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Original Article

Advancing River Health Assessments in the Tropical African Region Through Integrating Community Participation, Restoration Strategies, and River Order Sampling – A Review

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Despite the numerous studies and conservation efforts that have been put into the tropical African rivers, their environmental degradation and loss of the associated biodiversity remain at risk. This is attributable to factors, among the major ones being a lack of a holistic and inclusive approach to this challenge by researchers. This review examines key gaps in current research on stream ecosystem health and land use interactions in the tropical African regions, focusing on the lack of community involvement, inadequate restoration practices, and limited consideration of river orders in sampling efforts. The review analysed 34 publications, including 26 Journal articles, 5 technical reports, and 3 theses, published between 2005 and 2025. The findings reveal that only 20.6% of the reviewed studies answered all three gaps: community involvement, restoration practices, and consideration of river orders in sampling efforts. In contrast, 11.8% incorporated at least one component, 20.6% answered two aspects, and 47.0% did not embrace any of the three components in their study. The review highlights the importance of integrating these elements to enhance the relevance and impact of research, better inform policymakers, and contribute to the long-term preservation of river ecosystems in the region. By adopting a more holistic and inclusive approach, researchers can address the complex challenges facing tropical African rivers and foster sustainable management of these vital ecosystems. Future researchers should prioritise community engagement in river health assessments, incorporate restoration planning and implementation into study designs, and adopt sampling strategies that account for various river orders.

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INTRODUCTION

Stream ecosystem health is crucial in tropical African regions, where rivers face threats from anthropogenic pressures and land use changes, most especially in the urban settings where the urban dwellers throw in the rivers dead dogs and other domestic wastes the case in Mbale city, according to Turyahabwe et al. (2022). Assessment methods include fish-based indices of biotic integrity and diatom community analysis (Achieng et al., 2021a; Shibabaw et al., 2021). These approaches help evaluate ecological integrity and water quality, considering factors such as species richness, trophic structures, and physicochemical parameters.

Stream ecosystem health and land use interactions in tropical African regions have been the focus of numerous studies, but several key gaps remain. This review paper examines these gaps, including the lack of local human communities' involvement in river health assessments, inadequate restoration practices, and limited or no consideration of river orders while studying rivers and streams (Murphy et al., 2022). Many studies have identified problems affecting river ecosystems, but have not implemented or proposed restoration measures. Additionally, sampling efforts often fail to account for different river orders, limiting the understanding of stressor impacts across the river continuum. To

address these gaps, Aura et al. (2021) recommend that future researchers prioritise community engagements of the people living near the rivers/streams, also incorporate restoration planning and implementation into study designs, and adopt sampling strategies that consider various river orders. By involving riparian communities, researchers can access valuable local knowledge and foster community-based conservation efforts. Integrating restoration practices into river ecosystem assessments is crucial for addressing identified problems and promoting the long-term health of these systems (Elias et al., 2014). Furthermore, considering different river orders in sampling strategies provides a more comprehensive understanding of the impacts of various stressors on river ecosystems. Adopting these approaches will enhance the relevance and impact of research, better inform policymakers, and contribute to the sustainable management and preservation of tropical African river ecosystems in the face of the increasing anthropogenic pressures and climate change (Acosta et al., 2018; Mureithi et al., 2025; Murphy et al., 2022).

Numerous studies conducted in the tropical African region have sought to assess the impact of land use on ecosystem health by examining various components. Researchers have selectively focused

on aspects such as limno-chemical properties, macroinvertebrate assemblages, fish populations, nutrient levels, and habitat quality. Incorporating river order, community engagement, and restoration strategies in river health assessments is essential for achieving accurate, sustainable, and socially relevant outcomes. River order provides the ecological framework to capture variability along the stream continuum, ensuring that assessments reflect both headwater sensitivity and downstream resilience (Kaaya, 2015; Wami/Ruvu Basin Water Office, 2022). Community engagement integrates local knowledge, fosters stewardship, and increases the likelihood of compliance with conservation measures, while restoration strategies translate assessments into tangible ecological recovery and livelihood benefits (Ochieng et al., 2023; WWF Kenya, 2024). Neglecting these aspects risks producing incomplete diagnoses, overlooking localised stressors, and implementing top-down interventions that lack community support, often leading to ecological degradation, resource conflicts, and the failure of restoration initiatives. A holistic approach that unites these three elements is therefore critical to sustaining river ecosystem health and enhancing resilience in tropical African catchments.

This literature review examined studies on the impact of land use on river ecosystem health in tropical Africa. It identified three key gaps in current research for comprehensive river ecosystem health assessments: (i) the involvement of riparian communities, (ii) the establishment and performance assessment of stream ecosystem restoration techniques, and (iii) the assessment of anthropogenic disturbance using a stream/river order system. The paper notes that while many researchers in the region identify ecosystem health issues, they frequently fail to implement restoration efforts, leaving a critical gap in practical action to address degraded streams.

This review explored strategies to address identified gaps in lotic ecological investigations and evaluated

their influence on research conclusions. Recommendations were provided for future researchers on elements crucial for comprehensive studies.

MATERIALS AND METHODS

A comprehensive literature review was conducted about studies that have evaluated the impact of human activities on the ecosystem health of rivers in tropical Africa. In each study, irrespective of the aim/objectives of the study as long as they were assessing the lotic ecosystem health, we evaluated its completeness by looking at whether it addressed the three gaps or what ought to have been done to make it suitable and complete to evaluate the health and restoration of river ecosystems in the tropical African region, employing various assessment criteria. These criteria included community involvement in river health assessments, river restoration efforts, and consideration of river orders during the sampling process.

The exclusion and inclusion criteria were as follows: only studies carried out in tropical Africa were considered, and only studies that were centred on the assessment of the effect of anthropogenic activities on ecosystem health were considered. This is because of their relevance to the topic, and we wanted at least to have an informed discussion based on two decades (20 years) of research in this field of limnological studies. The study further involved an in-depth review and analysis of information from various peer-reviewed research reports and publications. The study utilised an extensive literature search through multiple search engines, including Science Direct, Research Gate, Google Scholar, and Web of Science. The search was refined using keywords such as ecosystem health, river assessment, bio monitoring, restoration techniques, bio indicators, and community engagement and community perception. The search resulted in a total of 26 (76.5 %) journal articles, 3 (8.8 %) academic theses, as well as 5 (14.7 %) technical reports that were reviewed for this publication, as shown in Figure 1 (*showing the*

distribution of Studies by Type in Tropical African River Health Research reviewed in this study).

