Tanzanian Journal of Population Studies and Development, Vol. 31 No. 1, 2024: 41-64

Managing Transboundary Water Resources At the Edge of Human Interface: The Case of Kagera River Basin, Tanzania

Estella Mgala,[*] Joel Nobert[§] & Edmund B. Mabhuye[‡]

Abstract

Globally, water concerns stemming from human factors are evident, and the Kagera River Basin exemplifies this challenge. This study investigated the influence of human elements on transboundary water resource management in the Kagera River Basin. Utilizing focus group discussions, household surveys, key informant interviews, and field observations, the study analysed land use changes via remote sensing; and processed quantitative data using SPSS 20 and ArcGIS 10.4. Results highlighted economic, political, and social factors as key factors influencing transboundary water resource management. The institutional analysis identified major players to include the Ministry of Water, Lake Victoria Basin Water Board, NELSAP, Ministry of Agriculture, village governments, and CONCERN/OXFAM. Non-climatic factors such as water infrastructure management, socio-economic factors, conflicting water uses, agricultural practices causing soil erosion, and land use/cover changes were identified as central to transboundary water resource challenges. Agricultural expansion and land use shifts in the basin in 1986, 2000 and 2021 were pinpointed as contributors to water resource challenges that impacted availability, access, and quality. Anthropogenic-driven land use changes emerged as significant contributors to pollution, habitat loss, and alterations in water quality. While human factors substantially influence water resources, their impact is exacerbated by anthropogenic activities. Thus, fostering collaborative planning and stewardship initiatives at the local level is crucial for sustaining transboundary water resources. This involves engaging community members and leaders in developing resilience plans and initiating international cooperation, and innovative participatory approaches for effective transboundary water resources management.

Keywords: *Kagera River Basin, transboundary water, water resource management, human factors*

1. Introduction

The global landscape is witnessing a complex interplay of factors that are intensifying water-related challenges in numerous countries. The confluence of anthropogenic activities, population growth, and urbanization has ushered in a new era of water problems, amplifying the difficulties in effectively managing transboundary water resources. Cooley and Gleick (2011) highlight the profound impacts of climate change, deeming them critical challenges for the

[*]PhD Student, Institute of Resource Assessment, University of Dar es Salaam, and Corresponding Author. Email: mgallaestella@gmail.com
[§]Institute of Resource Assessment, University of Dar es Salaam.
[‡]Institute of Resource Assessment, University of Dar es Salaam.

 ▪ *https://doi.org/10.56279/tjpsd.v31i1.251*

management of transboundary water resources due to the escalating scarcity and competition over water usage (Froese & Schilling, 2019). The resulting strain on freshwater resources globally, as articulated by Guo et al. (2016), has the potential to incite tension and fierce competition among nations.

Managing transboundary water resources is inherently one of the most challenging aspects of interstate relations (Baranyai, 2019). The complexity is further compounded by the increasing demand for water, and the far-reaching consequences of human anthropogenic activities (Baten & Titumir, 2016). Water scarcity—a direct consequence of these challenges—has sparked conflicts between nations and within countries among local government institutions and various user groups (Guo et al., 2016). Riparian state relationships bring an additional layer of complexity, marked by differences in capacity, institutional frameworks, perceptions, and governance systems (Al-Faraj & Tigkas, 2016).

The focus of this discourse shifts to the Kagera River Basin (KRB), a significant transboundary water resource spanning Burundi, Rwanda, Tanzania, and Uganda. Covering an expansive 59,800km^2, the KRB plays a pivotal role as the primary contributor to Lake Victoria and the remote headwater of the White Nile (Tolo et al., 2012). With approximately 14m inhabitants, constituting nearly 40% of the population in the Lake Victoria Basin, the KRB is a critical lifeline for East African ecosystems and a source of the Nile River, holding strategic importance for Northern African countries (Hagai, 2019). Despite its significance, the KRB faces substantial challenges arising from human activities and adverse impacts of climate change. Beyond climate change, non-climatic factors—including population growth, urbanization, and agricultural development—exert additional pressure on transboundary water resources. These factors interact with climate change, creating a compounded effect on already stressed water resources (Munia et al., 2020). Population increase, coupled with growing demands for fresh water across various sectors, is a significant contributor to global water scarcity (Kliot et al., 2001). In the KRB, land use/cover change (LUCC) has further exacerbated these concerns, leading to habitat loss, reduced water quantity, and diminished carbon sequestration, primarily due to intensive agricultural practices and urbanization relying on wetlands (Khan et al., 2019).

Efforts towards effective water resource management advocate for an integrated approach that considers the value of water, while evaluating costs and benefits with regard to environmental and social impacts (GWP, 2008). Social aspects are channelled through communication and shared decision-making among various stakeholders, emphasizing the importance of considering sustainable water and land management, domestic markets, social and environmental issues, and non-traditional factors such as energy and industry use in sustainable water resources management (Brien et al., 2018). The KRB, with vast opportunities for local use, agriculture, industry, transportation,

and hydroelectric power production, depends on ecosystems for sustenance, including food, fish, medicinal resources, fuel, and building materials.

Despite these invaluable social benefits, the unsustainable practices for the extraction of natural resources and competing demands for water resources pose a heightened risk of degradation. Socioeconomic and transboundary issues—including poverty, disease, water supply challenges, population pressure, migrations, conflicts, and regional competition—play a pivotal role in shaping the impact of human factors on water resources management within the KRB. Therefore, any assessment of adaptation plans for water management must comprehensively evaluate these socio-economic pressures to be able to effectively address the complex web of challenges facing transboundary water resources in this critical basin.

2. Literature Review

2.1 Empirical Review

Water resources—including surface water like lakes and rivers, and groundwater in aquifers—play a crucial role in sustaining human well-being, economic growth, and ecosystem health (UN Water, 2021). However, these resources face escalating challenges ranging from population growth and urbanization, to climate change, necessitating effective management to ensure sustainability (UN, 2021). Climate change introduces uncertainty and threatens water resources, compounding existing socio-economic drivers impacting water stress (Munia et al., 2020; Arnell & Lloyd-Hughes, 2014; Veldkamp et al., 2017).

Population increase intensifies water scarcity, driven by rising demands for fresh water in urban, agricultural, and industrial sectors. With over one billion people in the developing world who do not have access to safe drinking water, population growth heightens tensions over international river basins (Kliot et al., 2001). In the KRB, land use/cover change due to intensive agriculture and urbanization leads to habitat loss, reduced water quantity and quality, and diminished carbon sequestration. Population growth exacerbates these negative impacts on essential ecosystem services (Khan et al., 2019).

Multiple factors—including fast-changing population, rapid urbanization, economic disparities, deteriorating water infrastructure, land use changes, and climate change—alter freshwater flows with consequences across different spatial scales (Tramberend et al., 2021). Population growth, LUCC, and human factors contribute significantly to the decline in fresh water quality and quantity, emphasizing the need for sustainable water management practices (Khan et al., 2019). Comprehensive water resources management, which acknowledges the importance of water and considers environmental and social effects, is crucial for efficient water management. The social elements, enabled by communication and collective decision-making, propel the execution of sustainable water management efforts (GWP, 2008).

