EFFECT OF WASTE MANAGEMENT PRACTICES ON ENVIRONMENTAL SUSTAINABILITY: IMPLICATIONS FOR NATURAL RESOURCES.

CASE STUDY: RIVER RWIZI, MBARARA CITY

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LIST OF ACRONYMS

Acronym	Full Meaning
AFDB	African Development Bank
CETP	Common Effluent Treatment Plant
CO_2	Carbon Dioxide
EEA	European Economic Area
GHG	Greenhouse Gases
IPCC	Intergovernmental Panel on Climate Change
ISWA	International Solid Waste Association
MOUs	Memorandums of Understanding
MWE	Ministry of Water and Environment
NEMA	National Environmental Management Authority
NGOs	Non-Government Organizations
PAHs	Polycyclic Aromatic Hydrocarbons
PVC	Polyvinyl Chloride
SDGs	Sustainable Development Goals
SPSS	Statistical Package for Social Sciences
UBOS	Uganda Bureau of Statistics
UN DESA	United Nations: Department of Economic and Social Affairs
UNEP	United Nations Environment Programme
UNDP	United Nations Development Programme
UN-Habitat	United Nations Human Settlements Programme
WHO	World Health Organization

ABSTRACT

This study examined the effect of waste management practices on environmental sustainability and natural resources along the River Rwizi in Mbarara City. Specifically, it assessed the current status of waste practices, challenges faced by authorities and communities, and strategies for improvement.

A convergent parallel mixed-method design was adopted, integrating both qualitative and quantitative approaches. A total of 430 respondents were selected from a target population of 2,340 using stratified and systematic sampling, including 327 community members from Rwemigina and 103 from Mbarara Central Market. Key informants such as the city mayor, council clerk, environmental health officer, physical planner, and health inspector were purposively and snowball sampled. Data collection employed questionnaires for quantitative data and structured interview guides for qualitative insights. Quantitative data were analyzed using descriptive and inferential statistics, while qualitative responses were thematically summarized.

Findings revealed plastics (43.3%) and organic waste (39.6%) as the most common waste types, with municipal collection (24.7%) and open dumping (23.5%) as the dominant disposal methods. Only 32.7% of respondents were aware of waste segregation, indicating a major knowledge gap. Poor practices contributed to environmental degradation, contamination of the River Rwizi, waterborne diseases, reduced agricultural productivity, and loss of aquatic life. Challenges included inadequate funding, limited infrastructure, weak enforcement, and low community responsibility.

The study concludes that Mbarara City lacks an integrated and coordinated waste management framework, with gaps between policy and practice. It recommends increased budget allocation, stronger enforcement, public awareness campaigns, and the protection of the River Rwizi catchment zones through afforestation, drainage improvement, and strict anti-dumping laws. These measures would enhance sustainable waste management and safeguard natural resources.

CHAPTER ONE
GENERAL INTRODUCTION

1.1. Introduction

In recent decades, the global community faced escalating concerns related to rapid population growth, unsustainable resource exploitation, increasing environmental pollution, and ineffective waste management practices. These challenges triggered a renewed focus on sustainable development and environmental conservation, particularly in urban areas where the ecological footprint is most pronounced. In response, countries around the world began to realign their development priorities in pursuit of the Sustainable Development Goals (SDGs)**,** particularly Goal 15, which sought to "protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and biodiversity loss" (Piikani, and Magoma, 2021).

Urbanization, while often viewed as a driver of economic growth and modernization, increasingly contributed to a host of environmental challenges, chief among them being the generation and mismanagement of solid and liquid waste. In many developing countries, the pace of urban expansion has outstripped the capacity of municipal authorities to provide adequate infrastructure and services for waste collection, treatment, and disposal. The situation is especially dire in secondary cities such as Mbarara City in southwestern Uganda, where population growth, informal settlements, and industrial activity have led to mounting volumes of unmanaged waste, severely impacting local ecosystems, water bodies, and public health. River Rwizi, a critical water source for Mbarara and its surrounding communities, has been particularly affected by unregulated waste disposal, sewage discharge, and encroachment on riparian zones. These practices threaten not only the ecological health of the river system but also the livelihoods and well-being of residents who depend on the river for domestic, agricultural, and economic needs.

It is against this backdrop that this study sought to evaluate the impact of waste management practices on environmental sustainability in Mbarara City, which focused on the River Rwizi ecosystem. This research was meant to inform by both global discourses on sustainable urban development and local realities marked by governance, institutional, and infrastructural constraints. By examining the interplay between waste disposal methods (such as recycling, incineration, and

sewage treatment) and environmental outcomes, the study aimed to generate evidence that can guide policy reform, enhance community engagement, and support the implementation of integrated waste management strategies.

This introductory chapter outlined the foundational components of the study. It presented the background and rationale for the research, articulated the problem statement, defined the research objectives and questions, proposed hypotheses, and provided the justification, significance, and scope of the study. It also included operational definitions of key terms, which ensured clarity and consistency throughout the research process. Together, these elements established the framework for investigating how Mbarara City could move toward a more sustainable, inclusive, and environmentally resilient future.

1.2. Background of the Study

Across the globe, waste management has evolved from a peripheral concern to a central issue in discussions about environmental sustainability and public health. The global population has surpassed 8 billion, with a significant portion residing in urban areas, a trend that has driven the exponential increase in solid waste generation (UN DESA, 2022). This has placed immense pressure on national and local governments to rethink waste handling strategies in a way that conserves ecosystems, reduces pollution, and promotes sustainable development. Although global frameworks such as the Sustainable Development Goals (SDGs), particularly Goal 15, "Protect, restore and promote sustainable use of terrestrial ecosystems," set broad targets for environmental sustainability, the practical implementation of sustainable waste management remains fraught with inconsistencies, technical limitations, and region-specific challenges (UNDP, 2021).

Globally, disparities in waste management practices are stark. In many high-income countries, waste management systems are technologically advanced and embedded in strong policy frameworks. Legal mandates, infrastructure, and a robust recycling culture support these systems. For instance, countries like Germany and Sweden adopt the circular economy model, where waste is considered a resource and reintegrated into the production cycle through recycling, composting, and energy recovery (EEA, 2020). Germany, for example, boasts a municipal recycling rate of over 60% and utilizes waste-to-energy plants to reduce landfill use (European Commission, 2020).

Additionally, public awareness and compliance are often high in these contexts due to consistent environmental education and enforcement mechanisms.

Nonetheless, even in these countries, challenges such as electronic waste management, plastic pollution, and transboundary shipments of hazardous waste persisted. Reports indicated that a significant share of hazardous e-waste from developed countries ended up in developing nations, raising ethical and environmental concerns (Basel Convention Secretariat, 2020). This revealed that global waste issues were not confined within national borders but were part of broader systems of production and consumption that required coordinated international responses.

In contrast, developing nations faced a different set of realities. Waste management systems in low- and middle-income countries were often rudimentary and characterized by informal practices, weak regulation, and resource constraints (Wilson et al., 2015). Open dumping, burning of waste, and illegal landfills prevailed across many African, South Asian, and Latin American cities. These practices had serious environmental implications, polluting air, water, and soil, and posed significant public health risks (Hoornweg & Bhada-Tata, 2012). Urbanization in many developing countries outpaced infrastructural development, resulting in uncollected and mismanaged waste that accumulated in open spaces, drainage systems, and ecologically sensitive areas such as wetlands and rivers (UN-Habitat, 2020).

Regionally, East Africa grappled with balancing rapid urban expansion and environmental protection. In cities such as Nairobi and Dar es Salaam, community-based waste collection models and public-private partnerships emerged as partial solutions. However, the lack of comprehensive policy enforcement, fragmented institutional mandates, and limited financing hindered large-scale transformation (Kaza et al., 2018). Informal waste pickers, who played a vital role in collection and sorting, were often excluded from official waste management systems and faced unsafe working conditions without recognition or support (Medina, 2010).

Uganda exemplified these challenges. While the Local Government Act assigned responsibility for waste management to urban authorities, implementation remained weak due to budgetary constraints, inadequate equipment, and poor institutional coordination (NEMA, 2019). With rapid population growth and urban sprawl, cities like Mbarara were under immense pressure. Waste generated from households, markets, and commercial establishments was often disposed of through

open dumping or unregulated burning. These methods were both environmentally unsustainable and dangerous to public health (Ayorekire et al., 2021).

Mbarara City, a rapidly growing urban hub in western Uganda, faced an urgent waste crisis. The lack of sanitary landfills, waste segregation systems, and public education programs meant that solid waste was often discarded in wetlands or near water bodies. A particularly vulnerable site was River Rwizi, which traversed the city and served as a lifeline for surrounding communities. Studies indicated that River Rwizi experienced declining water quality due to direct dumping of solid and liquid waste, encroachment on buffer zones, and sedimentation from upstream activities (Biryahwaho et al., 2020). The river, which historically supported a variety of ecosystems and livelihoods, faced threats to biodiversity, water availability, and human health.

These environmental pressures were compounded by climate change. Increased rainfall intensity resulted in higher surface runoff, which mobilized uncollected waste into the river system, while periods of drought concentrated pollutants due to reduced water flow (IPCC, 2022). This complex interplay between waste, urban growth, and ecosystem decline signalled the need for more holistic and integrated responses to waste management, ones that were tailored to local realities and informed by community participation.

A major gap in addressing these challenges lay in the fragmented and technocratic approach to waste management. Policies often prioritized infrastructure, such as waste bins and trucks, over system-wide strategies that incorporated behavioral change, multi-stakeholder engagement, and ecological principles (Mwesigye et al., 2019). Additionally, there was limited investment in knowledge generation to understand how local cultural, political, and economic dynamics shaped waste practices. This resulted in the replication of global models that were not well-suited to the Ugandan context.

Another underexplored area was the link between waste management and natural resource conservation. In Mbarara, the degradation of River Rwizi was symptomatic of weak environmental governance and the disconnect between human settlements and natural ecosystems. Despite being critical for water supply, food security, and biodiversity, the river was treated as a dumping ground. This reflected a lack of awareness about ecosystem services and the absence of environmental education in waste management strategies (NEMA, 2021).

While countries worldwide shared a common goal of achieving sustainability, the capacities to reach this goal differed vastly. For secondary cities like Mbarara, the stakes were particularly high. Without urgent and context-specific interventions, the ecological and social consequences of poor waste management continued to escalate. The degradation of River Rwizi was not just a waste issue; it was an indicator of systemic failure in managing urban growth and environmental resources. This study, therefore, sought to investigate how waste management practices in Mbarara City influenced environmental sustainability, with a particular focus on the health of River Rwizi. By illuminating these interconnections, the study aimed to contribute to evidence-based policy and community-driven solutions for sustainable urban futures in Uganda.

1.3. Problem Statement

Mbarara City, one of Uganda's fastest-growing urban centers, is currently grappling with a deepening environmental crisis, primarily rooted in ineffective waste management systems and fragmented environmental governance. Over the past two decades, the city's population has more than doubled, from 82,000 in 2002 to over 195,000 by 2023 (UBOS, 2023), driven by increased rural-to-urban migration, industrial expansion, and economic activity. This rapid urbanization, however, has occurred without commensurate investment in sustainable infrastructure and public services, particularly in the area of solid and liquid waste management. The result has been an exponential increase in the volume, complexity, and diversity of waste produced, overwhelming the city's limited collection, transportation, and disposal capacity (Katusiime, Nabimanya, and Komwangi, 2022).

This surge in unmanaged waste has placed severe strain on natural ecosystems, most notably the River Rwizi, a critical freshwater body that supports domestic consumption, agriculture, fishing, and small-scale industry across the Ankole sub-region. Despite the presence of waste collection contracts with private firms and the existence of a composting facility at Rwentondo, waste service coverage remains highly uneven. Many peri-urban and informal settlements, such as Rwemigina and Biharwe, lack routine waste collection, leading to the proliferation of illegal dumping sites, open burning, and indiscriminate disposal into drainage channels and wetlands (Walter et al., 2019).