Limited research has been conducted on tropical riverine ecosystems, particularly in tropical Africa, over the past two decades. This scarcity of information hinders the sustainable management of these fragile and critical ecosystems.

DISCUSSION

River assessment studies in tropical Africa exhibit significant regional differences. In the East African Community (EAC) region specifically, approximately 25% of studies incorporate community participation, with examples like Tanzania's Mara River Basin. Around 30% of these studies concentrate on restoration efforts, such as those in the Kilombero Valley. River order classifications are considered in only about 10% of the studies (Antidius Raphael, 2023; WWF Tanzania, 2024).

In the ECOWAS region, community engagement appears in approximately 20% of studies, with restoration strategies in around 25% of cases, and river order considerations in roughly 5% of studies, exemplified by assessments in the Ouémé River, Benin. (Delta, 2020; UNESCO World Heritage Centre, 2014).

Central Africa exhibits low integration in restoration initiatives, with only 15% of studies involving community participation, 20% focusing on restoration, and 5% using river order classifications. This is exemplified in forest and river restoration efforts in the Democratic Republic of Congo and Cameroon (Peroches et al., 2025). Key challenges hindering holistic river assessments and restoration include limited data, uneven community capacity, inconsistent institutional support, and a scarcity of expertise in river order frameworks.

In East Africa, practical initiatives in Tanzania and Kenya illustrate the partial integration of river-specific planning, community engagement, and

restoration strategies, although few studies or projects fully combine all three elements. In Tanzania, the Wami/Ruvu Livelihood Restoration and Rehabilitation Plan (LRRP) categorizes rivers by size: small, medium, and large to apply tailored riparian buffer widths, incorporates extensive community participation in planning and monitoring, and implements practical restoration measures such as riparian vegetation planting, riverbank stabilization, and livelihood restoration initiatives (Wami/Ruvu Basin Water Office, 2022). This is a very good example where future researchers should beach mark for a holistic river/stream ecosystem assessment, as this study incorporated all three aspects of river orders, community engagement, and restoration efforts in Tanzania. Similarly, in Kenya, mangrove and estuary restoration projects in Mida Creek and Malindi Sabaki actively engage local communities in replanting and management while integrating multi-reach river planning to address ecological variability across river sections (WWF Kenya, 2024). While these cases demonstrate the benefits of linking ecological design with social participation and restoration, the approaches often remain fragmented, with river order, community engagement, and restoration rarely addressed simultaneously in a systematic framework. This highlights a critical gap in tropical African river management: the need for holistic, integrated frameworks that combine geomorphological assessment, participatory governance, and on-the-ground restoration to sustain river ecosystem health and community resilience across catchments.

Achieng et al. (2021b) evaluated the ecological health of Afrotropical rivers in the Lake Victoria Basin (Mara, Nyando, Nzoia, Sondu Miriu catchments) in Kenya, using fish assemblages to assess pollution and water quality. The study found these rivers are significantly impacted by human activities, primarily agricultural farming and livestock grazing, leading to substantial pollution. While the research recommended stakeholder conservation efforts, it lacked community

involvement and did not explicitly consider river order in its sampling design or evaluate restoration strategies. Thus, the study identified gaps in integrating community engagement, hierarchical river assessments, and restoration actions in tropical African river health research.

Aura et al. (2021) demonstrate the importance of community-based methods for assessing and managing Afrotropical riverine ecosystems, introducing a Citizen-based Index of Ecological Integrity (CIEI). The research, conducted in the Lake Victoria Basin, compared rivers of varying ecological integrity, implicitly considering river order by contrasting smaller, healthier rivers with larger, degraded ones. The methodology emphasised community participation in monitoring and evaluation, incorporating local socioeconomic and cultural knowledge. The CIEI not only facilitates ecosystem evaluation but also informs restoration efforts by identifying degraded areas and providing a foundation for targeted conservation and rehabilitation, offering a holistic strategy for the assessment and sustainable management of tropical African rivers.

Tampo et al. (2021) investigated the utility of benthic macroinvertebrates as ecological indicators to assess the impact of water quality and human disturbances on the River Zio in Togo. Their findings indicated that intensive agricultural practices severely degraded water quality, leading to changes in macroinvertebrate communities and a decline in ecological integrity. The study offered key insights into the river's ecological condition and the sensitivity of aquatic organisms to human pressures. However, the research did not incorporate river order into its analysis, engage local communities in monitoring or management efforts, or evaluate restoration practices, focusing exclusively on diagnosing ecological degradation.

Masese et al. (2023) performed a bioassessment of stressors in Afrotropical rivers within the Mara River Basin. The study integrated river order, community engagement, and restoration

considerations into ecosystem health assessment by comparing rivers of varying ecological statuses. Local community insights augmented ecological data, and a macroinvertebrate-based Index of Biotic Integrity was used to identify degraded segments for targeted conservation. This integrated approach provides a framework for sustainable river management in tropical African contexts.

Kitaka et al. (2024) advocated for community-based collaboration in the biomonitoring of East African rivers, emphasising citizen science. This approach involves training volunteers to conduct biomonitoring and conservation efforts, sensitising communities to river protection, and recognising that residents possess crucial knowledge about pollution sources. By including community participation, which has often been excluded by researchers, this method aims to improve the understanding and health of river ecosystems and reduce pollution.

Kitaka et al.'s (2024) review of biomonitoring in East African rivers did not incorporate river orders into ecological health assessments and only briefly touched upon stream restoration. While the authors acknowledged the significance of aquatic ecosystem integrity and community-based restoration in Tanzania, they did not thoroughly analyse restoration measures. This omission is important because successful river health management necessitates understanding longitudinal variations and implementing restoration techniques such as riparian re-vegetation, bank stabilisation, and habitat enhancement. Without these elements, biomonitoring may identify problems but not offer recovery solutions. Subsequent research should integrate stream order and restoration strategies with biomonitoring to enhance comprehensive river health management in tropical Africa.

The study by Nkurunungi et al. (2024) on the River Rwizi in Western Uganda integrated community engagement, restoration considerations, and river order analysis for a comprehensive river ecosystem

assessment. Using a Citizen Science-BioBlitz, the research involved local communities in macroinvertebrate collection and identification, promoting environmental awareness. Anthropogenic impacts on river biodiversity were evaluated to inform restoration and management. The study also segmented the river by habitat and pollution gradients to assess macroinvertebrate diversity across different ecological contexts. This approach provided valuable baseline data and demonstrated the benefits of integrating these aspects for holistic river management in tropical African regions.