The KRB holds vast potential for domestic use, irrigation, industry, transportation, and hydropower production. The ecosystems of the basin provide essential resources, yet increasing demands and competing uses pose a threat to water source degradation. Socio-economic and transboundary issues—including poverty, diseases, water supply challenges, population pressure, migrations, conflicts, and regional competition—underscore the importance of a comprehensive assessment for adaptive water management in the basin.

2.2 Theoretical Review

This study is anchored in Hardin's (1968) tragedy of the commons theory (ToCT), elucidating the challenge of overuse and depletion of common resources like land, water, and air; driven by self-interest and the lack of coordination among individuals. Hardin (1968) contends that the absence of costs encourages exploitation; resulting in resource overuse, depletion, and eventual destruction. The central assumptions of the theory posit that individuals act in self-interest to maximize utility, common resources are freely available to all without restrictions, and there is lack of consideration for others or the environment, reflecting a deficit in social responsibility and collective action (Delon, 2016). While widely applied, the theory has faced criticism for oversimplification, assuming individual homogeneity and neglecting the role of institutions in resource management, and overlooking potential cooperation, coordination, and collective action (Goldman, 1997).

Even with its detractors, the ToCT plays a significant role in shaping policies, highlighting the importance of joint efforts and societal accountability, and encouraging studies on efficient resource utilization and organizational structure. In this study, the theory guides the cross-examination of human stress factors influencing water resources management; aligning with its applications in environmental resource management, economics, and political science. The theory, particularly relevant in transboundary water resources management, illuminates challenges arising from individual countries prioritizing short-term interests over shared resources, exacerbating the tragedy. Poor governance worsens this scenario, heightening the demand for shared resources beyond supply capacities. Potential modifications to the theory involve incorporating diverse factors influencing resource use; including cultural norms, social values, and political systems. Additionally, nuanced considerations of human behaviour, such as poor cooperation and social responsibility, could enhance the realism of the theory, offering a comprehensive understanding of shared resource dynamics.

2.3 Conceptual Framework

A conceptual framework linking human factors and water resources management (Figure 1) guided this study. In this regard, human factors include

poverty, rapid population growth, unsustainable agricultural activities, inadequate institutional and policy framework, low enforcement and compliance to existing regulations and laws, low technology, and unplanned settlements. When these factors interact, they cause significant impacts on water resources, especially transboundary water resources. The impacts on transboundary water resources are considered significant, especially when there are no common approaches for managing the resources, and each riparian country has different perspectives and approaches to managing the resources. Irrespective of the impact level, the sustainability of water resources requires joint efforts among key players and actors.

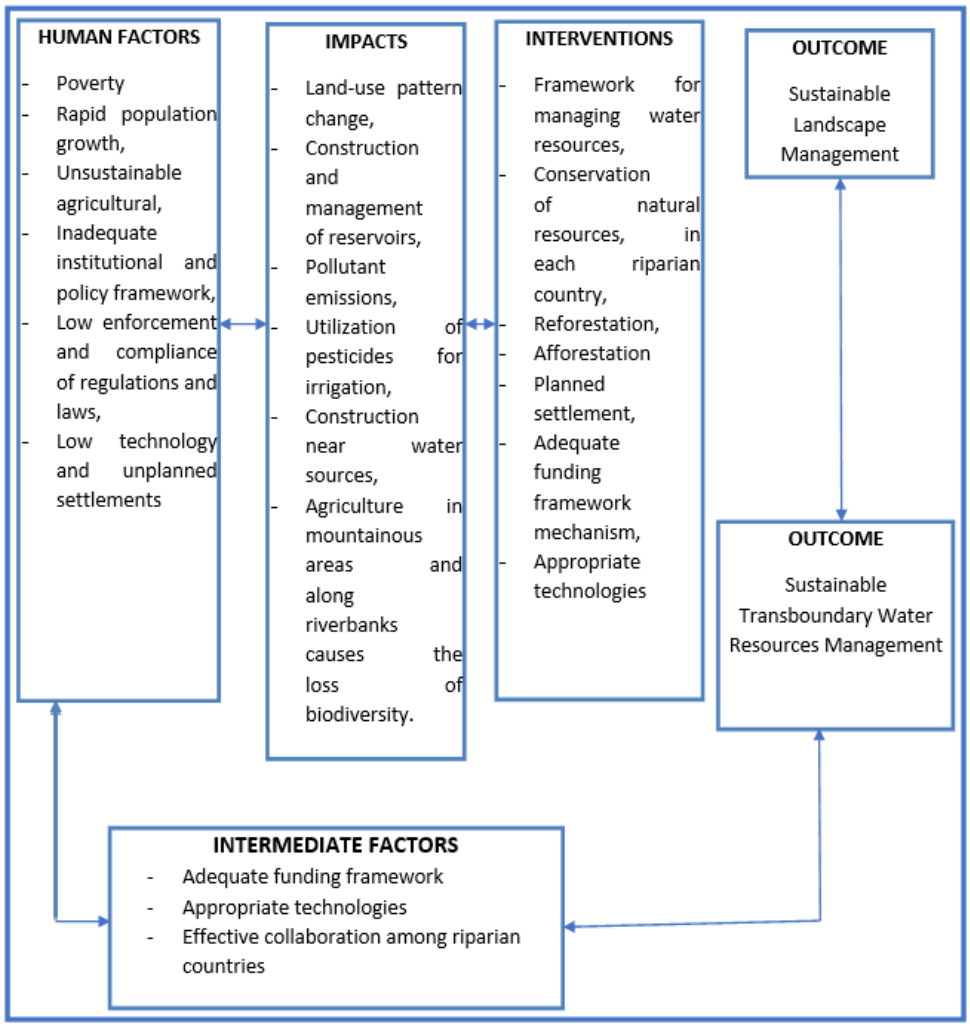

Figure 1: Transboundary Water Resources Management
Source: Modified from Rockstrom et al. (2009)

For transboundary resources to be managed sustainably, several interventions should be undertaken (Rockström et al., 2009). Transboundary interventions may include a common framework for managing water resources, conservation of natural resources (especially catchment resources in each riparian country), reforestation, afforestation, planned settlement, agricultural activities, and sustainable landscape management. For these interventions to be successful, each riparian country needs an adequate funding framework mechanism, appropriate technologies, and effective collaboration to achieve sustainable transboundary water resources management (Kristensen, 2004).

Besides, increasing awareness and adaptive capacity among local communities regarding the implications of human factors will reduce degradation and enhance sustainable transboundary water resources management (Kristensen & Hermansen, 2010). Generally, the sustainability of water resources, accelerated by human factors, requires certain preconditions such as sustainability of livelihoods, landscape management, and sustainability of natural resources management. When these elements are effectively connected, and interventions to enhance them are implemented effectively, they may result in the sustainability of water resources management and sustainable landscape management, as summarized in Figure 1.

3. Methodology

3.1 Description of the Study Area

This study was conducted in the Kagera River Basin (KRB), specifically in Ngara District, that covers approximately 3,744km². This area is divided into 3,260.90km² of land, constituting 87.09% of the total district area; and 483.1km² of water, representing 12.9% of the whole district area. Ngara District is geographically located in the south-western part of Kagera Regional Headquarters (Bukoba), situated between Latitudes 2° 45'S and Longitudes 30° 64'E. It shares borders with Rwanda in the northwest, Burundi in the southwest, Kakonko District Council to the south, Biharamulo District Council to the east, and Karagwe District Council to the north. The map in Figure 2 illustrates the Kagera and Ruvuvu Rivers within Ngara District, and locates the Rusumo, Kasange, and Katerere study villages.