A growing body of evidence indicates that these poor waste practices have led to severe pollution of the River Rwizi. Water testing reports and field observations have revealed alarming levels of pollutants, including plastic debris, nitrates, phosphates, heavy metals, and untreated sewage (Water Resources Institute, 2022, and Walter et al., 2019). These contaminants not only disrupt aquatic life and degrade biodiversity but also undermine irrigation systems and contribute to the decline in agricultural productivity. The health repercussions for downstream communities are equally significant, with frequent outbreaks of waterborne diseases such as cholera, dysentery, and typhoid (MWE, 2022; WHO, 2021; and Tumwebaze and Orach, 2012). In addition to environmental degradation, Mbarara's waste crisis exposes deep institutional weaknesses. There is poor coordination between various urban agencies, unclear roles and responsibilities, insufficient technical and financial capacity, and limited involvement of informal waste actors such as scavengers and pickers (Katusiimeh, Nabimanya, and Komwangi, 2022). These actors, despite playing a crucial role in materials recovery, operate outside the formal system and without institutional support, resulting in inefficiencies and lost opportunities for circular economy integration. The current waste management model remains largely reactive and infrastructure-driven, prioritizing collection logistics (e.g., trucks, bins) while neglecting softer but critical aspects such as enforcement, community education, behavior change, and participatory governance.

National-level policy frameworks, including the National Environment Act (2019), Uganda Vision 2040, and the National Urban Solid Waste Management Policy (2020), do exist. However, their impact is muted by weak local-level implementation, lack of contextualization, and inadequate stakeholder inclusion (Katusiimeh, Mol, and Burger, 2013). Policy instruments are often top-down, disconnected from local realities, and fail to integrate environmental sustainability into broader socio-economic development agendas. As a result, Mbarara's urban poor continue to bear the heaviest burden, facing higher exposure to pollution and being excluded from both decision-making and the benefits of environmental programs. This disconnect between policy and practice has reinforced systemic environmental injustice, where vulnerable communities living near dumpsites or riverbanks are exposed to higher risks but lack voice, services, or recourse (Njeru, 2006). These challenges underscore the need for a paradigm shift, from a fragmented, techno-centric, and enforcement-heavy approach to a holistic, participatory, and sustainability-driven waste management framework.

In response to these challenges, this study aimed to critically examine the effectiveness of current waste management strategies in Mbarara City, analyze the ecological and socio-economic consequences of River Rwizi's pollution, and identify both systemic weaknesses and opportunities for reform. By focusing on waste practices such as recycling, incineration, and sewage treatment, the study sought to inform a more integrated and inclusive urban environmental management model, one that promotes ecological resilience, environmental justice, and sustainable development in Uganda's fast-growing secondary cities.

1.4. Objectives of the Study

1.4.1. General Objective

The study examined the effect of waste management practices on environmental sustainability and natural resource conservation in the River Rwizi ecosystem within Mbarara City.

1.4.2. Specific Objectives

1. To assess the current status of waste management practices along the River Rwizi, Mbarara City.
2. To investigate the key challenges faced by local authorities, communities, and businesses in implementing effective waste management strategies that promote environmental sustainability along the River Rwizi.
3. To examine the socio-economic implications of ~~poor~~ waste management practices on local communities dependent on the River Rwizi for livelihoods and resources.

1.5. Research Questions

1. What was the status of waste management practices along the River Rwizi in Mbarara City during the study period?
2. What challenges are faced by local authorities, communities, and businesses in implementing effective waste management strategies?
3. What were the socio-economic implications of inadequate waste management practices on local communities that depended on the River Rwizi for their livelihoods and resources?

1.6. Scope of the Study

1.6.1. Content Scope

The study focused on assessing the impact of specific waste management practices on environmental sustainability in the River Rwizi ecosystem, Mbarara City. In line with the stated objectives, the content scope was limited to examining three main waste management approaches and their environmental implications:

The study analyzed the role of recycling practices along the River Rwizi in promoting This study specifically focused on assessing the impact of selected waste management practices on environmental sustainability within the River Rwizi ecosystem in Mbarara City. The scope was defined to align with the study's overall objective of understanding how solid and liquid waste disposal methods affect environmental quality, ecological balance, and public health outcomes in this rapidly urbanizing context. To maintain analytical depth and thematic coherence, the study concentrated on three primary waste management approaches: recycling**,** incineration, and sewage waste treatment, with each evaluated for its implementation, effectiveness, and environmental implications for the River Rwizi.

Recycling was explored as a proactive strategy for mitigating solid waste accumulation and conserving natural resources. The study examined both formal and informal recycling initiatives within Mbarara City, evaluating their scope, community involvement, logistical challenges, and impact on reducing plastic, paper, and organic waste along the River Rwizi. Particular attention was paid to whether existing recycling practices meaningfully reduce pollution levels, support resource recovery, and contribute to long-term sustainability.

Incineration was assessed as a disposal method with both potential benefits and drawbacks. The study investigated the extent to which incineration is practiced in the city, the types of waste typically incinerated, and the operational standards governing such facilities (if any). Emphasis was placed on understanding the environmental trade-offs, such as the emission of toxic substances and greenhouse gases, and determining whether incineration contributes to or undermines ecological sustainability and public health, especially in communities located near the river.

Sewage Waste Treatment was included in the study due to its direct link to water pollution in the River Rwizi. The research critically evaluated the existing sewage treatment infrastructure in Mbarara City, including centralized and decentralized systems, and their capacity to process domestic and industrial effluents. The study examined whether untreated or inadequately treated wastewater contributes to declining water quality, ecosystem degradation, and increased incidence of waterborne diseases. It also explored opportunities for improving sewage management to align with national environmental protection standards and support a healthier river ecosystem.

By focusing on these three pillars of waste management, the study has provided a comprehensive picture of how current practices shape the environmental sustainability of the River Rwizi ecosystem. It has also identified areas where policy, community action, and technological investment are urgently needed to restore ecological balance and enhance urban resilience in Mbarara City.

1.6.2. Geographical Scope

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The study was conducted in Mbarara City, which is located in southwestern Uganda. Mbarara City in the Western Region of Uganda is the second largest city in the country after Kampala. The city is divided into six boroughs: Kakoba Division, Kamukuzi Division, Nyamitanga Division, Biharwe Division, Kakiika Division, and Nyakayojo Division. The study focused on the effects of waste management on environmental sustainability in River Rwizi within Mbarara City. The independent variable was waste management approaches, while the dependent variable was measured using indicators such as sensitization, enforcement, and packaging

1.6.3. Time Scope

The time scope of this study spanned from 2010 to 2024. This period marked the onset and escalation of waste management challenges in Mbarara City, particularly regarding the pollution of River Rwizi. Since 2010, Mbarara City has undergone substantial urbanization, industrial growth, and population expansion, which led to increased waste generation and placed a strain on local waste management systems (Nabugoomu et al., 2017). Reports from the National Environment Management Authority (NEMA) highlighted these concerns, noting a steady rise in plastic pollution, untreated industrial waste, and poorly managed sewage discharge into River Rwizi. These developments contributed to water quality degradation and ecosystem disruption (NEMA, 2019).

1.7. Significance of the Study

This study on waste management practices and environmental sustainability in Mbarara City, with a specific focus on the River Rwizi ecosystem, holds substantial significance for multiple categories of stakeholders at the local, regional, and national levels. For local government authorities, the study offers data-driven insights into the effectiveness and shortcomings of current waste management systems. These findings are to enable policymakers and urban planners to design more robust, inclusive, and enforceable waste management policies that are responsive to both infrastructural constraints and community needs. Enhanced enforcement mechanisms and targeted resource allocation, guided by this research, are to contribute to reducing pollution levels in the city's waterways, especially the highly vulnerable River Rwizi.

For environmental agencies and advocacy organizations, the study is to provide empirical evidence that supports ongoing campaigns to promote sustainable environmental practices. It offers practical recommendations that can be used to lobby for stronger regulatory frameworks, improve inter-agency coordination, and guide the implementation of community sensitization programs. The data also strengthens grant proposals and funding justifications for environmental interventions in the region.

Local communities, particularly those residing near or depending on River Rwizi for drinking water, agriculture, fishing, and small-scale industries, stand to benefit both directly and indirectly. Directly, they may experience improved water quality, safer waste disposal practices, and cleaner public spaces. Indirectly, better environmental conditions reduce exposure to waterborne diseases such as cholera and typhoid, lower healthcare costs, and support agricultural productivity, thereby enhancing the overall quality of life and resilience of the community.

Furthermore, academic researchers and students in environmental science, public health, and urban studies will find this study valuable as a foundational reference. It is to contribute to the existing body of literature on urban waste management in secondary cities and offers a case study that can be adapted or expanded in other urban contexts facing similar challenges. In doing so, the study not only enriches academic discourse but also bridges the gap between research, policy, and practice, supporting Uganda's efforts to achieve Sustainable Development Goals (SDGs), particularly those related to clean water (Goal 6), sustainable cities (Goal 11), and climate action (Goal 13).

1.8. Justification of the Study

This study was critically necessary due to the rapid and unregulated urban expansion of Mbarara City, which has outpaced the development of effective environmental management systems. As the second-largest urban center in Uganda, Mbarara has experienced a surge in population, economic activity, and infrastructure development over the past two decades. However, this growth has not been matched by adequate investment in sustainable waste management strategies. One of the most visible consequences of this imbalance is the deterioration of the River Rwizi ecosystem, the city's primary water source for domestic, agricultural, and industrial use. River Rwizi has become increasingly polluted due to unchecked solid waste dumping, inadequate sewage treatment, and poor enforcement of environmental regulations.

Public concern over these issues has been growing. For instance, as early as 2006, reports highlighted the presence of open garbage dumping sites and the discharge of leachate into the nearby Rwentondo stream, raising alarms about groundwater contamination and the health risks posed to downstream communities (Bifubyeka, 2016). Despite national policy frameworks such as the National Environment Act (2019) and the Local Government Act (1997), implementation at the city level has been weak, fragmented, and under-resourced. Existing municipal waste collection services are concentrated in central urban zones, leaving peri-urban areas like Rwemigina underserved and heavily reliant on unsafe disposal practices such as open dumping and burning.

This study was therefore designed to fill critical knowledge and practice gaps by systematically assessing the effectiveness of current waste management approaches in Mbarara City and their implications for environmental sustainability, public health, and policy compliance. Through an integrated analysis of local waste management practices, community behaviors, and institutional frameworks, the study provides evidence-based insights that can inform targeted interventions, policy reforms, and community-driven solutions. It is particularly timely as it supports Uganda's broader environmental goals under Vision 2040 and the Sustainable Development Goals (SDGs), specifically Goal 11 on sustainable cities and Goal 15 on the protection of terrestrial ecosystems.

1.9. Theoretical framework

The theoretical framework for this study provides a structured lens through which the interrelationships between waste management practices and environmental sustainability can be systematically analyzed. It is grounded in Systems Theory, which emphasizes the dynamic interaction between various components within an ecosystem. At the core of this framework is the independent variable, waste management approaches**,** which the study disaggregates into three key thematic dimensions: recycling practices**,** incineration techniques, and sewage/wastewater treatment. Each of these dimensions encompasses specific sub-variables such as waste segregation, plastic reuse, composting, waste-to-energy conversion, effluent treatment, and public sensitization efforts.