The study by Turyahabwe et al. (2023) examined river discharge in relation to lotic ecosystem health, but did not specify the river order number. While it linked discharge to the magnitude of effects, it did not propose restoration techniques. The study also assessed human activities affecting the Sironko catchment using bioindicators to determine pollution levels, but overlooked community involvement. Engaging riparian zone residents could reveal pollution sources and provide conservation insights, while community members might offer superior ideas for pollution control and ecosystem health improvement. Furthermore, the study neglected the crucial aspect of restoring the degraded river to prevent further ecological damage and resource conflicts.

Much as (Turyahabwe et al., 2023) identified different stressors that's (animal grazing, rice growing and sugarcane growing) affecting the water quality and fish assemblages in Odoponyi seasonal stream in Tororo Uganda, this study only recommended that since fish migration is as a result of anthropogenic disturbance, NEMA should take action of enforcing the policy of *keep 30m off the river bank*, this works but establishing restoration attempts of the fish habitat would have not only been a good strategy but also establishing them in the stream would have been a good move other than only reporting about the effect. The study totally did not involve the community to participate in this

study and yet these are the very people carrying out those different activities along this stream and given opportunity that these people are involved in such studies, they would play a key role in doing community conservation of these streams because then after finding out the problem and you don't address the problem to the causer that means the problem will escalate along the stream and lastly this study did not involve river orders in their sampling efforts yet considering river orders plays a very crucial role in river assessment that's one is able to know the variation in physical and chemical characteristics across orders, differences in biodiversity and community composition influence on contaminant transport and ecosystem processing therefore ignoring river orders can lead to inaccurate evaluations, misguided restoration efforts, or overlooked vulnerabilities in the system, this study did not seal the gap of river orders in their research.

A study by Turyahabwe et al. (2022) examined the impact of in-stream ecosystem restoration techniques on fish ecology in the River Nabongo, Eastern Uganda. It found that interventions such as woody debris, boulders, and artificial shelters improved habitat complexity, leading to increased fish abundance, richness, and ecological balance. These methods created refuge areas, stabilised flow, and supported critical breeding habitats, aiding in the recovery of fish communities. The research focused on ecological aspects of restoration but did not incorporate river order as a determinant or include community engagement in its processes.

Turyahabwe et al. (2020) reviewed challenges in assessing stream ecosystem health and land use interactions in East and Southern Africa. The study identified gaps, emphasising the importance of factoring river orders into cumulative anthropogenic impact assessments, as impacts are more pronounced on lower-order rivers. Researchers recommend using river order alongside discharge/width during sampling for comprehensive health assessments, enabling

accurate pollution magnitude identification and informing policy. However, the review omitted the significance of community involvement in restoration, which enhances data collection accuracy and fosters sustainable conservation through ownership. Future studies should incorporate community engagement and restoration efforts for a holistic river health assessment.

A study by Turyahabwe et al. (2021) on macroinvertebrate responses to in-stream ecosystem restoration using woody debris in a tropical stream in Eastern Uganda found that all restoration structures had more macroinvertebrates than control and pre-treatment sites. Taxon richness was highest in complex woody debris plots, significantly exceeding other sampling plots. The relative abundance of macroinvertebrate taxa was also significantly higher in complex and simple woody debris structures compared to other plots at the pool site. The study recommends incorporating restoration efforts into ecosystem health studies to enhance conservation. However, the study's scope was limited by the absence of community engagement and consideration of restoration performance across different river orders, positioning it as incomplete for comprehensive catchment management.

Lukhabi et al. (2024) studied benthic macroinvertebrates as water quality indicators in Ghana's Ankobra, Kakum, and Volta estuaries. The research revealed spatial variations in ecological conditions, with pollution-tolerant species found in the Kakum Estuary and pollution-sensitive species in the Volta Estuary. Environmental factors such as dissolved oxygen, salinity, temperature, and nutrient levels influenced species distribution, reflecting different pollution levels. The study noted a lack of community involvement and restoration strategies, indicating a need to combine ecological monitoring with community engagement and pollution mitigation planning.

Ochieng et al. (2021) contributed to river ecosystem assessment in Uganda by studying benthic

macroinvertebrate diversity in the anthropogenically disturbed Aturukuku River. The study's strength lies in its use of stream order classification, identifying the river as a first and second-order stream, aligning its ecological findings with global stream ecology approaches, and enhancing the rigour of its bioassessment. Despite this scientific strength, the research did not include riparian community perspectives, which could have offered insights into local disturbance drivers and promoted stewardship. Additionally, while identifying anthropogenic impacts, the study did not propose or evaluate restoration strategies to address these pressures. Consequently, while scientifically robust in its assessment and use of river order, the study's practical applicability for holistic river health management in tropical Africa is limited by its absence of community engagement and restoration focus.

The study "Connecting the Riparian Communities Around Rapid Bio-assessment of Pollution in the Osia Stream in Tororo, Eastern Uganda" by Ochieng et al. (2023) highlights community involvement in river health assessment and its role in guiding pollution reduction and riparian land management efforts. While the research effectively integrates local knowledge with scientific monitoring and restoration planning, it did not explicitly use river order as an ecological framework for its sampling or interpretations, indicating a limited integration of geomorphological scaling with community-based river health assessments in Uganda.

Patrick (2015) is commended for their study of Kinshasa's Funa Stream, which successfully integrated community engagement, restoration strategies, and river order considerations. The research involved local communities in benthic macroinvertebrate sampling, promoting participatory monitoring and environmental awareness. Restoration recommendations focused on habitat rehabilitation and pollution mitigation to improve ecological integrity. The study also

considered spatial variations in macroinvertebrate communities, implicitly applying river order concepts to analyse ecological changes from upstream to downstream. This holistic approach serves as a model for urban river management in tropical Africa, highlighting the benefits of combining community participation, restoration planning, and ecological structuring.

Omoigberale et al. (2020) investigated the Ethiope River in Nigeria, a third-order river, integrating river order, ecological assessment, and community engagement to inform restoration strategies. By analysing spatial variations in physicochemical parameters and microbenthic invertebrate communities, the study revealed critical areas impacted by organic contamination and identified priority sites for intervention. Research indicates that integrating scientific assessment with community participation enhances the effectiveness and sustainability of river restoration efforts. A holistic approach to tropical African river ecosystem management emphasises the combined roles of ecological monitoring, river network structure, and stakeholder engagement in promoting long-term conservation and resilience.