According to the 2022 population and housing census, Ngara District had a population of 383,092 people, with 201,959 females (52.4%) and 181,133 males (47.6%). It is home to 13.0% of the regional total population of 1,777,823 (NBS, 2022). The district is in the north-western highlands of Tanzania, with an elevation of 1,800m above sea level. It is characterized by bimodal rainfall with four seasons: two dry seasons from June to September and January to February; and two rainy seasons from October to December and March to May. Strong winds/hazy air and temperatures vary between 18˚C and 30˚C experienced during the dry seasons, depending on the time of the day or night. Sudden and heavy downpours may occur daily during the rainy seasons, lasting from a few minutes to several hours. Rain is often associated with strong winds, floods, mud, fog, and temperatures between 12^0C and 26^0C (URT, 2017).

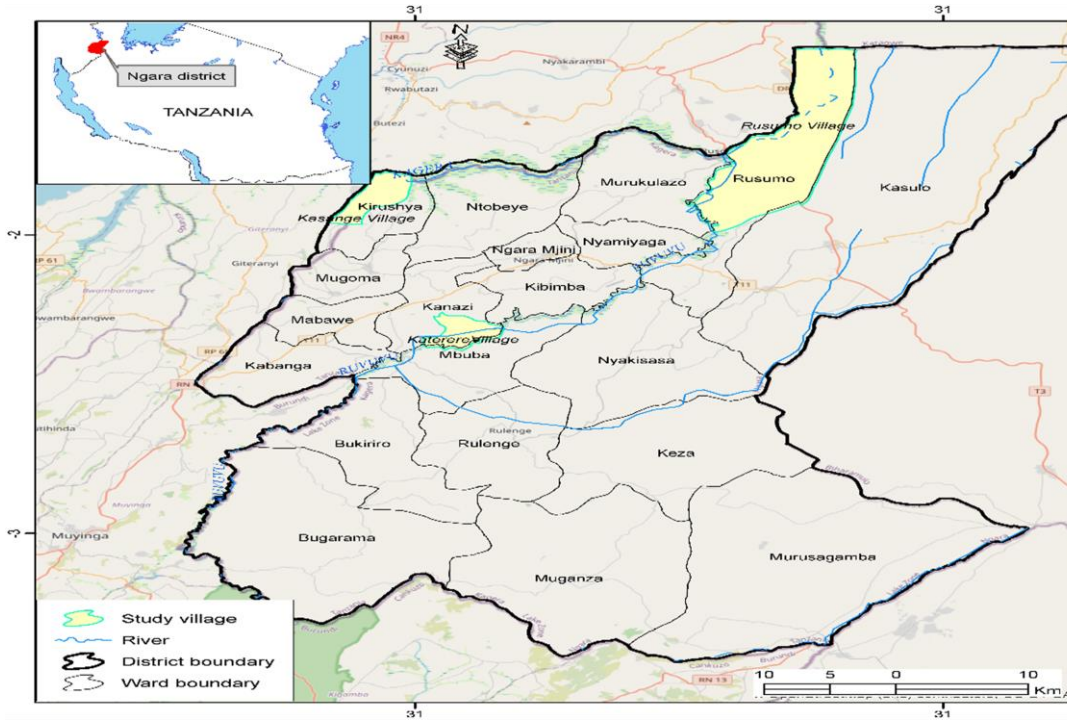

Figure 2: Map of Ngara District Showing the Study Area
Source: IRA Cartographic Unit, University of Dar es Salaam

The Kagera River is 400km long, with two headstreams of Ruvuvu and Nyabarongo tributaries. The Ruvuvu tributary begins from north of Lake Tanganyika in Burundi, and the Nyabarongo tributary begins from north-west Rwanda (Figure 2). These tributaries characteristically differ in colour before meeting (Habiyakare & Zhou, 2015). Nyabarongo leaves the tributary to join the Akagera Stream to form the Kagera River close to the Tanzanian border. Water in the Ruvuvu River is reddish, while that of the Kagera River is clear (URT, 2017).

Table 1: Coverage of Kagera Basin in the Study Area

Country	Country Surface Area (km²)	River Basin Total Area (km²)	River Basin Coverage (%)
Rwanda	26,340	19,900	33
Tanzania	945,100	20,800	35
Burundi	27,834	13,300	22
Uganda	241,000	5,800	10
Total	**1,240,274**	**59,800**	**100**

Source: Habiyakare & Zhou (2015)

The Ngara District Council is located at 1,200–1,800m above mean sea level, and features diverse landscape elements such as hills, ridges, swamps, and flood plains. It forms part of the most north-western highlands of the Kagera Region, with clay and red loamy soils, as well as hilly land. Soil composition varies from shallow to very deep clay soils, with low nutrient reserves and nutrient retention capacity. Regarding water supply, 58.95% of the households in Ngara District Council have access to improved drinking water sources, and 41.1% have access to unimproved water sources. The main sources of clean water for drinking used by households in the council include public tap or standpipe (20.4%), protected springs (16.4%), tube well/boreholes (8.9%), piped water into the dwelling (4.5%), and 3.8% piped water to yard/plot.

3.2 Research Design, Sampling Procedure

This study used a cross-sectional design, which flexibly allows data collection once, without the need for repetition. It utilized a mixed-method approach that simultaneously gathered quantitative and qualitative data (Dawadi et al., 2021). Study sites (region, district, wards and villages) were selected purposively. Purposive sampling is appropriate when a specific objective is required to obtain study units. The selection of Ngara District was due to its potential location in transboundary water resources, including its strategic position for community livelihoods in the KRB. It is worth noting that the Ngara District forms the catchment of the KRB. It is strategically located where Ruvuvu and Nyabirongo tributaries converge to form the KRB.

The study was conducted in three villages of Katerere and Kasange in the upper stream, and Rusumo village in the lower stream within the sub-basin of the Kagera River, in Ngara District. The villages are also located where Ruvuvu and Nyabirongo tributaries flow from the upper streams to the lower middle stream, forming the Kagera River. The Katerere village is in the Kanazi Ward of Ngara District, and it borders Kanazi village in the north, Ruvuvu river in the west, Mayenzi village and Ruvuvu in the south, as well as Mkalehe and Mkibogoye villages in the west. The Katerere village is within the upper stream of the Ruvuvu tributaries, wherein the community benefits from their resources and services. The Kasange village is located upstream of the KRB, and it borders Burundi in the south-west and Kagera River in north-west, which borders Burundi and Rwanda. Moreover, the Kasange village is inhabited by a beautiful scenery where the three countries border the Kagera River, locally called *mafiga matatu* ('three hearth stones'); whereas Rusumo Village sits across the Kagera River.

In the study, a minimum of 10% of the households (Table 2) were surveyed; and a specific group of people, including 25 key informants interviews (KIIs): one respondent at the regional level, seven at the district level, and 17 key informants at the village level. The use of 10% of the household representatives intended to achieve representativeness of the population, as recommended by

many scholars (for instance, Kothari, 2014). Focus group discussions (FGDs, N= 13) (Table 3), and household respondents (N=210) were also involved in the survey. Such respondents were considered adequate to gather the necessary information in achieving the research objectives.