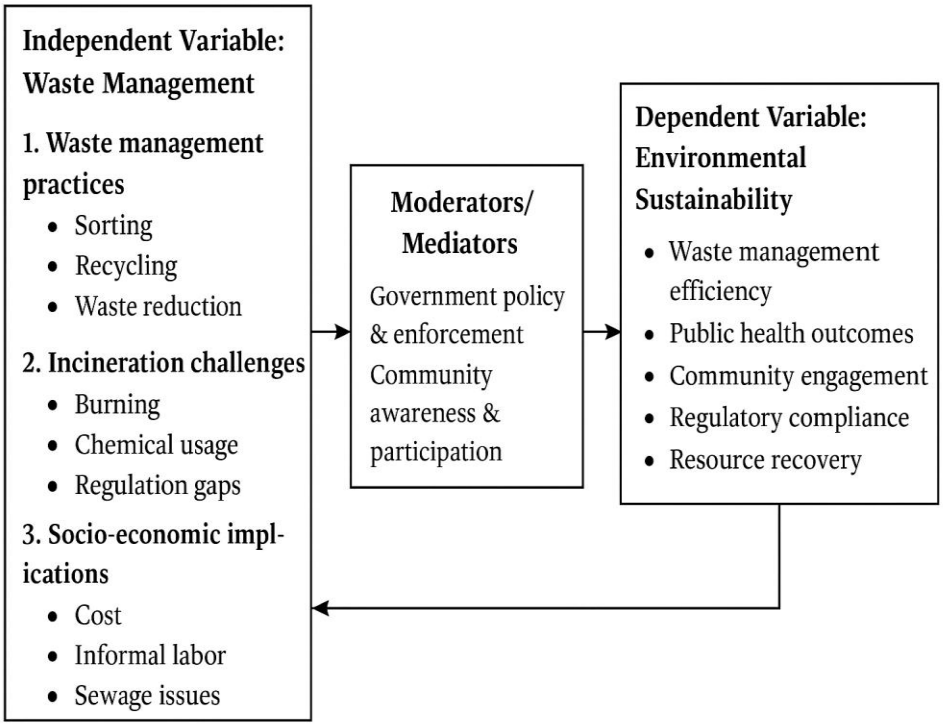
The dependent variables include environmental sustainability**,** waste management efficiency**,** public health outcomes**,** community engagement**,** regulatory compliance, and resource recovery**.** These indicators collectively capture the outcomes associated with effective or ineffective waste management systems. For instance, environmental sustainability is assessed through indicators such as water quality in River Rwizi, reduction in illegal dumping, and ecological restoration. Public health outcomes are linked to the prevalence of waste-related diseases like cholera and typhoid, while waste management efficiency encompasses service coverage, collection frequency, and infrastructure adequacy.

The theoretical framework also integrated mediating and moderating variables such as policy enforcement**,** institutional coordination**,** budget allocation, and community behavior, which influence how the core relationships manifest. These variables helped contextualize the complexities of waste governance in Mbarara City and highlight areas where interventions can be most effective.

By mapping out these relationships, the framework aligned directly with the study's research objectives and questions. It offered a comprehensive and coherent basis for analyzing how waste management practices shape environmental and public health conditions, and it guided both the methodological design and interpretation of findings. The framework thus served not only as a visual tool but also as an analytical blueprint for the entire research process.

1.10. Conceptual framework

Figure 1: Conceptual Framework



1.10. Definition of Terms

1.10.1. Waste Management

Waste management refers to the collection, transportation, treatment, recycling, and disposal of waste materials in a manner that minimizes environmental and health risks (United Nations Environment Programme [UNEP], 2020). It includes strategies such as recycling, composting, incineration, and landfill management to ensure proper waste handling and resource conservation (Hoornweg & Bhada-Tata, 2020).

1.10.2. Environmental Sustainability

Responsible interaction with the environment involves preventing the depletion of natural resources and ensuring the long-term health of ecosystems (Brundtland Report, 1987). It includes waste reduction, pollution control, biodiversity conservation, and sustainable resource use to maintain ecological balance (Meadows, 2008).

1.10.3. Solid Waste

Solid waste encompasses all discarded materials from households, industries, and institutions, including organic waste, plastics, paper, metals, and hazardous waste (International Solid Waste Association [ISWA], 2015). Proper solid waste management is crucial in preventing environmental pollution and maintaining public health (Mugabi, Tumusiime & Nabaasa, 2018).

1.10.4. Recycling

Recycling is the process of collecting and processing waste materials into new products, thereby reducing waste generation, conserving resources, and minimizing environmental pollution (European Commission, 2020). It is a key component of the circular economy and sustainable waste management (Ayeleru et al., 2020).

1.10.5. Incineration

Incineration is a waste treatment process that involves the combustion of organic substances in waste materials to reduce volume and generate energy, although it can release harmful pollutants if not properly managed (Gupta & Singh, 2018). It is often used as an alternative to landfilling in urban waste management systems (Ren et al., 2020).

1.10.6. Sewage Treatment

Sewage treatment is the process of removing contaminants from wastewater, including domestic and industrial effluents, to produce environmentally safe water that can be reused or discharged into natural water bodies (Rajasekhar et al., 2018). Effective sewage treatment helps to prevent water pollution and protect aquatic ecosystems (Kesari et al., 2021).

1.10.7. Water Pollution

Water pollution refers to the contamination of water bodies (rivers, lakes, oceans) by substances such as industrial waste, chemicals, plastics, and untreated sewage, leading to harmful effects on human health and aquatic life (Giri, Singh & Mahato, 2020). Poor waste management is a significant contributor to water pollution (NEMA, 2019).

1.10.8. Community Participation

Community participation in waste management involves the active engagement of residents in decision-making, waste segregation, recycling programs, and clean-up initiatives to promote environmental sustainability (Owino, Katumba & Owor, 2020). It enhances awareness and ensures the success of waste management programs (Mwesigye, Dalsgaard & Sarkar, 2019).

CHAPTER TWO
LITERATURE REVIEW

2.1. Introduction

This section reviewed scholarly literature, policy documents, theoretical perspectives, and empirical research related to waste management and environmental sustainability, particularly as it pertains to the River Rwizi ecosystem in Mbarara City. It drew from a wide range of sources, including books, peer-reviewed journals, government regulations, guidelines, workshop proceedings, newsletters, and web-based resources. The review aimed to establish a solid conceptual and empirical foundation for this study by highlighting key themes, theoretical frameworks, and the relationship between key variables. It also identified knowledge gaps that this study sought to address.

2.2. Theoretical review

The study was guided by Systems Theory, which emphasized the interconnectedness and interdependence of various components within a system. This theory was particularly relevant for understanding the complexities of waste management practices and their impact on environmental sustainability in the River Rwizi ecosystem. Systems Theory asserts that a system is made up of interconnected components that cooperate to accomplish a common objective (Von Bertalanffy, 1968). In the context of waste management, these parts included various stakeholders such as local government authorities, community members, businesses, and environmental agencies, all of which play a role in the waste management system. The interactions among these stakeholders significantly influence the effectiveness of waste management practices and their environmental outcomes.

Furthermore, Systems Theory allowed for the examination of feedback loops within the waste management system. For instance, the effectiveness of recycling initiatives can lead to reduced waste accumulation, which in turn improves the quality of the River Rwizi and enhances community health (Meadows, 2008). Conversely, poor waste management practices can create negative feedback loops that exacerbate environmental degradation and public health issues (Sterman, 2000).

By applying Systems Theory, the study explored how various waste management practices, such as recycling, incineration, and waste reduction, interact with environmental sustainability and public health outcomes. This approach provided a comprehensive understanding of the challenges and opportunities in managing waste effectively while promoting a sustainable environment in Mbarara City. This theory provided a robust framework for analyzing the interaction between waste management systems and their environmental consequences, which is central to the current study. The sections that follow elaborate on the current status of waste management in Mbarara City, including recycling, incineration, and sewage treatment, while identifying their implications for environmental sustainability and proposing locally relevant solutions.

2.3. Current status of waste management practices.

The current status of waste management practices in Mbarara City was a pressing issue that directly impacts the health of River Rwizi and the surrounding communities. The literature revealed a complex landscape characterized by rapid urbanization, inadequate infrastructure, and insufficient public awareness. As Mbarara City continues to grow, the volume of waste generated has increased significantly, yet the systems in place to manage this waste have not kept pace (NEMA, 2019). This discrepancy raised critical questions about the effectiveness of current waste management practices and their implications for environmental sustainability.

Research indicated that local authorities face numerous challenges in implementing effective waste management strategies. For instance, Byamukama et al. (2015) highlight the lack of community engagement and public participation as significant barriers to successful waste management. This disconnect between local authorities and residents not only hampers compliance with waste management regulations but also exacerbates the socio-economic impacts of poor waste management on communities that rely on River Rwizi for their livelihoods. Therefore, understanding the current status of waste management practices is essential for identifying effective strategies to enhance environmental sustainability and protect natural resources.

2.3.1. Recycling and environmental sustainability

Recycling is a critical component of sustainable waste management, yet its implementation in Mbarara City remains limited. The literature suggested that while recycling initiatives exist, they are often underfunded and lack the necessary infrastructure to be effective (Oduro et al., 2018). Community involvement is crucial for the success of recycling programs, as public awareness and

education significantly influence participation rates. When communities are informed about the benefits of recycling, they are more likely to engage in these initiatives, leading to reduced waste accumulation and improved environmental quality.

A quantity of plastic waste has accumulated in the environment (Wurm, Spierling, Endres & Barner, 2020). Post-consumer plastic waste is generally managed through landfills, incineration, and recycling (Mousavimehr & Nematzadeh, 2020). However, these methods have no substantial effects on decreasing the quantity of discarded plastic waste. Therefore, such techniques have nothing to do with practice because landfills and incineration cause serious environmental issues.

Currently, the application of discarded plastic in construction is considered one of the emerging concepts for managing large amounts of plastic waste and reducing environmental risks. The use of plastic waste is becoming one of the most stimulating processes in construction and has been extensively investigated in the last few years (Almeshal et al., 2020). The application of discarded plastic in civil construction reduces the intake of natural aggregates. Many scientists have worked on the possibility of using various types of plastic waste for construction activities (Aldahdooh et al., 2018).

Small plastic particles were added to various building activities, including bricks, mortar, pavement, concrete, and others. Coppola et al. (2016) showed that 10% and 25% of mortar comprising plastic aggregate could achieve tensile strengths of 35.12 and 22.86 MPa, respectively, which passed the American Concrete Institute's building standards (17.25 MPa). Several patents have been approved for the use of discarded plastic as a composite material. Since construction materials are made from plastic waste, various environmental problems significantly influence the successful implementation. According to Zhang et al. (2013), plastic trash can release small pollutants, negatively affecting the public and industry. Research studies on plastic waste applications in different construction activities.

Single-use plastic bags, disposable food containers, food wrap films, and their main components of polythene, polypropylene, and poly (vinyl chloride) can be photo-catalytically transformed into valuable fuels without using sacrificial agents. Jiao et al. (2020) described that plastic wastes could be converted into C2 fuels over a photo catalyst under simulated natural environment conditions. Plastic waste will be degraded into CO2 by a photo-oxidative C–C bond cleavage; then the produced

CO2 will be reduced into valuable C2 fuels by a photo-induced C–C bond coupling. Szarka et al. (2021) noted that PVC could be converted into oily products by a simple (and relatively low-temperature) thermo-oxidative process. Adamczak et al. (2020) reported a direct method to selectively convert polyolefin to branched, liquid fuels, including diesel, jet, and gasoline-range hydrocarbons over a nanomaterial in hydrogen. The process proceeds via tandem catalysis with the initial activation of the polymer, and then subsequent cracking. Transforming plastic waste into fuel may help address the white pollution crisis and harvest highly valuable multi-carbon fuels.