The study by Arimoro et al. (2025) investigated the effects of unplanned urban settlements on benthic macroinvertebrate communities in the Wuye River, Abuja. The research highlighted the ecological impact of urban pollution but lacked critical components for comprehensive river management in tropical Africa. These omissions include engagement with local riparian communities through participatory surveys or citizen science, the absence of restoration strategies such as riparian planting or pollution mitigation, and the failure to consider river order as an ecological framework, with results organised only by sampling sites. Future studies should incorporate community engagement, restoration measures, and river order to achieve a more complete assessment and management of river ecosystems in tropical African urban areas.

The study of the Etim Ekpo River in the Niger Delta by George & Effiong Jonah (2020) established crucial baseline data on water quality and benthic macroinvertebrate communities, revealing the effects of human activities on the river's ecological condition. By combining physicochemical analysis with biological markers, the research underscored the utility of macroinvertebrates for ecological monitoring and demonstrated how pollution impacts aquatic biodiversity. The study lacked riparian community input, potential restoration measures, and a river order framework, which would have provided a more comprehensive understanding and broader applicability of the findings.

A study by Effiong Jonah et al. (2024) on Eniong Creek in Akwa Ibom State, Nigeria, provided an ecological assessment of water quality and benthic macroinvertebrates, establishing baseline data on the creek's health. While the research utilised physicochemical parameters and macroinvertebrate diversity to evaluate the creek's ecological status and anthropogenic impacts, it lacked riparian community perspectives, restoration strategies, and river order classification. Despite these limitations, the study exhibits strong technical rigour, mirroring common issues in Nigerian river health assessments by not integrating community engagement, restoration plans, or geomorphological context.

A study by Jonah et al. (2024) generated crucial baseline data on aquatic invertebrates to support monitoring and highlight pollution impacts, particularly as such inventories are scarce in Central African freshwater systems. However, the research omitted riparian community engagement, potentially enriching the analysis with local knowledge and conservation ownership, and did not test or recommend restoration strategies. Furthermore, the analysis was not contextualised within a river order classification, which could have improved its geomorphological understanding and comparability with other catchments.

Zemo et al. (2024) analysed the distribution of benthic macroinvertebrates in rivers near Yaoundé to assess water quality and pollution. The study provided baseline data on macroinvertebrate assemblages but did not integrate community involvement through participatory surveys or co-management, nor did it propose or implement restoration strategies like riparian planting or pollution mitigation. Furthermore, the research did not utilise river order as an ecological framework, organising findings solely by sampling sites and pollution levels. Consequently, while contributing to macroinvertebrate distribution knowledge, the study omitted crucial elements for comprehensive river management: community engagement, restoration actions, and river order principles.

Abahi et al.'s (2020) study on the Upper Ouémé River's water quality, utilising biotic indices from benthic macroinvertebrates, is noted for its ecological insights but lacks comprehensive river ecosystem management components. The research did not include community engagement strategies, such as participatory surveys or co-management, nor did it propose restoration practices like riparian planting or pollution mitigation. Furthermore, it overlooked river order as an ecological framework, organising data solely by sampling sites and pollution levels. Integrating these elements would lead to a more holistic approach to managing the river ecosystem.

Doe (2023) investigated integrating indigenous ecological knowledge into mangrove restoration in Ghana's Volta River Estuary, prioritising active community engagement and environmental stewardship via awareness programs. The project focused on sustainable reforestation and coastal area revitalisation using traditional practices. Although successful in combining community participation and restoration, it did not explicitly include river order considerations in its ecological framework. The findings suggest that combining indigenous knowledge with local community involvement can improve the effectiveness and sustainability of

restoration efforts in tropical African riverine and estuarine systems.

A Rocha Ghana's (2015) report details a community-based mangrove restoration project at the Muni-Pomadze Ramsar Site. This initiative integrated community engagement and restoration strategies, with local members actively participating in planting, monitoring, and establishing bylaws for resource management. The project also connected mangrove recovery with livelihood improvements for riparian communities, showcasing a model where grassroots participation and ecological rehabilitation can restore degraded ecosystems and enhance resilience through community stewardship.

Elias et al. (2014) explored how habitat restoration and pollution control in Tanzanian rivers can aid sensitive macroinvertebrate recovery and enhance river health, though it did not detail river orders or involve local communities. (Elias, 2021) later advanced this by showing that longitudinally stratified restoration and biomonitoring in the Pangani and Wami-Ruvu basins effectively manage spatiotemporal variations. Both studies underscore the value of integrating restoration into river health research and identify the need for future work to include community engagement and river order considerations for sustainable management and ecosystem resilience.

In Kenya, the Macroinvertebrate Index of Biotic Integrity (M-IBI) was developed for the river Nyando to monitor ecosystem health, indirectly accounting for river order but lacking community participation and restoration measures (Raburu et al., 2009). In Uganda, riparian communities were involved in rapid bio-assessment of Osia Stream, linking findings to remedial actions but without explicit river order consideration. Tanzania's Wami/Ruvu Livelihood Restoration and Rehabilitation Plan (LRRP) offers a more integrated approach, categorising rivers by size, involving community consultations, and implementing restoration strategies like vegetation planting and erosion control. While these cases show progress in

ecological and social integration, a comprehensive framework combining river order, community engagement, and restoration remains a significant gap.

Abebe et al. (2021) examined the ecological status of the Gumara River basin in Ethiopia by integrating river orders to understand spatial ecological variations and inform conservation. While the study guided restoration, it lacked community engagement, a key aspect for sustainable river management. This highlights a gap in integrating community involvement with ecological assessments in tropical African river research, despite the importance of headwater streams and multi-order sampling for ecosystem health, as demonstrated in the Lake Victoria Basin (Achieng et al., 2021b).

Kasangaki (2007) assessed the impacts of logging, agricultural encroachment, and illegal fishing on stream fish assemblages in Bwindi Impenetrable National Park, Uganda, highlighting how anthropogenic stressors alter species diversity and community structure across streams of varying disturbance levels, with implications for restoration priorities. While community engagement was not central to Kasangaki's study, subsequent work emphasised its importance for sustainable conservation (Kasangaki et al., 2012). Extending this integrated approach to West Africa, (Omoigberale et al., 2020) explicitly incorporated river order, ecological monitoring, and community involvement in the Ethiopie River, Nigeria, to guide restoration interventions. Collectively, these studies underscore the value of combining ecological monitoring, longitudinal river analysis, and stakeholder participation to enhance the resilience and sustainability of tropical African river ecosystems (Kasangaki, 2012; Kasangaki, 2007; Omoigberale et al., 2020).

