or engagements with wetland riparian communities.

Within the realm of sustainable wetlands management, interest in capacity building and wetlands profiling, such as by using evidence-based inventories from micro-level wetlands zones is supported. However, this is largely unexplored, and riparian wetland communities are largely unaware of key sustainable governance mechanisms. Nevertheless, critical components for driving sustainable management practices are increasingly emphasized as most riparian communities are becoming more vulnerable to human-environmental pressures and changes. This emerging narrative partly implies that within the realm of sustainable wetlands management and governance, possibilities for successful co-development and implementation of co-governance mechanisms are emerging, albeit untapped. Development and scaling up of this are an urgent necessity. The transformative priorities should embody the spirit of localizing sustainability governance indicators from a global to a micro-level perspective and vice-versa. The developed SWeMAP provides an indelible direction that could aid the co-creation of sustainable safety nets embedding livelihood and ecological components, including local communities' stewardship of vulnerable wetland cultural assets and capitals. With the gazetting of wetlands as critical to Uganda's development, concerted efforts should go beyond 'total conservation of wetlands' to the protection of livelihoods, collaborative engagements, and the well-being of local citizens. By prioritizing collaborative wetland conservation and management, an opportunity could be birthed to exemplify or amplify local community stewardship, commitment, and willingness to drive sustainability agenda across different SDG targets, goals, and indicators, such as SDG 13: Climate Action. This could contribute to national and global efforts to collaboratively halt wetland biodiversity loss, ensure sustainable water management, and combat climate change. These benchmarks are explicitly documented under Resolution XII 2 of the Ramsar Strategic Plan (2016–2024).

Additionally, by coiling wetland governance mechanisms with evidence-based knowledge (generated through socio-ecological community engagement and narratives), Uganda could demonstrate that environmental co-management/protection and economic prosperity can indeed go together. This could pave new paths in the relatively uncharted territory for a more inclusive, equitable, and sustainable future for all Ugandans, aligned with SDG 10: Reduced Inequalities. Additionally, as we used a single case study of Mityana district to sample wetlands and obtain narratives, the novel and critical sustainability insights and wetland co-management journey shouldn't and doesn't end here. Rather, we re-echo a call for increased financing of micro-level evidence-based social and natural science research to create wetland situational profiles from other districts and regions of Uganda, and vulnerable tropical wetland zones, such as in Zimbabwe. This can foster avenues for broader collaboration among stakeholders and replenish the national repositories with evidence-based data/information. Such explicit information/databanks could support the national ambitious goal of creating national repositories that bring all wetland users and wetland zones under sustainable management. Achieving this goal will not only benefit Uganda but also contribute to achieving the SDGs, and sustainable wetland management pathways on a global scale, leaving a legacy for generations to come.

Ethical considerations

Consent was sought from respondents and the DNRO to use the field findings and photos exclusively for academic purposes.

CRediT authorship contribution statement

Baker Matovu: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Ming-An Lee:** Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition. **Mubarak Mammel:** Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Funding acquisition. **Isaac Lukambagire:** Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Formal analysis. **Bernard Lutalo:** Writing – review & editing, Writing – original draft, Validation. **Alex Ronald Mwangu:** Writing – review & editing, Writing – original draft, Validation. **Bridget Mwabvu:** Resources, Software, Validation, Writing – original draft, Writing – review & editing. **Tahmina Akther Mim:** Writing – review & editing, Writing – original draft, Validation, Resources. **Yasin Bbira:** Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition. **Yasin Lubega:** Writing – review & editing, Writing – original draft, Validation, Project administration. **Yosia Muhoozi:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation.

Declaration of competing interest

No conflict of interest.

Data availability

Data used in this study has been shared in a link.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.envc.2024.101014.

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