Plastic waste materials can be used to synthesize membranes and carbon-based adsorbent materials for wastewater treatment and reclamation. Adamczak et al. (2020) synthesized an ultrafiltration membrane from polystyrene waste material. The synthesized membrane is to be used to treat river surface water. The polystyrene waste ultrafiltration membrane was tested with different concentrations of waste polymer to determine the membrane with the most favorable properties. Kumari et al. (2020) converted solid waste plastic into activated carbon Nano fibers through chemical activation and carbonization processes. The synthesized activated carbon Nano fibers treated the thymus blue dye in wastewater via adsorption. These applications offered a great avenue for recycling plastic waste regardless of modifications or technical works to fulfil the important objective of water and wastewater treatment (Yuan et al., 2020).

Recently, the Anta group had a breakthrough; overcoming many technical barriers, they developed a proficient method for producing polyester fiber from plastic bottles. The waste plastic bottles of 1 L and 550 mL were recycled using single-energy technology clothing and resulted in a 30–50% reduction in overall processing costs compared to international brands. In China, carpet making using waste plastic is well developed. A Shandong-based carpet manufacturing company has recycled around 2.6 billion waste plastic bottles to make 6 million blankets. Recycling plastic bottles not only reduces pollution but also comes with economic benefits. Another example is the red carpet used in China's military parade in 2019; it will be spectacular, environmentally friendly, and prepared with 400,000 waste plastic bottles. The better functional properties observed in textiles and carpets produced by this technology are abrasion resistance, better elasticity, mildew, and insect resistance compared to animal and plant fibers (Qin et al., 2019).

Watson et al. (2020) reported that 50–75% of synthetic textiles collected in Europe had been recycled or reused in other value-added textile products. Most non-reusable synthetic materials have been landfilled or incinerated (Qin et al., 2019). PET is the most common fiber for sportswear, but acrylic, elastin, nylon, and propylene are also used. Fiber blends and functional coatings are commonly used in textiles for specific applications, such as footwear, which is comfortable, resistant to extreme weather, and fashionable. In sportswear textiles, moisture regulation and temperature are important characteristics to ensure adequate thermal insulation while releasing body heat and sweat during exercise.

A textile in sportswear also requires stretch ability, free movement, and coatings for reduced wear and tear or injuries. Kim et al. (2019) evaluated the feasibility of the valorization of plastic waste for its recycling. For biological plastic waste valorization, plastic debris will be depolymerized by chemical hydrolysis, and terephthalic acid and ethylene glycol monomers will be converted to a variety of higher-value chemicals using various metabolically engineered whole-cell microbial catalysts. By introducing a terephthalic acid degradation pathway into microbes, terephthalic acid will be converted into high-value-added aromatic or aromatic-derived chemicals, namely, protocatechuic acid, Gallic acid, pyrogallol, catechol, moronic acid, and vanillic acid, to be used for manufacturing pharmaceuticals, cosmetics, sanitizers, animal feeds, and bio plastic monomers.

Chaudhary et al. (2019) highlighted the sustainable approach of transforming plastic waste comprising bottles, used cups, and polythene bags via simple heating to fluorescent carbon dots (C-dots). The obtained C-dots displayed absorption peaks at around 260 nm with sizes of 5–30 nm. Recycling has produced structural changes in plastic waste and affected the optical properties of C-dots. The toxicity profiling of C-dots has been successfully tested by employing multi-assay biocompatible activities that are antibacterial and antifungal. The potential prospect of C-dots derived from plastic waste has been explored in analytical applications involving selective copper metal ion sensing in aqueous media. Chaudhary et al. (2019) highlighted the potential accomplishment in preserving the environmental fate and responding to the budding social issue of plastic waste.

The research questions regarding the current status of waste management practices and the socio-economic impacts of inadequate recycling efforts are particularly relevant in this context. By examining the effectiveness of existing recycling programs, this study aimed to identify barriers to

participation and propose strategies for enhancing community engagement. The literature indicated that successful recycling programs not only mitigate waste pollution but also contribute to the conservation of natural resources, thereby promoting environmental sustainability.

Despite global innovations in plastic recycling, Mbarara City has yet to adopt scalable solutions, such as plastic-to-fuel or plastic-based construction materials. This study investigated such gaps in local practice and perception

2.*3.2*. Incineration and environmental sustainability

One of the popular municipal solid waste treatment technologies is incineration (Ren et al., 2020). This is because incineration technology provides a more productive way of decreasing the amount of urban solid waste that needs to be landfilled. Incineration of municipal solid waste can minimize its mass by 70% and volume by 90% (Luo et al., 2019), as well as electricity and heat recovery (Allegrini et al., 2015). Compared with the most popular waste treatment methods (such as sanitary landfills and composting), incineration with air emission management systems is deemed a safer option (Li et al., 2019). The integration of incineration and other waste management methods, such as batch and semi-batch conventional distillation, biological treatment of wastewater, entrained-based distillation, physical adsorption, and extraction for the treatment of hazardous waste produced by the chemical industries, can help to achieve sustainable development in African countries (Omwoma et al., 2017).

Incineration is extensively applied as one of the treatment approaches used to decrease the volume of solid waste (dos Santos et al., 2020). Incineration can reduce approximately 80% to 90% of different kinds of debris, which is an important advantage (Yogalakshmi & Singh, 2020). The incineration of plastic waste would emit hazardous emissions and detrimental constituents, including particulate matter, dioxins, CO, furans, metals, and volatile organic chlorides (Guptaa & Singhb, 2018). The incineration process helps to dispose of plastic waste on an industrial scale. Moreover, it produces heat energy used for electricity generation and other accomplishments (Uekert et al., 2018). Incineration of waste with a high moisture content of 60% to 65% is not feasible because it will affect the rate of energy production during incineration (Adam & Nowack, 2017).

Guo et al. (2018) assessed the ecological impacts of urban solid waste incineration in a traditional Chinese business park. The researchers concluded that municipal solid waste incineration in-use reserves have favorable environmental advantages for climate impact, human pollution, and acidification, but have a detrimental effect on eutrophication potential. The emission features of parent halogenated PAHs in simulated solid waste incineration have been investigated (Li et al., 2019).

Ashkan et al. (2017) conducted an environmental life cycle assessment for the incineration of municipal solid waste in Iran. It was found that due to the production of electricity and phosphate fertilizers, incineration reduces detrimental factors related to toxicity. The authors also realized the estimated GHG emissions from the incineration of solid waste to be 4499.07 kg CO2 eq. As can be seen from the above international literature, most authors have only focused on GHG emissions from waste incineration. Besides, some of the authors concentrated on fossil depletion potential, acidification potential, eutrophication potential, and toxicity, but did not consider the dioxin emissions potential of waste-to-energy incineration technology.

In the context of Mbarara City, the effectiveness of incineration as a waste management strategy raises important questions about its sustainability. The literature suggests that without proper regulation and monitoring, incineration can lead to environmental degradation rather than mitigate it. This aligns with the research questions focused on improving waste management practices to enhance environmental sustainability, as it is essential to evaluate the long-term impacts of incineration on the River Rwizi ecosystem. The study will explore whether incineration can be managed sustainably and what measures can be implemented to minimize its negative effects. Although widely used globally, incineration in Mbarara City remains controversial due to limited regulatory oversight and community health concerns. This study assesses whether it offers a viable path for waste reduction without exacerbating environmental risks.

2.3.3. Sewage water treatment on environmental sustainability

Wastewater results from normal life activities too, and domestic wastewater, along with agricultural, industrial, and commercial waste, have emerged as major sources of wastewater (Rajasekhar, Nambi & Govindarajan, 2018). Industries need water of high quality, but, in exchange, a massive amount of contaminated and polluted water is produced and discharged into enormous bodies of water, polluting them (Rout et al, 2020). Worsening water quality exacerbates water

shortages and endangers human health. Wastewater originates from different sources of sewage, industrial, agricultural, and commercial waste, and can be differentiated by its physical appearance, chemical composition, and microbiological load (Giri Singh & Mahato, 2020). A complex matrix, wastewater is made up of 99.9 per cent water, and the remaining 0.1 per cent is made up of suspended solids, organic and inorganic solids, dissolved biodegradable organics, and other particulate matter (Warwick, Guerreiro & Soares, 2013).

Effluent Treatment Plants are used in chemical- and pharmaceutical-related industries. These industries use water-purification technologies for the elimination of dangerous and harmless chemicals. In the production of medicines, contaminants and effluents are generated, which need to be treated before being discharged into the water bodies. The medication's pollution, dust, debris, polymers, and grain are collected from treatment facilities (Soller, Eftim & Nappier, 2018). The plant uses the process of drying and evaporation to treat wastewater. Wastewater treatment facilities are structured as such to minimize the danger of contamination.

Chemical, physical, and biological processes are used to eliminate natural and physiological contaminants. Pre-treatment processes aid in the elimination of untreated wastewater components. Stress is applied to sewage water, and other contaminants are removed from the sewage flow. This results in the production of clean water that can be used in homes or business properties for different purposes (Bagheri et al., 2015). Common and Combined Wastewater Treatment Facilities are utilized when tiny industrial units are placed because bigger systems cannot be employed. The CETP is situated in small industrial units. The primary objective of the CETP is to lower the costs of dealing with small enterprises (Kesari et al., 2021). CETP systems aid small industries in processing wastewater with little expenditure.

The biological treatment of wastewater involves two aerobic processes, i.e., suspended growth and fixed film. Activated sludge is often used for suspended growth systems. Anaerobic bacteria present in wastewater convert the organic material into biogas. When the organic content of effluent becomes too dissolved, anaerobic treatment is advised (Deshpande et al., 2020). The quantity of the pollutant that needs to be removed and the technology being used generally determine the number of stages required to treat wastewater (Yaqoob et al., 2020).

The first step in wastewater treatment is the elimination of large and heavy particles by preliminary treatment. Screening the particles and removal of grit are typically the steps of preliminary treatment. The process of screening removes floating trash such as papers and plastics. Removal of grit then takes place, which removes inorganic particles such as sand and other particulate matter. The primary treatment of wastewater also consists of a sedimentation process that eliminates suspended debris. Sedimentation of the particles takes place in large tanks where it is allowed to settle for several hours, enabling suspended particles to settle or form smut, which is then skimmed off, and the sludge is removed (Kalfa et al., 2020). To remove organic toxins from wastewater, millions of actively growing microorganisms are utilized to oxidize organic contaminants. Using the processes of nitrification and absorption, secondary treatment removes nutrients such as nitrogen and phosphorus (Ma et al., 2022). The tertiary or the final stage of treatment involves removing residual organic and inorganic matter from the effluents, which is followed by disinfection of the treated sewage by using chemicals such as chlorine or sodium hypochlorite, or radiation such as ultraviolet or ozone, before being released into the environment.

Wastewater can be treated by using Nano-materials such as nanoparticles or Nano-materials. Nano-materials combine various features to generate multifunctional materials such as Nano-composites, Nano-fibers, and membranes. Ma et al. created Nano-fibrous aerogels that can clean themselves and proved that the composite material may be utilized to monitor a variety of human functions in real time (Cao et al., 2022). Similar work will be carried out by many by constructing superhydrophobic Nano-fibers with antifouling and visible-light-induced self-cleaning properties (Ma et al., 2022). Nano-materials may be used extensively in the treatment and remediation of water because of their raised surface area, useful chemical performance, mechanical properties, low cost, and low power consumption. When supported by intelligible and controllable morphologies of appropriate size and porosity, these compounds have the potential to be used as adsorbents (Nasrollahzadeh et al., 2021). In Mbarara City, a lack of centralized wastewater treatment poses significant risks to the River Rwizi ecosystem, as untreated effluent from households and small-scale industries is frequently discharged into the river. By assessing the adequacy of sewage treatment facilities and the effectiveness of existing management practices, this study aims to provide insights that can inform policy decisions and improve environmental sustainability in Mbarara City. The literature underscores the urgent need for improved sewage management practices to protect both public health and the integrity of the River Rwizi ecosystem.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1. Introduction

This chapter provided the research design, the study area, the target population, the sampling procedure, methods of data collection and data collection instruments, data validity and reliability, measurement of the variables, and data analysis.