A study by Kasangaki et al. (2008) on Ugandan rainforest streams found that deforested sites exhibited poorer water quality than forested sites, characterised by higher turbidity, dissolved solids,

and conductivity, and lower water transparency. These water quality differences correlated with distinct benthic macroinvertebrate community compositions, with sensitive taxa present in forested areas and tolerant taxa in deforested/agricultural areas. The study highlighted the problem without proposing ecosystem restoration solutions.

At a broader scale, Mureithi et al. (2025), in a review of bioassessment approaches across East African rivers, significant methodological gaps were highlighted, including the absence of systematic frameworks that incorporate river order in evaluating ecosystem health. The lack of such consideration risks masking critical ecological variations between headwater streams and downstream sections, potentially leading to incomplete assessments of stressor impacts. Consequently, conservation strategies derived from such studies may be less effective, as they fail to recognise the disproportionate ecological significance of headwaters or the cumulative pressures often observed in larger downstream sections.

The book "Ecosystem Restoration through Managing Socio-Ecological Production Landscapes and Seascapes (SEPLS)" by Maiko et al. (2023) emphasises community engagement and restoration practices for ecosystem health, citing examples of local participation in Ghana's Songor Wetland and Kenya's Chyulu Hills. The work details restoration methods like bioengineering and native planting. However, it does not explicitly incorporate river order, a critical element for assessing river ecosystem structure and function. The text suggests that integrating river classification frameworks, such as SAFRASS, with community-based restoration could enhance the management of tropical African rivers.

Obubu's (2010) Master's thesis, conducted under UNESCO-IPGL, advanced the assessment of river health in Uganda by exploring bio-assessment and monitoring techniques using macro-benthic invertebrates as ecological indicators. The research

highlighted the efficacy of benthic macroinvertebrates for reliable river water quality insights, especially where traditional chemical monitoring is prohibitive. The study developed a context-specific framework for Ugandan rivers, underscoring the importance of tailored biomonitoring for sustainable regional river management. However, the work did not include community involvement or specifically utilise river order as a spatial organising concept, potentially limiting the recording of longitudinal biological variation crucial for conservation and restoration.

Of the 34 reviewed studies, only 7 (20.6%) fully integrated community engagement, restoration strategies, and river order. Another 7 (20.6%) included two aspects, typically community participation and restoration, but seldom linked them to river order. Four studies (11.8%) addressed a single aspect, usually restoration or river order, without community input. Notably, 16 studies (47.0%) excluded all three aspects as shown in Figure 2, relying solely on technical ecological assessments, suggesting that river order is the least considered element in tropical African river health studies, despite increasing integration of community roles and restoration actions.

Figure 1: Distribution of Studies by Type in Tropical African River Health Research Reviewed in this Study

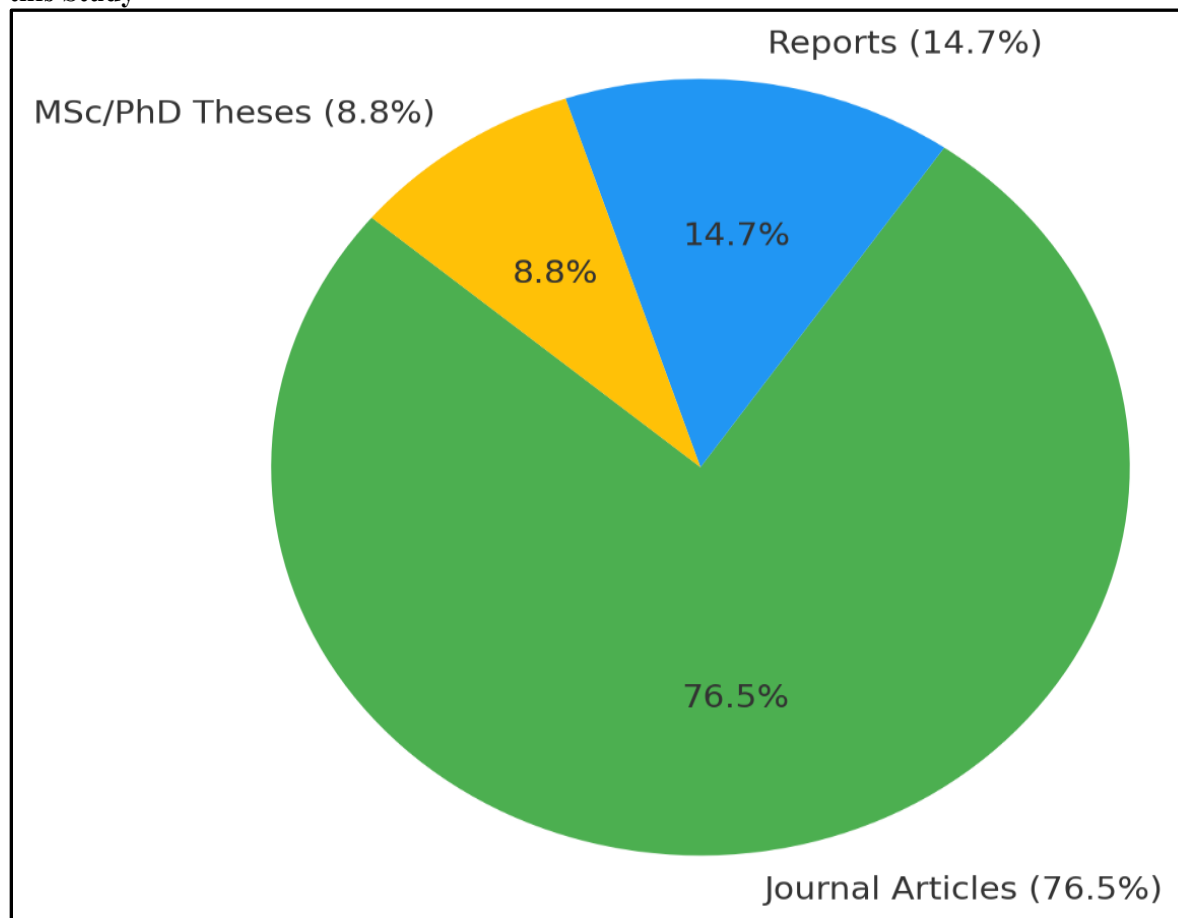
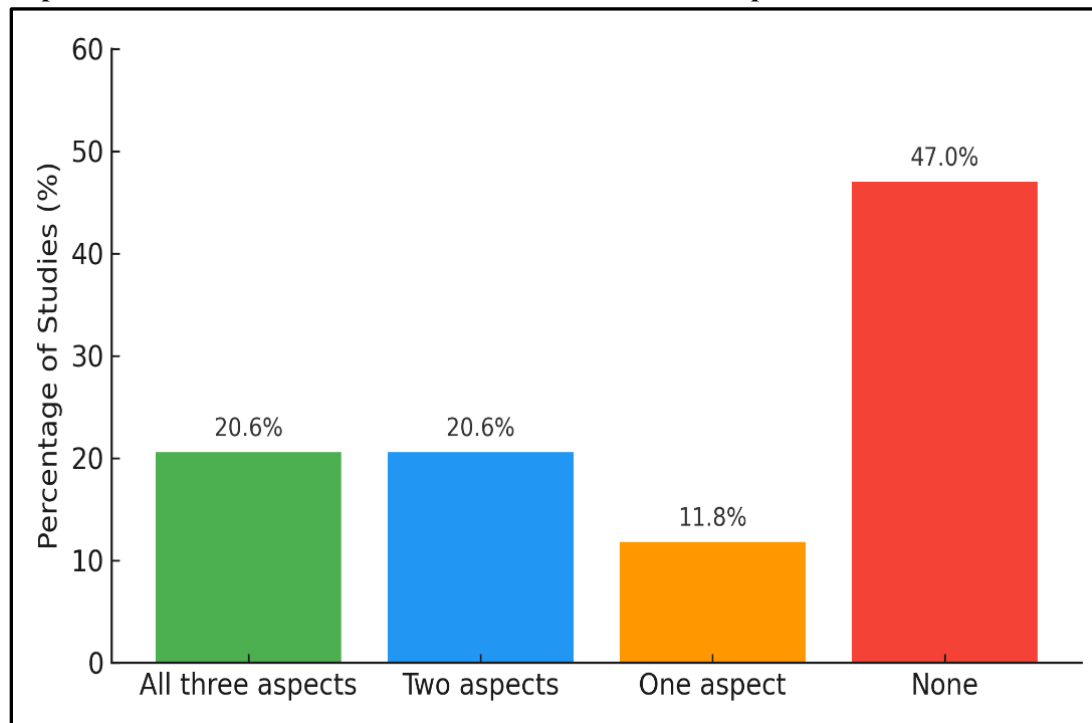