Table 2: Sample Size of Household Questionnaires in the Study Area

S/N.	Village	No. of Households	Sample Size	Percent
1.	Katerere	588	67	11.40
2.	Kasange	494	62	12.55
3.	Rusumo	780	81	10.38
	Total	**1862**	**210**	**11.28**

Source: Field survey, 2020

Table 3: Number of Participants in each Method of Data Collection

S/N	Category	Category of Source	No. of Participants
1.	Key informants	Regional Administration	1
		Ministry of Water	1
		District Commissioner	1
		Agricultural and Livestock Officer	1
		Natural Resources Officer	1
		Planning and Statistics Officer	1
		Administrative Officer	1
		Meteorological Officer	1
		RUWASA	3
		RAS	1
		LVBWB	3
		MoW	2
		TFS	2
		Influential people	6
		RRFHP/LADP	1
		BENGUKA-NGO	1
		TCRS	1
2.	Focus Group Discussions	Village leaders	4
		WUAs	4
		Men and women	4
		Environmental conservation group	1
3.	Household Interview	Rusumo	81
		Katerere	67
		Kasange	62

Source: Field survey, 2020

3.3 Data Collection

Quantitative data involved collecting information and datasets related to land use/cover change, strategies for sustaining transboundary water resources, and the effectiveness of institutions responsible for water resource

management. Qualitative data was collected using participatory research methods, including interviews, FGDs, historical timelines and seasonal calendars, and household surveys. Four FGDs (involving village government officials, water users associations, men and women), each comprising 8 to 12 participants with different social and economic characteristics, were conducted in each village. Information collected from the field was used to validate information collected in household surveys and key informant interviews. This facilitated qualitative data collection of local perceptions of climate change and variability with the associated effects, vulnerability, and adaptations on water availability and management.

At the household level, a structured questionnaire was used to gather information from household heads. If the household head was unavailable for some reason, then a close relative familiar with household activities, income and expenditure was interviewed instead. The identification of a household was as per the 2012 National Census, which defined a household as an individual or a group of people who live together, share expenses and provide themselves with food and other essentials (URT, 2013). The household representative per ward was stratified based on income level. The questionnaire was pre-tested for validation before the actual fieldwork. The interview with key respondents was designed and guided by a checklist administered to different key/target groups. Interviews were conducted in the offices of the respective officials, or in a venue/place of their choice for the target groups that included expertise from the basin water board, Ministry of Water, natural resources, land, environment and local government at the district, ward and village levels. The number and persons interviewed were identified during the field visit, and suggestions were made by respondents themselves in their respective areas. A non-participant observation technique through field visits was deployed in the sampled areas to validate information gathered through the questionnaire. Multiple sources of information and designs were used to ensure the validity of the information given by respondents. These involved taking photos and identifying other pieces of information in the area.

3.4 Data Processing and Analysis

In this study, the images that were chosen had been captured during the same season (July-September) with minimal cloud cover (<10%). These images came from various sensors with 30-meter spectral resolution, specifically Landsat Thematic Mapper (TM) in 1986 and 2000, and Landsat Operational Land Imager (OLI) in 2022. The images were obtained from the freely accessible United States Geological Surveys (USGS) and Earth Explorer websites, and specifically from Landsat Path 172, row 62. For land use and cover change detection, ArcGIS 10.4 software was used. Three land cover layers were employed, corresponding to the years 1986, 2000, and 2021; and utilized a spatial analysis tool with the zonal

tabulate area function to create a land cover change matrix. This function computes the areas where two datasets intersect, and presents the data in a table format. It contains information about unique zone dataset values, and exceptional class dataset values. The calculated geometry was utilized to determine the areas in hectares for each land cover category within the matrix. Finally, the classified land cover scenes were converted into a vectorised shapefile format. The land cover change analysis and cross-tabulation were performed using the spatial analysis function within the ArcGIS 10.4 software.

Quantitative data obtained from the questionnaire were analysed using the Statistical Package for Social Sciences (SPSS) software, version 20, by cross-tabulation techniques to obtain the percentage of respondents in the study area. The analysis of qualitative information followed procedures deployed by Burnard et al. (2008), whereby interviews were transcribed verbatim, and notes taken. Later, the notes were summarized into short phrases that summed up what had been said in the text. Most of the data analysed qualitatively was that from FGDs and KIIs.

4. Results and Discussion

4.1 Institutions Responsible for the Transboundary Water Resources Management in the Study Area

Results on the institutions responsible for the management of water resources revealed that the Ministry of Water was the main institution recognized by the respondents. The Ministry of Water was mentioned by 15.3% of the respondents as having many officers engaged with projects for water conservation and management. Other institutions listed by the respondents were NELSAP (14.3%), international organizations such as OXFAM and CONCERN (5.2%), Ministry of Agriculture (4.9%), the village government (4.9%), and the Lake Victoria Basin Water Board (1.2 %) (Figure 2).

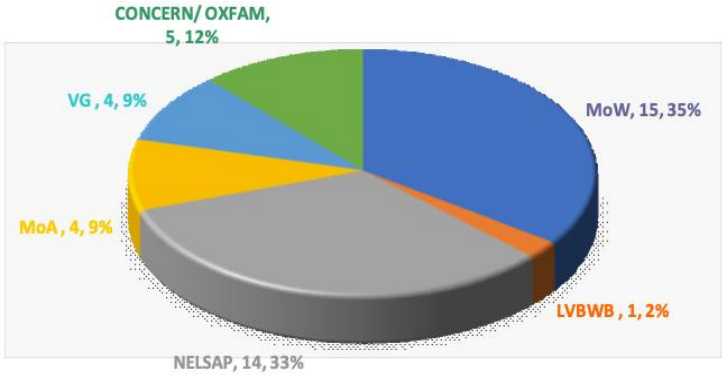

Figure 3: Institutions Responsible for the Management of Water Resources
Source: Field survey (2020)

The institutions and activities involved in water management linked many stakeholders, including villagers, and thus recognized their presence in water resources management. For instance, NELSAP is the main implementer of the RHEP project, which includes livelihood activities such as water supply to villagers.

4.2 Human Stressor Factors on Transboundary Water Resources Management

This study found that numerous economic, political and social shifts—including differences in water governance among the riparian countries—influence transboundary water resources management in the basin. The results from KIIs noted that there were differences in water management in terms of ideology, policies, legal frameworks, and institutional arrangements. Results on human factors affecting water resources management described during KIIs and FGDs are presented in Table 4.