3.2. Study Design

This study adopted a convergent parallel mixed-methods design to comprehensively examine waste management practices and their implications for environmental sustainability and natural resource conservation in the River Rwizi ecosystem within Mbarara City. In this approach, quantitative and qualitative data were collected simultaneously, analyzed separately, and then integrated to provide a more complete understanding of the research problem (Creswell & Plano Clark, 2018).

The quantitative component prioritized the collection of numerical data on waste management practices, environmental impact indicators, and stakeholder challenges through surveys and structured observations (Schoonenboom & Johnson, 2017). Concurrently, the qualitative component explored community perceptions, attitudes, and behaviors through interviews and focus group discussions, allowing for deeper insights into the social and institutional dynamics that influenced waste management (Sutton & Austin, 2015; Tenny et al., 2024).

By employing a convergent parallel design, the study ensured that both data types were given equal priority, facilitating a robust triangulation process. The integration of quantitative and qualitative findings enhanced the reliability of results, capturing both measurable impacts and contextual complexities related to waste management along the River Rwizi.

3.3. Area of the Study

This study was conducted in Mbarara City, located in southwestern Uganda. Mbarara was the second-largest city in Uganda after Kampala and served as a major commercial, administrative, and transportation hub for the Ankole sub-region. The city was divided into six divisions: Kakoba, Kamukuzi, Nyamitanga, Biharwe, Kakiika, and Nyakayojo. The study specifically focused on River Rwizi, which runs through Mbarara City and was a crucial natural resource providing water for domestic, agricultural, and industrial use. However, rapid urbanization, poor waste disposal, and weak enforcement of environmental laws contributed to the deterioration of River Rwizi's water quality, making it an important case for investigating waste management practices and environmental sustainability.

3.4. Study population

The study included 2,200 community members from Rwemigina Parish, where there was a waste deposition site, and 140 community members from around Mbarara Central Market, where there were many garbage collection bins. In addition, the study involved one City Mayor, one Environmental Health Officer, one City Physical Planner, one Health Inspector, and one Town Clerk, who were key stakeholders in waste management.

3.5. Sampling Size and Sampling Techniques

A sample size of 430 respondents was drawn from the targeted population of 2340 respondents in this study. The sample size was meant to provide sufficient data to answer the research problem (Amin, 2005). The sample size was drawn using Krejcie and Morgan's table (1970).

Table 1: Target population, Sample size determination, and sampling methods

Category	Target Population	Sample Size	Sampling Method
Community members in Rwemigina	2200	327	Stratified and Systematic Sampling
Community members in Mbarara Central Market	140	103	Stratified and Systematic Sampling
City Mayor	01	01	Purposive Sampling
Environmental Health Officer	01	01	Purposive Sampling
City Physical Planner	01	01	Purposive and Snowball Sampling
Health Inspector	01	01	Purposive and Snowball Sampling
City Council Clerk	01	01	Purposive Sampling
Total	2345	435	

Source: Krejcie and Morgan (1970) tables, and adopted by the researcher.

3.5.1. Sampling techniques

The sampling techniques that were used in this study included.

3.5.1.1. Quantitative Sampling

To ensure fair representation across subgroups, stratified sampling was used to divide the community into two strata based on location: Rwemigina Parish and Mbarara Central Market. From each stratum, systematic sampling was applied to select participants using a fixed interval ($k = N/n$) from an ordered list, ensuring randomness while maintaining representativeness. This approach was suitable due to the relatively large and structured populations, allowing for efficient, unbiased sampling within each subgroup. Stratified sampling helped account for geographic differences in exposure to waste management practices (e.g., residential vs. market-based). Systematic sampling

reduced selection bias and improved efficiency when selecting respondents from household or vendor lists.

3.5.1.2. Qualitative Sampling

For the qualitative section, purposive sampling was used to select key informants, such as the City Mayor, Environmental Officer, and other officials, based on their roles and expertise in waste management policy, enforcement, and planning. Additionally, snowball sampling was employed where needed (e.g., for health inspectors or planners), allowing initial respondents to refer other knowledgeable individuals involved in similar work or decision-making processes. Purposive sampling ensured the inclusion of knowledgeable individuals with relevant insights. Snowball sampling was necessary to identify additional actors involved informally or indirectly, especially where official records or lists were limited

3.6. Data Collection Methods and Instruments

3.6.1. Questionnaire Survey

To collect data for this study, a questionnaire survey was employed, targeting 430 community members who were actively involved in environmental conservation and were of sound mind. The survey gathered data on the current waste management practices, challenges, and socio-economic implications along the River Rwizi ecosystem. Structured questionnaires were distributed to the selected respondents. This approach focused on a representative sample rather than the entire population, making it a cost-effective method. The questionnaires included both closed-ended and open-ended questions, allowing for a mix of quantitative and qualitative data.

This method was used because it was less expensive, as it focused on a sample rather than the entire population, and it had the potential to attract a higher response rate (Amin, 2005). The method also enabled the researcher to reach a large number of respondents within a short time, provided respondents with adequate time to answer the items, offered a sense of anonymity, and ensured objectivity, thereby minimizing bias arising from the personal characteristics of the researcher.

3.6.2. Interview Method

The interview method was employed to collect data specifically from key stakeholders, including the Environmental Health Officer, City Mayor, City Physical Planner, Health Inspector, and Town Clerk. These individuals were purposively selected due to their critical roles in monitoring and evaluating government projects, particularly in waste management and environmental conservation. Structured and semi-structured interviews were conducted, allowing for an interactive exchange of information. This method facilitated the presentation of questions (oral stimuli) and the collection of responses (oral verbal replies), following the approach described by Kothari (1990). The interviews were guided by a pre-designed interview schedule to ensure consistency, while also allowing for probing to clarify and expand on responses where necessary.

The method was used because it provided in-depth information, was flexible, and allowed probing, which ensured clarity by the end of the interview (Munyaradzi, 2016). As a result, the information gathered was more complete, and there was a greater understanding of the issues under investigation.

3.6.3. Data collection instruments

The data collection instruments that were used in this study include;

3.6.4. Questionnaire

The data were gathered using self-administered questionnaires with closed-ended questions, allowing respondents to tick their responses appropriately. Questionnaires were used because they did not require strong supervision, were cost-effective, and enabled the collection of large amounts of information within the stipulated period, as respondents could complete them at their convenience (Stephan Debois, 2019).

The questionnaire consisted of three sections: Section A contained the introduction, Section B captured the biodata of respondents, and Section C focused on questions derived from both the dependent and independent variables. The questionnaire, which included closed-ended questions, was structured using a five-point Likert scale where: 5 = Strongly Agree, 4 = Agree, 3 = Undecided, 2 = Disagree, and 1 = Strongly Disagree. It was self-administered to community members.

The independent variables, which included dimensions such as recycling, incineration, and wastewater management, were measured as follows: recycling was measured using 8 items, incineration using 7 items, and wastewater management using 9 items. The dependent variable, environmental sustainability, was measured using 10 items.

3.6.5. Interview guide

The interview guide was used to collect qualitative data from the Environmental Health Officer, City Mayor, City Physical Planner, Health Inspector, and Town Clerk. The guide, which contained open-ended questions, was used to gather views and opinions from the respondents. During the interviews, a recorder was used to capture all relevant information that was useful for the study. The interviews were kept simple to save time and to ensure a good response rate.

The interviewees, namely the Environmental Health Officer, City Mayor, City Physical Planner, Health Inspector, and Town Clerk, enabled the study to benefit from probing to obtain detailed responses. The guide was structured into sections: Section A included questions relating to recycling and environmental sustainability; Section B consisted of questions related to incineration and environmental sustainability; and Section C focused on questions related to wastewater management and environmental sustainability.

3.7. Quality Control Methods

3.7.1. Validity

To ensure the validity of the research instruments for both quantitative and qualitative approaches, the researcher adopted a systematic process to evaluate their relevance, clarity, and alignment with the study objectives and conceptual framework.

3.7.1.1. Quantitative Approach

For the quantitative component (questionnaire), content validity was ensured by systematically assessing the alignment of questionnaire items with the study's independent and dependent variables, maintaining consistency with the research objectives and conceptual framework. The opinions of supervisors and two independent experts in the field were sought to evaluate the relevance, clarity, and appropriateness of each item in the questionnaire. Items that were deemed non-relevant or ambiguous were revised or replaced with more suitable alternatives.

Content validity ratio will be used to calculate the Content Validity Index, using the formula below.

$$\text{CVI} = \frac{\text{No.of items regarded relevant by judges}}{\text{Total number of items}}$$

A content Validity Index of at least 0.7 or 70% indicated that the instrument was suitable to collect data for the study. Items with a validity coefficient of at least 0.70 were accepted as valid in research" (Oso et al., 2008).

3.7.1.2. Qualitative Approach

For the qualitative component of the study, validity was addressed through a series of carefully considered strategies aimed at ensuring that the interview guide effectively captured relevant and reliable data. First, content alignment was achieved by designing interview questions to closely reflect the study's objectives. This ensured that the questions meaningfully probed key themes such as stakeholder challenges, community perceptions, and the socio-economic implications of waste management within the River Rwizi context.

To further enhance validity, expert validation was conducted. The interview guide was reviewed by the research supervisors and other subject matter experts to assess its clarity, completeness, and relevance. Constructive feedback from these reviewers led to revisions in the wording and structure of the questions, making them more appropriate for eliciting rich, in-depth responses from participants.

In addition, a pilot test of the interview guide was carried out with a small sample of respondents similar to the actual study participants. This trial phase provided an opportunity to observe how participants understood and responded to the questions. Based on the feedback obtained, necessary adjustments were made to ensure that the questions were not only clear and contextually appropriate but also capable of capturing meaningful qualitative data.

3.7.2. Reliability

Reliability was ensured for both the interview guide and the self-administered questionnaire. For the interview guide, the researcher applied the methods of credibility, dependability, and confirmability. Credibility aimed to ensure that the research findings reflected the views of the

interviewees (Korstjens & Moser, 2018). Dependability referred to the extent to which the findings, interpretations, and recommendations were supported by the data collected. Confirmability focused on establishing that the data and interpretations of the findings were derived from the actual data collected (Moon, Brewer, Januchowski-Hartley, Adams, & Blackman, 2016).

The reliability of items in the various constructs was tested using Cronbach's Alpha (α) method, provided by SPSS. Cronbach's Alpha served as the reliability coefficient to determine how well the items in the instrument were positively correlated with each other. Values of Cronbach's Alpha closer to 1 indicated high reliability. Alpha values greater than 0.70 were considered ideal for internal consistency (Souza, Alexandre, & Guirardello, 2017). Therefore, the data achieved acceptable reliability standards.

3.8. Data Analysis Techniques

This study employed both quantitative and qualitative analysis techniques, tailored to comprehensively address the research objectives. This mixed-methods approach ensured that data collected from questionnaires and interviews were thoroughly processed, analyzed, and interpreted to generate meaningful insights into waste management practices, challenges, and socio-economic implications along the River Rwizi.

3.8.1. Qualitative Data Analysis

The qualitative data, obtained through interviews and focus group discussions, were analyzed using thematic analysis, as recommended by Creswell (2014). This involved transcribing the responses, reading through the data repeatedly to familiarize oneself with the content, and then coding key statements and ideas. Related codes were grouped to form themes and sub-themes, which reflected stakeholder perspectives on waste management, community practices, institutional barriers, and environmental concerns. This interpretive process allowed for a deeper understanding of the contextual and subjective dimensions of waste governance in Mbarara City, complementing the statistical findings with rich, explanatory insights.