Figure 2: Extent to Which Studies Address Community Engagement, Restoration, and River Order Aspects in River/Stream Assessment as Reviewed in this Paper

CONCLUSIONS

The review paper draws several conclusions that simultaneously serve as recommendations, which are as follows: This review highlights several key gaps in current research on stream ecosystem health and land use interactions in tropical African regions.

- In this paper, we managed to review 34 studies and only 7 studies (20.6%) successfully integrated all three critical aspects of river ecosystem health: community engagement, restoration strategies, and river order consideration. Another 7 studies (20.6%) incorporated two of the aspects, most commonly combining community participation with restoration, though rarely linking them to river order frameworks. A smaller proportion, 4 studies (11.8%), addressed only one aspect, usually focusing on restoration alone or on river order without community involvement. Notably, nearly half of the works, 16 studies (47.0%), did not include any of the three aspects, relying mainly on technical ecological assessments. These findings suggest that while commendable progress has been made in strengthening community roles and implementing restoration actions, the consideration of river order remains the least integrated element in river health studies across tropical Africa.
- Firstly, many studies have neglected to involve riparian communities in assessing river ecosystem health, hence missing valuable local knowledge and opportunities for community-based conservation efforts.
- Secondly, there is a lack of focus on restoration practices in river ecosystem assessments, with many researchers identifying problems but not implementing or proposing restoration measures.
- Lastly, sampling strategies often fail to consider different river orders, limiting the comprehensive understanding of stressor impacts across the river continuum.

Recommendations

- Future research on river health in tropical Africa should prioritise community engagement in assessments, integrate restoration planning into study designs, and employ sampling strategies that consider different river orders. These methods will foster a comprehensive understanding of ecosystem health, enhance conservation effectiveness, and support sustainable management.
- Integrating specific research elements can improve the relevance and impact of academic works, thereby better informing policymakers and contributing to the long-term preservation of river ecosystems in the region. This approach, which embraces more comprehensive and inclusive research methodologies, is vital for confronting the multifaceted challenges confronting tropical African rivers due to escalating anthropogenic pressures and climate change.

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REFERENCES

- A. Kasangaki, R. B. P. S. M. R. and A. M. (2012). *The ecological impact of long-term changes in Africa's Rift Valley*. Nova Science Publishers.
- A Rocha Ghana. (2015). *Community Mangrove Restoration Project, Muni Pomadze Ramsar Site*.
- Abahi, K. S., Gouissi, M. F., Akodogbo, H. H., Sanni Worogo, S. H., Adje, A. S. D. D., & Gnossou, P. M. (2020). Assessment of the water quality of the upper reaches of the ouémé river in Benin using benthic macroinvertebrate-based biotic indices. *Revue Des Sciences de l'Eau*, 32(4), 433–444. <https://doi.org/10.7202/1069576ar>
- Abebe, W. B., Tilahun, S. A., Moges, M. M., Wondie, A., Dersseh, M. G., Assefa, W. W., Mhired, D. A., Adem, A. A., Zimale, F. A., Abera, W., Steenhuis, T. S., & McClain, M. E. (2021). Ecological status as the basis for the holistic environmental flow assessment of a tropical highland river in Ethiopia. *Water (Switzerland)*, 13(14). <https://doi.org/10.3390/w13141913>
- Achieng, A. O., Masese, F. O., Coffey, T. J., Raburu, P. O., Agembe, S. W., Febria, C. M., & Kaunda-Arara, B. (2021a). Assessment of the Ecological Health of Afrotropical Rivers Using Fish Assemblages: A Case Study of Selected Rivers in the Lake Victoria Basin, Kenya. *Frontiers in Water*, 2. <https://doi.org/10.3389/frwa.2020.620704>
- Achieng, A. O., Masese, F. O., Coffey, T. J., Raburu, P. O., Agembe, S. W., Febria, C. M., & Kaunda-Arara, B. (2021b). Assessment of the Ecological Health of Afrotropical Rivers Using Fish Assemblages: A Case Study of Selected Rivers in the Lake Victoria Basin, Kenya. *Frontiers in Water*, 2. <https://doi.org/10.3389/frwa.2020.620704>
- Acosta, A. L., d'Albertas, F., de Souza Leite, M., Saraiva, A. M., & Walter Metzger, J. P. (2018). Gaps and limitations in the use of restoration scenarios: a review. In *Restoration Ecology* (Vol. 26, Issue 6, pp. 1108–1119). Blackwell Publishing Inc. <https://doi.org/10.1111/rec.12882>
- Antidius Raphael. (2023). *Meet AWF's ecohydrologist working to restore Tanzania's ecosystems*.
- Arimoro, F. O., James, J., Ikayaja, E. O., Assie, F. A. G. J., Edegbene, A. O., & Keke, U. N. (2025). Dissecting the urban footprint of unplanned settlements shaping