Table 4: Human Factors on Transboundary Water Resources Management

SN	Factors	Description	KIIs	FGDs
1.	Conflicting policies/laws and regulations (for each country)	Contravention of water resources management laws, e.g. Tanzania is 60 meters, but Burundi is 10 meters close to the water source. Burundians get water from the Mwibu River to irrigate their fields. Conflicting water laws (Rwanda, Burundi and Tanzania). At the grassroots level, there is no environmental protection enforcement in Burundi.		
2.	Political Differences	Political differences among riparian countries result in timely delays of decisions on the management of water resources.		
3.	Water infrastructure management	Lack of water infrastructure and poor management of water resources affect availability, access, and the economic infrastructure of other sectors.		
4.	Conflicting water uses	Conflict between water sources among countries and different sectors, including communities.		
5.	Agricultural activities lead to soil erosion and affect water quality and quantity.	Utilization of pesticides that enter the water sources for irrigation, agriculture, mining, construction near water sources, industry, transportation, etc. Agriculture in mountainous areas and along riverbanks destroys native vegetation and biodiversity.		
6.	Use of poor and unsustainable technology in the extraction of resources related to water	Use of unsuitable fishing methods and disputes between fishermen from these three countries Mining activities The advancement of technology The growth of industry and human activities causes carbon dioxide, methane, and pollution.		

SN	Factors	Description	KIIs	FGDs
7.	Environmental degradation	Charcoal and brick making, wildfires, tree felling/logging, unregulated timber harvesting, and arbitrary pastoralism exceeding carrying capacity lead to grass loss and soil erosion.		
8.	Unfavourable cultural beliefs and taboos	Misconceptions of forest fires that kill insects and destroy trees and ecosystems.		

Source: Field Survey, 2020

According to Bates et al. (2008), land-use pattern change, construction and management of reservoirs, pollutant emissions, and water and wastewater treatment incline human factors on water resources management. Results from this study reveal that anthropogenic activities are responsible for the observed changes in transboundary water resources attributed to changes in population, food consumption, economy (including water pricing), technology, lifestyle, and societal views regarding the value of freshwater ecosystems.

4.2.1 Conflicting Policy and Regulations

The study revealed that policies and regulations in riparian countries are conflicting and, in some cases, there are no enforcement mechanisms. For example, the Tanzania Environmental Act of 2004 has identified challenges in water source management, especially the issue of avoiding human interaction activities within 60 meters of water sources. The applicability of this law faced many implementation challenges at the community level (Photo 1).

Photo1 1: Human Activities Conducted within 60m of a Water Source in Kasange Village in Tanzania

(A shared water source between Burundi and Tanzania)

Source: Field survey photo, 2020

Participants acknowledged this problem during the FGDs; and one had this to say:

> *"…plans lack a regional aspect to manage the resources and a land use plan to guide the use of resources from border zones. For example, the migration of pastoralists is noted to be a source of friction in the border zone, apart from causing environmental destruction and depletion of water resources."*

A study conducted in the United States of America revealed the negative effects of administrative, political, and legal barriers on water resources management. For example, on-site waste disposal responsibilities are divided between state and local-level authorities, and between state agencies in the USA (Daniel et al., 2013).

The study revealed that land conflicts are closely linked to traditional inheritance systems, which result in land fragmentation and the creation of disputes within families. One respondent made the following comment:

> *"Farm households retain plots that are too small to ensure food security; hence, they encroach on protected areas, such as water sources and natural reserves. Unplanned migration and traditional movement of pastoralists with their cattle cross into the protected area and reserve, searching for pasture and water for their animals. In due course, they start fires, and often conflicts with natural predators, conservationists, and resident farmers*."

During FGDs, it was reported that, in March 2003, pastoralists kept 80,000 cattle in protected areas for the entire dry season when crossing the Kagera River and papyrus swamps from Rwanda to Tanzania in search for pastureland.

4.2.2 Political Differences

Political differences among riparian countries delayed decision-making on the management of water resources. During FGDs, one respondent revealed that "... there are differences in political agenda among the riparian countries with differences in socio-economic status." This conforms to a study by Brels et al. (1996), who revealed that transboundary water resources management remains a significant challenge to the conservation of inland water ecosystems among partner states. Different political ideologies—such as modernized agricultural technologies and management strategies—negatively affect the utilization and management of shared resources such as water. Some countries apply improved technology, while others do not; with the latter also lacking commitment to resource management. In addition, ethnic and political tensions cause overpopulation in Ngara, and increase the demand for natural resources. Ultimately, these lead to environmental degradation and depletion of water sources. Equally, different initiatives have insisted on development rather than conservation/management. It is conventional wisdom regarding cooperation in shared watercourses whose results can be achieved best within a climate of trust, the prerequisites of which are internal political stability of each riparian state, and a demonstration of political commitment to shared river basin issues.

4.2.3 Low Levels of Technology and Education

The study established that poor agricultural production, water extraction and supply technology affected the availability, access, and management of water sources. During FGDs and KIIs, technology was reported to have affected access to, and management of, water resources. Participants of FGDs revealed that all riparian countries had poor water resource utilization and management technologies. Literature on water resources indicates that inadequate water supply, distribution and management result from low levels of technology in water resources (Bates et al., 2008). The results from the household survey indicate that 49% of respondents with primary education reported that there were no changes in water resources (Figure 4). In comparison, 16.2% and 5.7% reported increased and decreased awareness, respectively, which conforms to other studies which have affirmed that education could help secure inclusive and resilient development around water resources (see, e.g., Lyon et al., 2019).

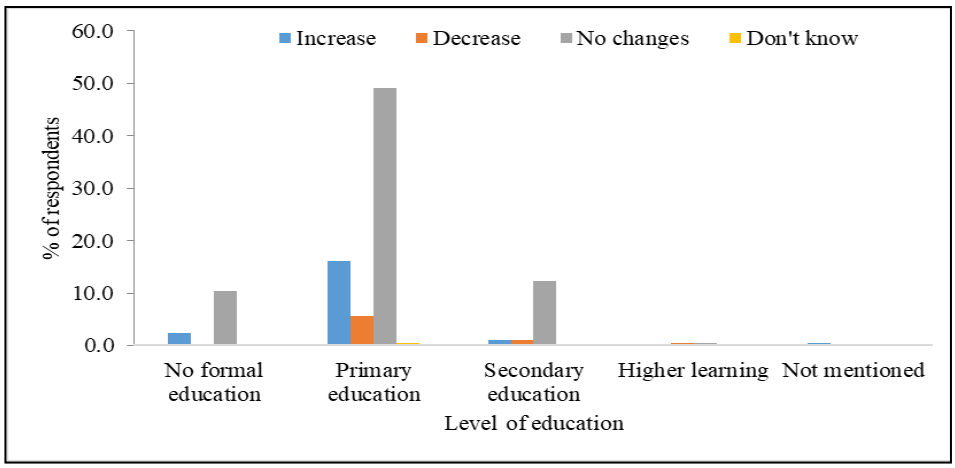

Figure 4: Water Resource Awareness Based on Education Level
Source: Field Survey, 2020

4.2.4 Low Level of Socio-economic Development

The results from FGDs and KIIs indicated that the presence of disparate levels of development among riparian countries affected water resources management. This conforms to a study by Gomez et al. (2019), who noted that the income of individual households affects water access in rural areas. For example, one respondent from the FGDs gave the following comment:

> *"… in Burundi, insufficient land for agricultural production forced most farmers to disregard contouring and terracing steep slopes, thereby increasing soil erosion in upstream and downstream silts…. while in Rwanda, despite the shortage of land, land management practices are monitored well, especially in areas adjacent to Tanzania."*

In addition, language differences among the riparian countries were challenges that affected joint management of water resources and community relations. Language forms a bridge for the joint management of shared resources; and helps people understand and coordinate utilization, and suitably manage shared water resources. The local languages of Lundi (Burundi), Nyarwanda (Rwanda), Kiganda (Uganda), and Kiswahili (Tanzania), which are spoken as common languages in the riparian countries, have implications in awareness raising for water resources management among the local communities.