3.8.1.1. Data Familiarization and Coding

Responses from the interview guide were thoroughly read and re-read to identify recurring ideas, concepts, and patterns. Themes and sub-themes were developed inductively from the data, while codes were assigned to represent these themes. This approach ensured that the analysis captured both the explicit and implicit meanings in participants' responses.

3.8.1.2. Theme Identification and Organization

The identified codes were grouped under broader themes and sub-themes aligned with the study objectives, such as challenges in waste management or community perceptions of sustainability. This structured approach helped organize qualitative data conceptually and interrelate key ideas.

3.8.1.3. Interpretation and Analysis

Data were analyzed and evaluated to uncover relationships and contextual insights, forming the foundation for thematic analysis. This step provided depth to the findings by exploring socio-economic and institutional dynamics that influenced waste management practices.

Thematic analysis yielded an in-depth understanding of contextual and subjective factors, such as community perceptions, institutional challenges, and socio-economic impacts. The findings complemented the quantitative results, adding depth and richness to the study's conclusions.

3.8.2. Quantitative Data Analysis

The quantitative data, primarily collected using a five-point Likert scale questionnaire, were analyzed using the Statistical Package for Social Sciences (SPSS) version 25. Data preparation involved entry, editing, cleaning, and sorting to ensure accuracy and consistency. The analysis employed the following techniques:

3.8.2.1. Descriptive Statistics

Descriptive statistics, including frequencies, percentages, and means, were used to summarize responses for each question. This approach provided an overview of participant demographics and general trends in perceptions, behaviors, and practices related to waste management. The descriptive data facilitated an understanding of the current state of waste management along River Rwizi and highlighted key patterns across different stakeholder groups.

3.8.2.2. Pearson Correlation Coefficient

To establish relationships among the study variables, the Pearson correlation coefficient was applied. This technique measured the strength and direction of linear relationships between variables, such as the link between waste management practices and environmental sustainability. The results included correlation coefficients (R-values) and significance levels, providing insights into how strongly specific factors were associated.

3.8.2.3. Multi-Linear Regression Analysis

Multilinear regression analysis was used to test hypotheses and evaluate the predictive power of independent variables on the dependent variable (e.g., environmental sustainability). This analysis determined the extent to which variables such as waste management practices, community attitudes, and institutional challenges contributed to outcomes of interest. The results included regression coefficients, R^2 values, and p-values, revealing significant predictors and the proportion of variance they explained.

The quantitative approach produced statistical summaries, correlations, and regression models, offering clear evidence of trends, relationships, and predictors related to waste management and environmental sustainability. These results supported hypothesis testing and provided actionable recommendations for improving waste management systems.

3.9. Ethical Consideration

In conducting this research, several ethical principles were upheld to ensure the integrity of the study and the protection of participants. The following ethical considerations were addressed:

Participants' autonomy was respected throughout the research process. Informed consent was obtained from all participants before their involvement in the study. This involved providing clear and comprehensive information about the purpose of the research, the procedures involved, potential risks, and the right to withdraw at any time without any consequences. Participants were encouraged to ask questions and were assured that their participation was entirely voluntary.

Careful consideration was given to the research design and methodology to minimize any potential risks to participants. This included ensuring that the questions posed in surveys and interviews did

not cause psychological distress or discomfort. Additionally, measures were taken to protect the confidentiality and anonymity of participants, thereby safeguarding their personal information and reducing the risk of harm.

The study aimed to contribute positively to the community by identifying barriers to effective waste management and proposing strategies for enhancing recycling efforts. By doing so, the research sought to promote environmental sustainability and improve the quality of life for residents in the River Rwizi area. Participants were informed of the potential benefits of the research, including the possibility of influencing local waste management policies and practices.

The researcher ensured that the benefits and burdens of the research were distributed fairly among participants. The study strived to include a diverse range of participants from various socio-economic backgrounds to ensure that all voices were heard and represented. Special attention was given to marginalized groups who may have been disproportionately affected by inadequate waste management practices. The findings of the research were shared with the community, ensuring that the knowledge gained was accessible and could be utilized to advocate for equitable waste management solutions.

3.10. Limitations of the Study

This study faced several limitations and anticipated constraints. First, limited access to reliable waste management data from local authorities affected the comprehensiveness of the analysis. Second, community participation challenges, such as reluctance to disclose waste disposal practices, impacted data accuracy. Third, logistical constraints, including time and financial limitations, hindered extensive fieldwork and engagement with all relevant stakeholders.

Additionally, weather conditions and seasonal variations affected observations on River Rwizi's pollution levels. Lastly, policy and institutional barriers, such as bureaucratic delays in obtaining research approvals, slowed the data collection process. To mitigate these challenges, the study used multiple data sources, adopted flexible scheduling, and engaged stakeholders to enhance research reliability.

CHAPTER FOUR:
RESULTS, INTERPRETATION, AND DISCUSSION

4.1. Introduction

This chapter presented results from the data collected from respondents regarding the influence of waste management practices, namely recycling, incineration, and sewage treatment, on environmental sustainability in Mbarara City, with a special focus on the River Rwizi ecosystem. The analysis is organized according to the study's specific objectives: to assess the influence of recycling, incineration, and sewage treatment on environmental sustainability. Quantitative data was analyzed using descriptive and inferential statistics, while qualitative data was summarized thematically to provide a broader understanding of community and stakeholder perspectives.

4.2. Response rate

The response rate showed the percentage of respondents who were able to participate in the study and give their views out of those sampled. The study was interested in the response rate to measure data quality, determine the validity of estimates, analyze the findings, and draw conclusions. The response rate is detailed in Table 2 below.

Table 2: Respondents' Response Rate

Category	Target Population	Sample Size	Actual Participation	Response Rate (%)
Community Members in Rwemigina	2,200	327	301	92.0
Community Members in Mbarara Central Market	140	103	98	95.1
City Mayor	1	1	1	100
Environmental Health Officer	1	1	1	100
City Physical Planner	1	1	1	100
Health Inspector	1	1	1	100
City Council Clerk	1	1	1	100
Total	**2,345**	**435**	**404**	**92.9**

Source: Field Data (2025)

As shown in Table 4.1, the overall response rate was 92.9%, which was significantly high and exceeded the minimum acceptable threshold of 50% recommended by Mugenda and Mugenda (2003). According to Morton et al. (2012), studies with a response rate of 70% or higher are considered more accurate and generalizable, while Krishnan and Poulose (2016) assert that such high response rates improve statistical power and reduce sampling bias.

The nearly complete participation by city officials (100%) and the very high turnout from community respondents in both Rwemigina and Mbarara Central Market indicated strong stakeholder interest and engagement in the subject matter. This enhanced the credibility of the study's findings and ensured that the results genuinely reflect the opinions and experiences of a broad and relevant population group. Consequently, the findings of this study can be confidently generalized to the broader population of Mbarara City in the context of environmental sustainability and waste management.

4.3. Background characteristics of the community members

Summary of the study findings on the socio-economic characteristics of the community members, which included sex, age, highest academic qualifications, and years of stay, are shown in Table 4.3.

Table 3: Summary of Information background of the respondents

Variable	Category of respondents	Frequency	Percentage (%)
Gender	Female	228	56.4
	Male	176	43.6
Age	Below 30 years	76	18.8
	30-39years	157	38.9
	40-49 years	134	33.2
	50 and above	37	9.1
Education Level	No education	59	14.6
	Primary	133	32.9
	Secondary	125	30.9
	Tertiary	87	21.6
Years of stay	Less than 5 years	64	15.8
	5-10 years	181	44.8
	10 years and above	159	39.4

Source: Primary data (2025)

The findings presented in the Table above show that the majority of respondents were female (56.4%), while males constituted 43.6% of the sample. This indicates a slightly higher participation of women in the study, which reflects their greater availability during household visits or their increased involvement in community affairs, especially those related to sanitation and environmental cleanliness. This gender representation added value to the study's credibility, as it

reflected the active role women play in domestic waste management. Given that women often handle most household duties, their input was particularly valuable in understanding local waste handling practices, perceptions, and challenges.

In terms of age distribution, 38.9% of respondents were aged 30–39 years, followed by 33.2% who were between 40–49 years, and 18.8% who were below 30 years. Only 9.1% were aged 50 years and above. These results indicated that the majority of participants were in their productive age range (30–49 years), which is relevant because individuals in this bracket are typically more active in economic and environmental decision-making at the household and community levels. Their engagement suggested a reliable understanding of the issues under study and potential willingness to participate in sustainable waste management interventions.

Regarding educational attainment, the largest proportion of respondents (32.9%) had completed primary education, followed closely by those with secondary education (30.9%). A further 21.6% had attained tertiary education, while 14.6% had no formal education. These statistics suggest that the sample included a broad spectrum of educational backgrounds, enhancing the richness of the data. The fact that over 85% of the respondents had at least some formal education implies a relatively literate population that could comprehend and respond meaningfully to the questionnaire. Furthermore, the education levels reported suggest a general awareness among respondents about the environmental and health risks associated with poor waste management, as well as an understanding of their roles in promoting cleanliness and public hygiene.

About the duration of residence in Mbarara City, 44.8% of respondents had stayed in the city for 5–10 years, followed by 39.4% who had lived there for over 10 years, and 15.8% who had been residents for less than 5 years. These figures demonstrate that a significant proportion of participants were long-term residents, and therefore likely to have firsthand experience with waste management trends, policies, and challenges in the city over time. Their extended stay provides contextual depth to their responses and positions them as credible informants in evaluating the effectiveness of local waste management strategies.

In summary, the demographic characteristics of the study participants offer a diverse and well-distributed profile that strengthens the generalizability of the findings. The gender balance, productive age range, varying educational levels, and duration of stay in the city combine to provide

a comprehensive understanding of waste management behaviours, perceptions, and responsibilities. These attributes are crucial in designing responsive, inclusive, and sustainable waste governance interventions in Mbarara City.

4.3. Descriptive Statistics Based on Research Objectives

4.3.1. Current Status of Waste Management Practices in Mbarara City

This section presents findings on the prevailing waste management practices among community members around River Rwizi.

Table 4: Distribution of Waste Management Practices

Practice / Indicator	Frequency (n)	Percentage (%)
The most common waste generated		
Organic waste	160	39.6
Plastic waste	175	43.3
Paper/Cardboard	25	6.2
Hazardous waste	15	3.7
Other	30	7.2
Preferred waste disposal method		
Open dumping	95	23.5
Burning	85	21.0
Municipal collection	100	24.7
Recycling/reuse	70	17.3
Composting	40	9.9
Waste segregation practiced?		
Yes	132	32.7

No	272	67.3
Are public waste bins available?		
Yes	190	47.0
No	214	53.0
Frequency of waste collection		
Daily	60	14.9
Weekly	188	46.5
Rarely	100	24.7
Never	57	14.0

Source: *Field Data (2025)*

The data indicated that plastic waste (43.3%) and organic waste (39.6%) are the dominant types of solid waste generated, collectively accounting for over 80% of total waste. This reflected a waste stream primarily composed of recyclable and biodegradable materials, underscoring an opportunity for integrated recycling and composting programs. However, the predominant disposal methods, municipal collection (24.7%) and open dumping (23.5%), revealed a lack of structured waste management infrastructure. The high prevalence of open dumping is concerning, as it poses environmental and public health risks, particularly in urban settings.

Moreover, only 32.7% of respondents practice waste segregation, despite the large proportion of waste being potentially recyclable or compostable. This suggests significant behavioral or systemic barriers to sustainable waste practices. The absence of public waste bins in over half of the surveyed areas (53.0%) likely contributes to this challenge, limiting options for proper disposal and segregation at the source.