- macroinvertebrate communities in Wuye River, Abuja, Nigeria. *Scientific Reports*, 15(1). <https://doi.org/10.1038/s41598-025-00552-y>
- Aura, C. M., Nyamweya, C. S., Owiti, H., Odoli, C., Musa, S., Njiru, J. M., Nyakeya, K., & Masese, F. O. (2021). Citizen Science for Bio-indication: Development of a Community-Based Index of Ecosystem Integrity for Assessing the Status of Afrotropical Riverine Ecosystems. *Frontiers in Water*, 2. <https://doi.org/10.3389/frwa.2020.609215>
- Delta, O. (2020). *Community Management of Protected Areas for Conservation Site Strategy Engaging Local Communities In Conservation And Management Of World Heritage Sites In Africa Planning Framework For The Implementation Of The Community Management Of Protected Areas For Conservation (COMPACT) Replication Project At The Panhandle Of The Okavango Delta World Heritage Site, Botswana*.
- Effiong Jonah, U., Kokoete Esenowo, I., & Enin, U. (2024). Water Quality And Macroinvertebrates Assessment Of Eniong Creek, Akwa Ibom State, Niger Delta, Nigeria. In *Article in Journal of Bioresource Management*. <https://corescholar.libraries.wright.edu/jbm>
- Elias, J. D. (2021). Simple and Cost-Effective Biomonitoring Method for Assessing Pollution in Tropical African Rivers. *Open Journal of Ecology*, 11(04), 407–436. <https://doi.org/10.4236/oje.2021.114027>
- Elias, J. D., Ijumba, J. N., Mgya, Y. D., & Mamboya, F. A. (2014). Study on Freshwater Macroinvertebrates of Some Tanzanian Rivers as a Basis for Developing Biomonitoring Index for Assessing Pollution in Tropical African Regions. *Journal of Ecosystems*, 2014, 1–8. <https://doi.org/10.1155/2014/985389>
- George, U., & Effiong Jonah, U. (2020). *Assessment of Water Quality and Benthic Macroinvertebrates Assemblage of Etim Ekpo River, Niger Delta, Nigeria*. <https://doi.org/10.7537/marswro120120.03>
- Kaaya, L. T. (2015). Towards a classification of Tanzanian rivers: a bioassessment and ecological management tool. A case study of the Pangani, Rufiji and Wami–Ruvu river basins. *African Journal of Aquatic Science*, 40(1), 37–45. <https://doi.org/10.2989/16085914.2015.1008970>
- Kasangaki, A. (2007). Effects of anthropogenic disturbance on stream fish assemblages of Bwindi Impenetrable National Park, southwestern Uganda [Unpublished doctoral dissertation]. *Mbarara University of Science and Technology, Mbarara, Uganda*.
- Kasangaki, A., Chapman, L. J., & Balirwa, J. (2008). Land use and the ecology of benthic macroinvertebrate assemblages of high-altitude rainforest streams in Uganda. *Freshwater Biology*, 53(4), 681–697. <https://doi.org/10.1111/j.1365-2427.2007.01925.x>
- Kitaka, N., Omondi, L. A., Mureithi, P. W., Bauer, A., Melcher, A., & Ssanyu, G. A. (2024). A critical review of biomonitoring in East African rivers: fostering community-based collaboration for environmental change observation. In *Frontiers in Water* (Vol. 6). Frontiers Media SA. <https://doi.org/10.3389/frwa.2024.1360941>
- Lukhabi, D. K., Mensah, P. K., Asare, N. K., Akwetey, M. F. A., & Faseyi, C. A. (2024). Benthic macroinvertebrates as indicators of water quality: A case study of estuarine ecosystems along the coast of Ghana. *Heliyon*, 10(7). <https://doi.org/10.1016/j.heliyon.2024.e28018>
- Maiko Nishi and Suneetha M. Subramanian. (2023). *Ecosystem Restoration through Managing Socio-Ecological Production Landscapes and Seascapes (SEPLS)* (Nishi, Maiko,