4.2.5 Unfavourable Cultural Values on Water Resources Management

Culture is an important component in water resource utilization and management. This is in line with a study by Heinrichs and Rojas (2022), which stressed the need to consider cultural values when dealing with water resource management and governance. Gender issues also featured in water use and management in the local community. Results indicated that water for domestic use at a household level was mainly taken care of by women and children in all riparian countries (Photo 2).

Photo 2: Women and Children Fetching Water for Domestic Use at Kasange Village
(A shared water source between Tanzania and Burundi)
Source: Field survey photo taken by the researcher (2020)

4.3 Land Use Change as a Factor Influencing Water Resources Management

4.3.1 Major Drivers of Land Use/Cover Change

Land use/cover change is one of the factors that cause soil erosion and sedimentation in rivers. It is attributed to anthropogenic activities such as agriculture and livestock keeping, which destroy the quantity and quality of water resources. The main causes of land use/cover change are related to the management of water resources, as presented in Table 5.

Table 5: Causes of Change in Land Utilization and Management of Water Resources

S/N	Sources of Change	Descriptions (Contribution to Water Resources Management)
1.	Limited government support and inadequate incentives for natural resources management	Poor water resources management because of land degradation
2.	Inadequate policies, laws and regulations and their enforcement and poor extension services	Deterioration of water sources caused by poor enforcement of laws and/or by-laws
3.	Weak local government land resources planning capacity (few staff, limited training and equipment), sectoral ineffectiveness in terms of bringing about change from unsustainable to sustainable land use and resources management	Unsustainable water resources management
4.	Disjointed endeavours guided by distinct land, environmental, agricultural, forestry, and water policies, institutions, strategies, and action plans	Encroachment of water sources results in their deterioration
5.	Lack of awareness and understanding of land users and local governments	Unsustainable water resources management

Source: Field survey (2020)

This study also revealed ongoing land degradation and soil fertility loss, corresponding to previous research conducted by Li et al. (2021), who reported that human-driven land use/land cover changes are the main causes of soil loss in dryland basins of Sub-Saharan Africa. This is exacerbated by deforestation resulting from poor agricultural practices, use of firewood, displaced persons, and soldiers. There is an indifference among the local people to policies regarding the maintenance and reforestation of public land, e.g., the use of radial terraces on the slopes of farmland that take large spaces of land, thus becoming unacceptable in Rwanda and Uganda. In Burundi, food-for-work has supported the construction of terraces, resulting in farmers having no sense of ownership and poorly maintained terraces. Also, there is unrestricted cultivation of wetlands and riverbanks in Burundi. Moreover, only little manure can be incorporated into land since cattle herds were decimated during decades of civil conflicts. Khan et al. (2019) revealed that the intensification of agro-food systems has led to concerns about water pollution, especially regarding excessive use of fertilizers and pesticides in the KRB.

Due to population pressure, respondents reported that there was insufficient access to pasture, and no fallow land was available for grazing. Poor farm inputs and primitive agricultural methods lead to low yields, and as population pressure increases, more land is cultivated, including steep hillsides, thereby accelerating soil erosion. This affects water sources as well as river banks, and has implications on water availability, access, and management.

4.3.2 Observed Land Use and Cover Changes in the Basin

Nine (9) land use and land cover categories—namely, agriculture, bare soil, bushland, grassland, natural forest, urban area, water, wetland, and

woodland—were identified in the years 1986, 2000 and 2021. The results show that, in the Kagera Water Basin, agricultural land increased in 1986, 2000 and 2021; as well as grassland, natural forest, urban areas and water. Furthermore, the study revealed that bushland was increasing from 1986 to 2000, but decreased in the period 2000–2021. Also, bare soil, wetlands and woodland decreased from 1986 to 2021 (Figures 5 & 6).

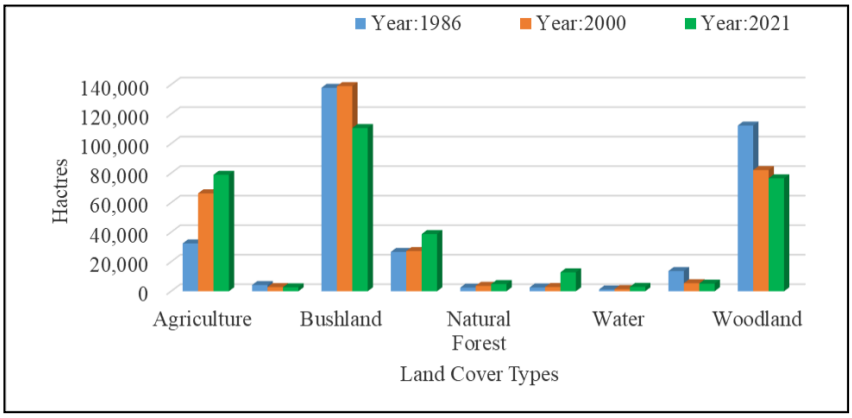

Figure 5: Land Use Cover Types and Changes in KRB 1986, 2000 and 2021
Source: IRA GIS Lab (2022)

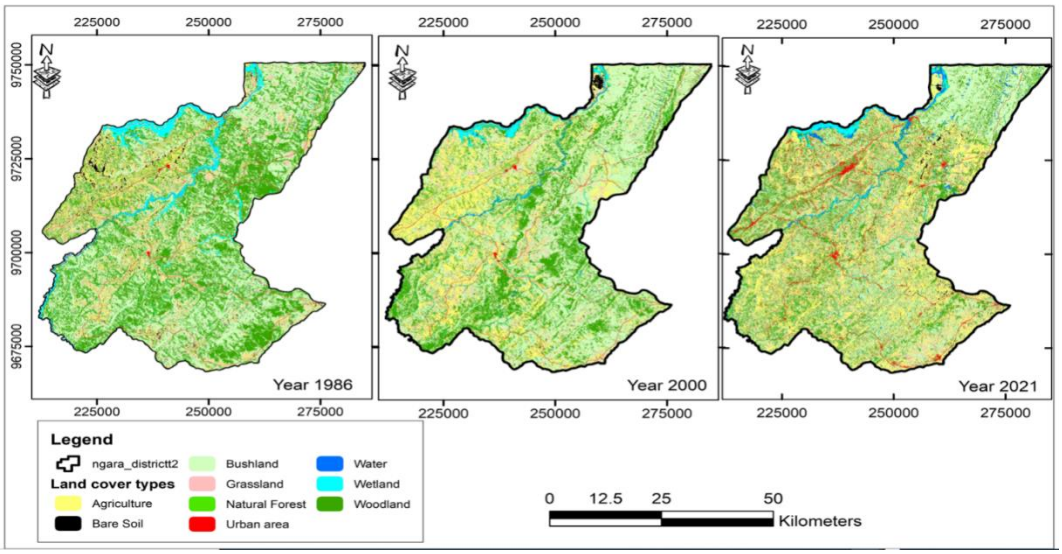

Figure 6: Land Use/Cover Maps of Kagera Basin from Satellite Data for 1986, 2000 and 2021
Source: IRA GIS Lab (2022)

Results show that agricultural land increased by 9.7%, 19.9% and 23.7% in the years 1986, 2000 and 2021, respectively; with an annual change of 2.7% and 0.6% for the period 1986–2000 and 2000–2021 (Table 6). Furthermore, results indicate that changes in land use cover through urbanization and the use of wetlands for intensive agriculture have led to water pollution in the KRB. Also, there has been excessive use of agrochemicals, which results in habitat loss, low water quantity and poor quality (Berakhi et al., 2015). Similarly, due to the reliance on agriculture, combined with high population density, wetlands along watersheds have been infringed on and converted into cultivable farmlands, and use for seasonal livestock grazing (Khan et al., 2018; Tahiru et al., 2020).