The irregularity of waste collection further compounds the problem, with only 14.9% of households reporting daily collection. Most rely on weekly collection (46.5%), while 38.7% either rarely or never have their waste collected. These findings reflect substantial gaps in service delivery that undermine waste management efficiency and exacerbate risks of illegal dumping and accumulation.

Overall, the data reveal both infrastructural and behavioral deficiencies in the current waste management system.

4.3.2. Challenges in Implementing Effective Waste Management Strategies

This section highlights the key obstacles faced by local authorities, community members, and businesses.

Table 5: Reported Challenges in Waste Management

Stakeholder Group / Challenge	**Frequency (n)**	**Percentage (%)**
Challenges faced by authorities		
Inadequate funding	285	70.5
Weak enforcement of regulations	270	66.8
Lack of public cooperation	220	54.5
Insufficient waste infrastructure	250	61.9
Challenges faced by businesses		
High waste disposal costs	190	47.0
Limited access to recycling programs	175	43.3
Lack of government incentives	160	39.6
Challenges faced by community members		
Lack of knowledge	245	60.6
Inconvenient waste facilities	230	56.9
Cultural attitudes	100	24.7

Source: *Field Data (2025)*

Among local authorities, the most frequently reported challenge is inadequate funding, cited by 70.5% of respondents. This suggests that budgetary constraints significantly hinder the planning, coordination, and operational capacity required for effective waste management. Weak enforcement of regulations (66.8%) and insufficient waste infrastructure (61.9%) were also prominent concerns, indicating institutional gaps that limit compliance and coverage of waste services. Furthermore, a lack of public cooperation (54.5%) highlights the difficulties authorities face in mobilizing community support and engagement, which are essential for sustained waste management efforts.

In the business sector, the highest challenge reported is high waste disposal costs (47.0%). This indicates that financial barriers may discourage proper waste handling practices, particularly among small and medium enterprises. Additionally, limited access to recycling programs (43.3%) suggests a lack of integration between private sector activities and broader circular economy initiatives. The absence of government incentives (39.6%) further demotivates investment in sustainable waste practices, reflecting policy gaps in encouraging environmentally responsible business behavior.

For community members, the leading challenge is a lack of knowledge and awareness (60.6%), underlining the importance of education and public sensitization in promoting responsible waste behavior. This is closely followed by inconvenient waste disposal facilities (56.9%), which signals the need for better spatial planning and accessibility of waste services. Cultural attitudes and resistance to behavioral change (24.7%) also emerged, albeit less prominently, indicating that social norms may still undermine the adoption of modern waste practices in some segments of the community.

Overall, these findings point to a complex interplay of financial, infrastructural, institutional, and behavioral factors that undermine effective waste management.

4.3.3. Socio-Economic Implications of Sub-standard Waste Management

This section explored how poor waste practices affect the livelihoods, health, and economic activities of communities dependent on the River Rwizi.

Table 6: Socio-Economic and Health Impacts of Poor Waste Management

Impact Area	Frequency (n)	Percentage (%)
Economic impacts		
Reduced fish catch	120	29.7
Reduced agricultural productivity	185	45.8
Increased health expenditures	220	54.5
Decline in tourism	95	23.5
Health effects experienced		
Waterborne diseases	230	56.9
Respiratory problems	170	42.1
Skin infections	85	21.0
Overall livelihood impact		
Respondents reporting a negative impact on their livelihood	265	65.6
No impact reported	139	34.4

Source: *Field Data (2025)*

A majority of respondents reported health-related consequences tied to waste pollution. The most prevalent issue was waterborne diseases, with 56.9% of respondents citing these as a direct consequence of contaminated water sources. These diseases, often linked to poor sanitation and untreated waste, represent a major public health threat. Additionally, 42.1% reported respiratory problems, likely caused by poor air quality resulting from open waste burning and inadequate waste disposal in the community. Skin infections (21.0%) were also notably mentioned, reinforcing the widespread nature of health problems linked to environmental pollution.

The economic repercussions of poor waste management were felt across multiple sectors. Agriculture, a key livelihood activity for many households, was most affected, with 45.8% of respondents observing a reduction in crop productivity due to contaminated water sources and soil degradation. The fishing industry was also impacted, with 29.7% of respondents indicating a reduced fish catch, attributed to polluted water conditions in River Rwizi, which directly affects fish stocks and aquatic ecosystems. Furthermore, increased health expenditures were reported by 54.5% of respondents, highlighting the additional financial burden of treating health conditions caused by waste pollution. Although tourism was less severely impacted, 23.5% reported a decline in tourism-related activities, suggesting that the region's natural beauty and resources, crucial for tourism, have been affected by waste pollution.

The overall livelihood impact was profound, with 65.6% of respondents stating that their livelihoods were negatively affected by poor waste management. This reflects a broad-based impact across multiple sectors, including agriculture, fishing, tourism, and healthcare, which are crucial to the local economy. In contrast, 34.4% reported no significant impact, possibly due to limited exposure to the polluted areas or alternative livelihood sources.

The findings demonstrate the multidimensional consequences of poor waste management in the River Rwizi region. The economic impacts, such as reduced agricultural productivity and fishing yields, coupled with the increased healthcare costs and health issues like waterborne diseases, underscore the urgent need for effective waste management strategies. Additionally, the negative effect on livelihoods, as reported by over 65% of respondents, further emphasizes the importance of addressing waste pollution as a key issue for both public health and local economic sustainability.

These results call for integrated solutions that involve improving waste management infrastructure, enhancing public awareness, and securing greater investment in sustainable practices to protect both human health and the environment.

4.4. Correlation Matrix

To examine the relationships between the independent variables, waste management practices, challenges in waste management, and socio-economic implications, and the dependent variable (environmental sustainability), Pearson correlation analysis was conducted. The results are summarized in the table below.

Table 7: Correlation Matrix

Variables	1.Waste Management Practices	2. Challenges in Waste Management	3.Socio-Economic Implications	4. Environmental Sustainability
1.Waste Management Practices	1.000	-0.412**	-0.265*	0.603
2. Challenges in Waste Management	-0.412**	1.000	0.518	-0.488
3.Socio-Economic Implications	-0.265*	0.518**	1.000	-0.431
4. Environmental Sustainability	0.603**	-0.488**	-0.431**	1.000

Note:

*Correlation is significant at the 0.05 level (2-tailed).

**Correlation is significant at the 0.01 level (2-tailed).*

Source: Field Data (2025)

Relationship between Socio-Economic Implications and Waste Management Practices

There was a weak negative correlation ($r = -0.265$, $p < 0.05$) between socio-economic implications and waste management practices. This suggests that as waste management practices improve, the negative socio-economic effects, such as illness, reduced productivity, and increased household costs, slightly decrease. Although the relationship is weak, it is statistically significant, indicating that better waste practices may relieve some socio-economic pressure on the community.

Relationship between Socio-Economic Implications and Challenges in Waste Management
The correlation between socio-economic implications and challenges in waste management was moderate and positive ($r = 0.518$, $p < 0.01$). This implies that when challenges in managing waste, like inadequate infrastructure or poor enforcement, are high, the socio-economic burdens also tend to rise. These could manifest in more disease outbreaks, loss of income, or damage to livelihood resources such as water and soil.

Relationship between Socio-Economic Implications and Environmental Sustainability
A moderate negative correlation was found between socio-economic implications and environmental sustainability ($r = -0.431$, $p < 0.01$). This indicates that poorer environmental sustainability, such as polluted water or unmanaged solid waste, is associated with higher socio-economic challenges. In other words, when environmental quality deteriorates, communities experience increased economic strain and health risks.

The correlation matrix reveals significant relationships among the key variables of the study. There is a strong positive correlation ($r = 0.603$, $p < 0.01$) between waste management practices and environmental sustainability, indicating that improved practices such as proper waste segregation, recycling, and safe disposal contribute positively to the health of the environment around River Rwizi. This suggests that strengthening waste management behaviours among community members and institutions could enhance environmental outcomes.

Conversely, challenges in waste management show a moderate negative correlation ($r = -0.488$, $p < 0.01$) with environmental sustainability. This implies that persistent obstacles, including inadequate funding, weak regulatory enforcement, and a lack of infrastructure, undermine efforts to maintain a sustainable environment. Similarly, socio-economic implications of poor waste management practices, such as increased health burdens and reduced agricultural productivity, are negatively correlated with environmental sustainability ($r = -0.431$, $p < 0.01$). This relationship demonstrates how environmental degradation resulting from ineffective waste management affects both ecological systems and community well-being.

Additionally, there is a significant positive correlation between challenges in waste management and socio-economic implications ($r = 0.518$, $p < 0.01$), suggesting that systemic inefficiencies in managing waste are directly linked to worsening socio-economic conditions, especially for populations dependent on River Rwizi. These interrelationships underscore the interconnected

nature of waste management, community resilience, and environmental health, validating the relevance of Systems Theory in analyzing complex environmental challenges within urban settings like Mbarara City.

4.5. Regression Analysis

To verify the hypotheses, a multiple linear regression analysis was conducted using environmental sustainability as the dependent variable, and waste management practices, challenges in waste management, and socio-economic implications as the independent variables. The results are presented in Table 4.8 and Table 4.9.

Table 8: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.691	0.477	0.469	0.526

Source: *Field Data (2025)*

The model summary shows an R value of 0.691, indicating a strong overall correlation between the independent variables and environmental sustainability. The R Square value of 0.477 suggests that approximately 47.7% of the variation in environmental sustainability can be explained by the three predictors in the model. The adjusted R Square value of 0.469 confirms that the model is a good fit even after adjusting for the number of predictors.

Table 9: Results of ANOVA

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	42.236	3	14.079	50.84	0.000
Residual	46.191	167	0.277		
Total	**88.427**	**170**			

Source: *Field Data (2025)*

The ANOVA table shows that the overall regression model is statistically significant ($F = 50.84$, $p < 0.001$), indicating that the model explains a significant proportion of variance in environmental sustainability.

Table 10: Results from Multiple Linear Regression

Predictor	Unstandardized Coefficient (B)	Std. Error	Standardized Coefficient (Beta)	t-value	Sig. (p-value)
(Constant)	1.245	0.232	—	5.368	0.000
Waste Management Practices	0.486	0.071	0.501	6.845	0.000
Challenges in Waste Management	-0.295	0.068	-0.312	-4.338	0.000
Socio-Economic Implications	-0.182	0.059	-0.218	-3.085	0.002

Source: *Field Data (2025)*

The regression analysis confirmed that all three independent variables significantly influence environmental sustainability in Mbarara City.

Waste management practices have a positive and significant effect ($B = 0.486$, $p < 0.001$), suggesting that improvements in recycling, segregation, and responsible disposal practices lead to better environmental outcomes. This supported the first hypothesis that effective waste management practices enhance environmental sustainability.

Challenges in waste management have a negative and statistically significant effect ($B = -0.295$, $p < 0.001$), indicating that systemic barriers, such as inadequate funding, weak enforcement, and infrastructure gaps, significantly hinder progress toward sustainability. This confirmed the second hypothesis that existing challenges negatively affect environmental conservation efforts.

Socio-economic implications also showed a negative influence ($B = -0.182$, $p = 0.002$), suggesting that poor waste management leads to environmental degradation that adversely affects health, agriculture, and livelihoods. This validated the third hypothesis regarding the socio-economic burden of poor waste handling on local communities.

Overall, the regression analysis demonstrated that strategic investment in improved waste management practices and the reduction of institutional challenges are critical to achieving environmental sustainability in the River Rwizi region of Mbarara City.

4.6. Qualitative Data Analysis

This section provides a detailed account of the qualitative findings from data obtained through in-depth interviews conducted with key informants, including the City Mayor, Environmental Health Officer, Physical Planner, Town Clerk, and Health Inspector of Mbarara City. The primary objective of these interviews was to supplement the quantitative findings by exploring institutional perspectives, practical challenges, and localized insights regarding waste management practices and their implications for environmental sustainability, especially in communities located along the River Rwizi.