- Subramanian, & Suneetha M., Eds.). Springer Nature Singapore.
- Masese, F. O., Wanderi, E. W., Nyakeya, K., Achieng, A. O., Fouchy, K., & McClain, M. E. (2023). Bioassessment of multiple stressors in Afrotropical rivers: Evaluating the performance of a macroinvertebrate-based index of biotic integrity, diversity, and regional biotic indices. *Frontiers in Environmental Science*, 11. <https://doi.org/10.3389/fenvs.2023.1015623>
- Mureithi, P. W., Aine, A., Basooma, R., Namumbya, J., Nansumbi, F., Yegon, M. J., Meimberg, H., & Graf, W. (2025). Advancements in macroinvertebrate-based river bioassessment research in the Afrotropical region: review and steps towards a regional framework. In *Environmental Monitoring and Assessment* (Vol. 197, Issue 8). Springer Science and Business Media Deutschland GmbH. <https://doi.org/10.1007/s10661-025-14272-3>
- Murphy, B. M., Russell, K. L., Stillwell, C. C., Hawley, R., Scoggins, M., Hopkins, K. G., Burns, M. J., Taniguchi-Quan, K. T., Macneale, K. H., & Smith, R. F. (2022). Closing the gap on wicked urban stream restoration problems: A framework to integrate science and community values. *Freshwater Science*, 41(3), 521–531. <https://doi.org/10.1086/721134>
- Nkurunungi, J. B., Muhairwe, G., Nuwagira, U., Araka, N., Mugabe, N., Natwijuka, O., & Atwebembeire, J. (2024). Diversity of Macro Invertebrates of the River Rwizi in Western Uganda: A Citizen Science-BioBlitz Approach. *Open Journal of Ecology*, 14(04), 343–365. <https://doi.org/10.4236/oje.2024.144021>
- Obubu, J. P. (2010). Identifying applicable bio-assessment and monitoring methods for sustainable management of Ugandan river quality using macro-benthic invertebrates as indicators (Unpublished M.Sc. thesis). UNESCO–IPGL, The Netherlands.
- Ochieng, H., Egor, M., Gudoyi, P., & Olowo, M. (2023). *Connecting the riparian communities around rapid bio-assessment of pollution in the Osia Stream in Tororo, Eastern Uganda. A Report*. <https://ochienghannington.busitema.ac.ug/index.php>
- Ochieng, H., Gandhi, W. P., Magezi, G., & Okot-okumu, J. (2021). *Diversity of benthic macroinvertebrates in anthropogenically disturbed Aturukuku River, Eastern Uganda. March*. <https://doi.org/10.1080/15627020.2021.1885309>
- Okoth Raburu, P., Okeyo-Owuor, J. B., & Masese, F. O. (2009). Macroinvertebrate-based Index of Biotic Integrity (M-IBI) for monitoring the Nyando River, Lake Victoria Basin, Kenya. *Scientific Research and Essay*, 4(12), 1468–1477. <http://www.academicjournals.org/SRE>
- Omoigberale, M. O., Ezenwa, I. M., Biose, E., & Otoberise, O. (2020). *Spatial Variations in the Physico-chemical Variables and Macroinvertebrate Assemblage of a Tropical River in*.
- Patrick, M. (2015). Benthic macroinvertebrates as indicators of water quality: a case-study of urban Funa Stream (in Kinshasa, Democratic Republic of Congo). *Open Journal of Water Pollution and Treatment*, 2015(1), 8–24. <https://doi.org/10.15764/WPT.2015.01002>
- Peroches, A., Dubiez, E., Fayolle, A., Koutika, L. S., Mapenzi, N., Vermeulen, C., Oswald, M., & Lescuyer, G. (2025). From Tree Fellers to Planters: A Systematic Review of Forest Restoration Initiatives Involving Local Populations in Central Africa. In *Small-scale Forestry* (Vol. 24, Issues 1–2, pp. 1–34). Springer Science and Business Media B.V. <https://doi.org/10.1007/s11842-025-09586-6>

- Remigio Turyahabwe, C. M. and W. A. S. (2020). *Challenges Associated with Incomplete Assessment of Stream Ecosystem Health and Land Use Interaction Studies in East and Southern Africa – A Review*.
- Shibabaw, T., Beyene, A., Awoke, A., Tirfie, M., Azage, M., & Triest, L. (2021). Diatom community structure in relation to environmental factors in human influenced rivers and streams in tropical Africa. *PLoS ONE*, 16(2 February 2021). <https://doi.org/10.1371/journal.pone.0246043>
- Sylvanus S.P. Doe. (2023). *Promoting indigenous knowledge for sustainable mangrove restoration in Ghana's Volta River estuary*.
- Tampo, L., Kaboré, I., Alhassan, E. H., Ouéda, A., Bawa, L. M., & Djaneye-Boundjou, G. (2021). Benthic Macroinvertebrates as Ecological Indicators: Their Sensitivity to the Water Quality and Human Disturbances in a Tropical River. *Frontiers in Water*, 3. <https://doi.org/10.3389/frwa.2021.662765>
- Temgoua Zemo, M. A., Foto Menbohan, S., Atchrimi, B. T., Assou, D., Biram à Ngon, B. E., Betsi, N. C. W., Gwos Nhiomock, S., Harissou, Lactio, N. L., Far Ndurwe, B., Nwaha, M., Mbia, D. l'or N., Tchouapi, L. Y., Tchouta, G. U., Mboye, B. R., & Dzavi, J. (2024). Distribution Profile of Benthic Macroinvertebrates in Some Rivers of Yaoundé City and Its Surroundings Using Self Organizing Map and Indicator value methods. *Diversity*, 16(7). <https://doi.org/10.3390/d16070385>
- Turyahabwe, R., Asaba, J., Mulabbi, A., Wamono, E., & Gudoyi, P. M. (2022). Environmental and Socio-Economic Impact Assessment of Solid Waste Management Practices in Mbale City, Uganda. *Ghana Journal of Geography*, 14(3), 55–89. <https://doi.org/10.4314/gjg.v14i3.3>
- Turyahabwe, R., Mulabbi, A., Asaba, J., & Olowo, M. (2021). Ecological Responses of Macroinvertebrates to an In-Stream Ecosystem Restoration Technique in a Tropical Stream in Eastern Uganda. *East African Journal of Environment and Natural Resources*, 3(1), 129–144. <https://doi.org/10.37284/eajenr.3.1.398>
- Turyahabwe, R., Nabalegwa, M. W., Asaba, J., & Mulabbi, A. (2022). Influence of In-stream Ecosystem Restoration Techniques on the Fish Ecology of the River Nabongo in Eastern Uganda. *Jurnal Perikanan Universitas Gadjah Mada*, 24(2), 173. <https://doi.org/10.22146/jfs.73889>
- Turyahabwe, R., Turyabanawe, G. L., Andama, E., Othieno, T., & Wamono, E. (2023). Spatio-Temporal Variations in Water Quality and Fish Assemblages in Odoponyi Seasonal Stream as a response to disturbance from Selected Agricultural Landscapes in Tororo, Uganda. *Journal of Applied Sciences and Environmental Management*, 27(9), 1895–1902. <https://doi.org/10.4314/jasem.v27i9.2>
- UNESCO World Heritage Centre. (2014). *Engaging local communities in the conservation of the Okavango Delta World Heritage site*.
- Wami/Ruvu Basin Water Office. (2022). *United Republic Of Tanzania Ministry Of Water Wami/Ruvu Basin Water Board Water Sector Support Project Phase Ii In The Wami/Ruvu Basin Livelihood Restoration And Rehabilitation Plan For Ruvu, Mvuha And Mgeta Rivers Wami/Ruvu Safeguard Unit January 2022*.
- WWF Kenya. (2024). *restoration-plan-for-mida-creek-2024-2029*.
- WWF Tanzania. (2024). *Community-led river health assessment in action in Mara*.