Table 6: Land Cover Changes in the Kagera River Basin 1986 – 2021

Land Use/ Cover Types	Land Cover						Annual Change Rate	
	Year: 1986		*Year: 2000*		*Year 2021*		*1986-2000*	*2000-2021*
	ha	*%*	*ha*	*%*	*ha*	*%*	*%*	*%*
Agriculture	32,385	9.7	66,291	19.9	78,886	23.7	2.7	0.6
Bare Soil	4,210	1.3	2,794	0.8	2,676	0.8	-1.5	-0.2
Bushland	137,798	41.4	138,980	41.7	110,556	33.2	0.0	-0.8
Grassland	26,654	8.0	27,234	8.2	38,756	11.6	0.1	1.3
Natural Forest	2,471	0.7	3,650	1.1	4,847	1.5	1.4	1.1
Urban area	2,554	0.8	2,895	0.9	12,806	3.8	0.5	5.5
Water	1,198	0.4	1,431	0.4	2,934	0.9	0.7	2.7
Wetland	13,693	4.1	5,460	1.6	5,157	1.5	-3.4	-0.2
Woodland	112,245	33.7	82,076	24.6	76,466	22.9	-1.2	-0.3
Total	**333,209**	**100**	**330,812**	**99**	**333,084**	**100**		

Source: IRA GIS Lab (2022)

4.4 Impacts of Human Stress Factors on Water Resources Management

Various human factors affect transboundary water resources, such as population growth, urbanization, and agricultural development. The study explored how these factors interact with climate change to impact water resources, especially in regions facing water scarcity. Through KIIs, it became apparent that human factors were a potential hindrance to long-term water resource policies and management. Apart from temperature and precipitation changes, socioeconomic drivers also influence water resources. Evaluating these socioeconomic pressures is crucial when assessing the influence of human factors on the future of water resources, particularly in the context of adaptation plans for water management.

The growing global population, compounded by an increasing demand for fresh water in urban, agricultural, industrial, and other uses, has been one of the primary causes of water scarcity. Providing safe drinking water to over one billion people in the developing world is a substantial challenge. As the global population grows, water resources become a source of tension among neighbouring nations, especially those sharing international river basins.

Land use and cover changes in the KRB have led to habitat loss and reduced water quantity. These changes are important due to intensive agricultural practices and urbanization that depend on wetlands. Factors like population growth further worsen these negative impacts on critical ecosystem services. Human factors significantly impact the availability, access and management of water resources. The same factors have also contributed to climate change and variability. Deforestation, forest degradation, and the lack of reforestation activities have worsened the basin's water resource availability and access, and have led to management challenges. During KIIs, a participant said:

> *"Lack of successful reforestation projects or agro-forestry campaigns in the area was declared, which later affected water sources. There is also a lack of consensus on who should plant trees and how to execute the activity."*

According to the FGDs, communities were reluctant to invest labour in reforestation projects, where tenure rights could be more explicit, and rights to cut down trees in the future may be restricted. Communities were also reluctant to practise land management, such as growing hedges to control erosion because cattle graze and devour them. While some farmers may be interested in agro-forestry, the small size of most holdings is a severe constraint and, thus, adds to existing challenges in water resource management. A study by Froese and Schilling (2019) indicates that stress on land, and the resulting land use changes and land degradation, can adversely impact human security when subsistence farmers lose land, or pastoralists lose access to pasture and water points. Acritical informant revealed the effect of this combination of factors by saying:

> *"… rapidly changing population, fast urbanization, uneven economic growth, deteriorating water infrastructure, land use changes, and the effects of climate change result in alterations to fresh water flows. These alterations have far-reaching consequences at various spatial scales."*

Munia et al. (2020) have identified human factors as potential obstacles to effective long-term policies and water resource management. While climate change poses an additional threat to already stressed water resources—for example, by adding uncertainty, changes in temperature and precipitation—many socioeconomic drivers also affect water resources and water stress (Arnell & Lloyd-Hughes, 2014; Veldkamp et al., 2017). Incorporating evaluation of these socioeconomic pressures is thus crucial while assessing the impact of human factors on future water resources, particularly when discussing adaptation plans for water management (Munia et al., 2020).

4.5 Sustainability of Transboundary Water Resources Management

The sustenance of water resources in the changing climate is a necessity. Managing transboundary water resources requires a favourable environment for investment, especially for water-related infrastructure and services among partner states. Thus, concerted efforts in development and conservation

outcomes require joint adaptation planning and stewardship initiatives at the local level, including the participation of resource users (community leaders). These would need to mainstream adaptation, develop plans, and create awareness of the impacts of human factors on water resources management.

The management of transboundary water resources is difficult because the decision-making process requires the involvement of government bodies that have the power to allocate benefits and costs. This requires innovative approaches to ensure cooperation between countries having access to such water sources. Without collaboration and innovative participatory approaches, a governance vacuum may exist, resulting in the absence of responsive regulation and failure to address common concerns in a timely manner (Mogomotsi et al., 2020). About 21.9% of the respondents admitted that tree planting alongside the river would be among the main strategies for sustainable management of riverbanks due to its importance for the community. Likewise, 20.0% of the respondents were of the opinion that environment conservation training also was part of the sustainability plans for water resources management. The need for water supply among the communities was mentioned by 12.4% of the respondents across the studied villages, as indicated in Table 7.

Table 7: Options for Sustaining Transboundary Water Resources Management

Opinions	Rusumo		Kasange		Katerere		Total	
	N	*%*	*N*	*%*	*N*	*%*	*N*	*%*
Planting trees alongside the river	16	19.8	12	19.4	18	26.9	46	21.9
Forming a water committee comprising members from both countries	6	7.4	3	4.8	8	11.9	17	8.1
Conducting environmental conservation training for all riparian countries	16	19.8	10	16.1	16	23.9	42	20.0
Need for water	13	16.0	6	9.7	7	10.4	26	12.4

Source: Field Survey, 2020

Biomass is the only energy source in the area, and there is no alternative fuel source for cooking other than firewood or charcoal. Solar energy and electricity in the villages are often used for lighting only because they are expensive and seldom available. Plants for biogas have been introduced only in a few locations within the basin. This has negative effects on the Kagera River, causing increased sediment load in the river, and negatively impacting hydropower and irrigation infrastructure. Soil erosion results in increased nutrient load in the river, as well as in Lake Victoria, leading to problems with water and eutrophication.

5. Conclusion and Recommendations

Transboundary water resources are important for all riparian countries. However, they are facing several challenges for their management, which is brought about by ineffective coordination among the riparian countries,

including inadequate joint planning and decision-making processes for initiatives related to transboundary water resources management. Major human factors affecting transboundary water resources management include rapid population growth and urbanization, which trigger land use/cover dynamics, natural resources degradation, water pollution and biodiversity loss. The human factors exacerbating the condition of water sources in the sub-basin highlight the pressing need for comprehensive and collaborative solutions. To address these issues, the establishment of community-based collaborative enforcement mechanisms becomes imperative, emphasizing the importance of active engagement of key stakeholders, particularly local communities and village governments. Sustainable water resource management hinges on a successful implementation of practices that eliminate unsustainable resource use. Therefore, the paper recommends practical approaches that focus on alleviating pressure on drainage systems, promoting water conservation, addressing human impacts, and enhancing the resilience of socio-ecosystems, biodiversity, and the overall sustainability of water resources. Collective efforts in adopting and implementing these measures is crucial for ensuring a resilient and sustainable future for water resources in the sub-basin.

Everybody is the winner in the conservation of the environment, so the involvement of each stakeholder in environmental management enhances the sustainability of water resources. This requires an understanding of water sources and a good management system that would attract more investments to facilitate water protection, conservation, and strengthening the availability of water supply and water sources protection. Central governments should coordinate basin activities, and foster international dialogue and consensus-building among stakeholders. Education and awareness programmes play a pivotal role in basin improvement; thus, these need to be enhanced. In addition, improved data and information management systems are necessary for informed decision-making. Policy harmonization, by-laws, and equitable resource sharing are also crucial in transboundary cooperation between countries. Hence, local government authorities, water resource managers, and other stakeholders in water resources management: all have the responsibility to improve data and information management systems for informed decisions.

References

Arnell, N. W. & Lloyd-Hughes, B. (2014). The Global-Scale Impacts of Climate Change on Water Resources and Flooding Under New Climate and Socio-Economic Scenarios. *Climatic Change*, 122(1–2): 127–140. https://doi.org/10.1007/s10584–013–0948–4.

Baranyai, G. (2019). *Emerging Challenges to Transboundary Water Governance*. 1–186. https://doi.org/10.1007/978–3–030–22541–4.

Baten, M. A. & Titumir, R. A. M. (2016). Environmental Challenges of Trans-Boundary Water Resources Management: The Case of Bangladesh. *Sustainable Water Resources Management*, 2(1): 13–27. https://doi.org/10.1007/s40899–015–0037–0.

Bates, B., C., Z. W. K. & Wu, S. Palutikof. (2008). Climate Change and Water. Technical Paper of the Intergovernmental Panel on Climate Change. In *IPCC Secretariat* (Vol. 71: Issue 12). https://doi.org/10.1029/90EO00112.

Burnard, P., Gill, P., Stewart, K., Treasure, E. & Chadwick, B. (2008). Analysing and Presenting Qualitative Data. *British Dental Journal*, 204(8): 429–432. https://doi.org/10.1038/sj.bdj.2008.292.

Cooley, H. & Gleick, P. H. (2011). Climate-proofing Transboundary Water Agreements. *Hydrological Sciences Journal*, 56(4): 711–718. https://doi.org/10.1080/ 02626667. 2011.576651.

Dawadi, S., Shrestha, S. & Giri, R. A. (2021). Mixed-methods Research: A Discussion on Its Types, Challenges, and Criticisms. *Journal of Practical Studies in Education*, 2(2): 25–36. https://doi.org/10.46809/jpse.v2i2.20.

Froese, R. & Schilling, J. (2019). The Nexus of Climate Change , Land Use , and Conflicts. *Current Climate Change Reports*, 24–35. https://doi.org/https://doi.org/ 10.1007/ s40641–019–00122–1.

Guo, L., Zhou, H., Xia, Z. & Huang, F. (2016). Evolution, Opportunity and Challenges of Transboundary Water and Energy Problems in Central Asia. *Springer Plus*, 5(1). https://doi.org/10.1186/s40064–016–3616–0.

Habiyakare, T. & Zhou, N. (2015). Water Resources Conflict Management of Nyabarongo River and Kagera River Watershed in Africa. *Journal of Water Resource and Protection*, 07(12): 889–896. https://doi.org/10.4236/jwarp.2015.712073.

Hagai, M. (2019). An Investigation of Kagera River Basin Land Cover Dynamics for Sustainability of Lake Victoria Water Regime. *Journal of Sustainable Development*, 12(4): 166. https://doi.org/10.5539/jsd.v12n4p166.

Khan, A. S., Yi, H., Zhang, L., Yu, X., Mbanzamihigo, E., Umuhumuza, G., Ngoga, T. & Yevide, S. I. A. (2019). An Integrated Social-ecological Assessment of Ecosystem Service Benefits in the Kagera River Basin in Eastern Africa. *Regional Environmental Change*, 19(1): 39–53. https://doi.org/10.1007/s10113–018–1356–0.

Kristensen, T. & Hermansen, J. E (2010). Concept for Farming Systems Research. The Lithuanian Dairy Farms demonstration Project. Danish Institute of Agricultural Science; 2002:1–15. http://web.agrsci.dk/jbs/bepro/concept%20pdf%20format.pdf (Acceded March 23: 2020).

Li, C., Li, Z., Yang, M., Ma, B. & Wang, B. (2021). Article Grid-scale Impact of Climate Change and Human Influence on Soil Erosion Within East African Highlands (Kagera Basin). *International Journal of Environmental Research and Public Health*, 18(5): 1–17. https://doi.org/10.3390/ijerph18052775.

Munia, H. A., Guillaume, J. H. A., Wada, Y., Veldkamp, T., Virkki, V. & Kummu, M. (2020). Future Transboundary Water Stress and Its Drivers Under Climate Change: A Global Study. *Earth's Future*, 8(7): 1–21. https://doi.org/10.1029/2019EF001321.

Tahiru, A. A., Doke, D. A. & Baatuuwie, B. N. (2020). Effect of Land Use and Land Cover Changes on Water Quality in the Nawuni Catchment of the White Volta Basin, Northern Region, Ghana. *Applied Water Science*, 10(8): 1–14. https://doi.org/10.1007/s13201–020–01272–6.

Tolo, C. U., Majule, E. A. & Perfect, J. (2012). Changing Trends of Natural Resources Degradation in Kagera Basin: Case Study of Kagera Sub-Basin, Uganda. *Natural Resources*, 03(03): 95–106. https://doi.org/10.4236/nr.2012.33014.

United Republic of Tanzania (URT). (2015). United Republic of Tanzania: Ngara District Council Socio-economic Profile Report. In *Population Policy Compendium*. https://doi.org/10.5089/ 9781513547442.002.

Veldkamp, T. I. E., Wada, Y., Aerts, J. C. J. H., Döll, P., Gosling, S. N., Liu, J., Masaki, Y., Oki, T., Ostberg, S., Pokhrel, Y., Satoh, Y., Kim, H. & Ward, P. J. (2017). Water Scarcity Hotspots Travel Downstream Due to Human Interventions in the 20th and 21st Century. *Nature Communications*, 8. https://doi.org/10.1038/ncomms15697.