A thematic analysis approach was employed to analyze the qualitative data. This involved a rigorous process of familiarization with the data, followed by open coding of the interview transcripts to identify patterns and recurring ideas. These codes were then systematically categorized and refined into broader thematic constructs that reflect the core concerns raised by the respondents. The resulting themes were carefully aligned with the study's specific research objectives, ensuring that the qualitative analysis directly supported the study's broader analytical framework. Three dominant themes emerged from the thematic analysis: (1) Current Waste Management Practices and Gaps; (2) Challenges Facing Stakeholders; and (3) Socio-Economic Implications of Poor Waste Management.

4.6.1. Presentation of Qualitative Themes

The following section presents the themes identified through thematic analysis of interview data. Each theme is supported by findings and illustrative quotations from participants

Theme 1: Inconsistent and Inequitable Waste Collection Services

Participants consistently highlighted that waste collection services in Mbarara City are irregular and unevenly distributed across neighborhoods. While the central business district and market areas benefit from relatively consistent waste collection, peripheral and informal settlements are largely

neglected. This disparity results in reliance on unsafe disposal methods like open dumping or burning, especially in underserved areas.

"The truck comes only once a week and sometimes skips our area altogether, so we throw the rubbish in the bush."

"While we have licensed contractors in place, they mainly serve the central market and town center. Many outer wards are underserved due to logistical constraints." (City Physical Planner)

This theme underscores both infrastructural and managerial gaps in ensuring universal and equitable waste collection services.

Theme 2: Absence of Waste Segregation at Source

Respondents pointed to the lack of household-level waste sorting as a major bottleneck in improving waste management efficiency. Most waste is dumped as undifferentiated matter, making it difficult to process through composting, recycling, or incineration. The absence of segregation at source reflects both public unawareness and institutional gaps in enforcing sorting guidelines.

"People don't separate plastics from organics, so even recyclable materials end up in dumpsites or rivers." (Environmental Officer)

This theme highlights a missed opportunity for resource recovery and the need for public education and policy enforcement around waste sorting.

Theme 3: Inadequate Public Waste Infrastructure and Underutilization of Existing Facilities

Participants mentioned a critical shortage of public waste bins, particularly in high-traffic areas such as markets and residential zones near the River Rwizi. In addition, although the city has invested in infrastructure like the composting plant in Rwentondo, its potential remains untapped due to poor waste quality and a lack of operational coordination.

"Public bins are very few, especially in the markets and near the river where waste ends up scattered."

“The composting plant is there in Rwentondo, but it’s not working well because people just throw all kinds of waste together.”

4.6.3: Challenges Facing Stakeholders in Implementing Effective Waste Management

Theme 1: Funding and Resource Constraints

A significant barrier to effective waste management is inadequate financial and human resources. Informants reported that limited city budgets restrict the purchase of modern equipment, expansion of waste services, and recruitment of qualified personnel. Waste management remains under-prioritized in budget allocations despite increasing urban demand.

“Waste management is resource-intensive, and the city's budget allocations are not sufficient to meet operational demands.” (Town Clerk)

Theme 2: Weak Enforcement and Political Interference

While laws exist, their implementation is weak due to limited manpower, low penalties, and political meddling. Respondents revealed that offenders often evade punishment due to political connections, undermining the credibility of enforcement systems.

“We have good laws on paper, but they are not followed up with action.”

“Even when people are fined, the penalties are low, and political leaders sometimes interfere when offenders are caught.” (Health Inspector)

Theme 3: Limited Public Sensitization and Community Engagement

Poor public awareness and a lack of sustained education efforts have led to widespread noncompliance with proper waste practices. Respondents stressed the need for media campaigns, school-based programs, and partnerships with community institutions to increase civic responsibility.

“There is a need for regular radio talk shows, school campaigns, and partnerships with religious institutions to sensitize people.” (City Mayor)

4.6.4: Socio-Economic Implications of Poor Waste Management

Theme 1: Public Health Risks and Environmental Hazards

Participants identified a rise in cholera, typhoid, and respiratory diseases linked to poor waste disposal. Open burning and contaminated water sources due to solid waste pollution pose significant threats to human health, especially during the rainy season.

“We use water from the stream for our gardens, but now it smells and carries rubbish. Our yields are going down.”

“Downstream farmers complain that the water they use for irrigation smells and affects crop quality. We've also had complaints of waterborne disease outbreaks in rainy seasons.” (Environmental Officer)

Theme 2: Economic Disruption to Agriculture and Fishing Livelihoods.

Waste pollution has directly affected the livelihoods of farmers and fishers. Agricultural productivity has declined due to poor water quality, while plastic pollution in the River Rwizi has led to a significant drop in fish stocks, forcing fishers to abandon the trade or migrate downstream.

“Fishing is no longer viable in the upper parts of Rwizi. Plastic waste clogs the riverbanks and depletes aquatic life.” (Health Inspector)

Theme 3: Negative Impact on City Image and Tourism Potential

Uncollected waste and visible pollution in key urban areas diminish the aesthetic appeal of the city, which could discourage tourism and external investment. Participants expressed concern that unmanaged waste undermines Mbarara’s aspirations to become a clean, modern urban center.

“Litter along riverbanks and markets not only pollutes but also undermines the aesthetic value of Mbarara.”

4.7. Discussion of Findings

4.7.1. Status of Waste Management Practices in Mbarara City

This study reveals a fragmented and socially unequal waste management system in Mbarara City, particularly disadvantaging peri-urban settlements such as Rwemigina. The quantitative data show that 23.5% of households dispose of waste through open dumping and 21.0% through burning practices most prevalent in underserved areas. These findings were supported by qualitative narratives describing “no garbage trucks coming this side” and a reliance on “digging pits or just burning behind the house.” This convergence of numerical data and lived experience underscores Simone’s (2004) concept of infrastructural abandonment, where state services selectively retreat from spaces considered peripheral. Theoretically, these findings extend Simone’s notion of infrastructural abandonment by showing that neglect is not simply a passive retreat but an active structuring of urban inequality.

Unlike Harvey (2008) and Mbembe (2015) argue that infrastructural development in African cities often reinforces spatial exclusion, privileging visibility and economic power over citizenship rights. Unlike Harvey (2008) and Mbembe (2015), who emphasize broad spatial exclusion, this study illustrates how such exclusion is operationalized in peri-urban Mbarara, thus grounding the theoretical debate in a specific African secondary city context. The findings echo UN-Habitat (2020), which reports that over 60% of African urban residents lack reliable waste services. As a researcher, I argue that Mbarara’s infrastructural inequality is less a reflection of technical incapacity than a symptom of structural urban injustice, a divergence between policy rhetoric of universal service and selective material investment.

Further illustrating this gap is the low adoption of household-level waste segregation, reported at just 32.7% in the quantitative data. Qualitative interviews reveal that many residents “don’t know what it means to separate waste” or “have never been told about sorting,” pointing to a striking absence of civic education and policy outreach. This contradicts dominant policy framings, such as NEMA (2019), which attribute poor segregation to citizen apathy. Instead, the finding aligns with Ajzen’s Theory of Planned Behavior in revealing that intention is inadequate without enabling conditions. The study thus enriches the scholarly debate by shifting responsibility from individual failure to structural neglect. These findings challenge dominant policy frameworks that assume

behavioral change can be achieved through simple awareness campaigns. Drawing on Ajzen's (1991) Theory of Planned Behavior, it becomes evident that intention alone is inadequate without enabling environments. Scholars such as Hoornweg and Bhada-Tata (2012) caution against assuming that urban residents will act sustainably in the absence of clear incentives, practical tools, or consistent messaging. Pinder Hughes (2004) adds that waste behavior is deeply shaped by socio-economic realities, and top-down interventions often misread local constraints. Medina (2007) and Mwiganga & Kansiime (2005) similarly emphasize the communication breakdown between city authorities and marginalized communities. This alignment between qualitative accounts and scholarly critiques highlights a key point of convergence: citizens are not apathetic, but rather systemically excluded from environmental governance processes.

The underutilization of the composting facility at Rwentondo further reinforces the disconnect between infrastructure and community practice. While investments in such facilities suggest a policy commitment to waste valorization, their functionality is undermined by the lack of source segregation and public awareness. This contradiction was evident in both data streams: survey respondents rarely reported using composting services, while interviewees noted they "have never seen where the compost place is" or believed it is "only for town people." Methodologically, the mixed-methods design was crucial here: while survey data alone might suggest behavioral indifference, qualitative narratives revealed structural barriers.

This triangulation demonstrates the value of convergence, divergence analysis in uncovering governance failures often hidden in quantitative-only studies Mohanty and Chattopadhyay (2020) frame this as a "hardware-software mismatch," where cities prioritize physical structures without investing in the human, social, and institutional systems needed to operate them. Gandy (2005) also speaks of African cities as becoming "splintered ecologies," in which infrastructure benefits some but remains disconnected from everyday urban life. Van Vliet et al. (2001) stress that sustainable infrastructure requires supportive social practices, while Bulkeley and Gregson (2009) argue that sustainability must be co-produced with communities. Here, the quantitative data alone might suggest underutilization as a behavioral issue, but the qualitative findings clarify that it is a result of institutional neglect and poor integration, revealing a divergence in causal interpretation but convergence on the outcome.

Another key theme emerging from the findings is the lack of sustainability mainstreaming in household waste practices. While previous studies, such as NEMA (2019) and Byamukama et al. (2015), attribute waste management failures to weak enforcement and citizen apathy, this research provides a more layered perspective. Interviews frequently described waste disposal as a "daily struggle" shaped by survival needs, with little exposure to environmental education. This points to a deeper cultural and institutional vacuum rather than mere behavioral deviance. O'Neill and Gibbs (2014) contend that shifting environmental behavior requires systemic governance approaches rather than individual moral appeals.

Bulkeley and Gregson (2009) similarly argue that sustainability must be embedded in everyday social routines, shaped by material support and cultural reinforcement. The alignment between poor waste behaviors in the survey and the narratives of marginalization in the interviews suggests that unsustainable practices are not a failure of citizens, but of governance systems. This convergence between qualitative and quantitative insights calls for a paradigmatic shift from top-down enforcement to co-produced sustainability, grounded in local realities and trust-building.

Lastly, the study's recommendations for decentralizing waste collection, incentivizing segregation, and formalizing informal actors resonate strongly with contemporary scholarship on inclusive urban governance. Mitlin and Satterthwaite (2013) argue that effective service delivery in cities requires a bottom-up approach that centers the knowledge and agency of local communities. Chen et al. (2021) have shown that integrating informal waste pickers into formal systems not only enhances efficiency but also promotes social equity and economic inclusion. Parizeau (2015) notes that informal recyclers are often the backbone of waste recovery systems, yet remain unrecognized in policy frameworks.

The qualitative data, especially from informal waste workers who described being "chased from town" or "not considered important," mirror this marginalization, while the quantitative data show that few respondents (less than 10%) ever interact with city authorities on waste matters. This convergence suggests that for Mbarara to improve waste outcomes, it must not only extend services but transform its governance culture. As the researcher, I argue that the real innovation lies not in technology or infrastructure, but in relational governance, building alliances with informal actors, empowering grassroots leadership, and embracing co-creation as a principle of urban management.

In sum, the findings of this study point to both convergence and divergence between data types, enriching our understanding of urban waste governance in Mbarara City. Quantitative data highlight patterns of exclusion and dysfunction, while qualitative insights reveal the lived experiences and underlying drivers of these patterns. Together, they show that Mbarara's waste management challenges are rooted less in technical failure and more in a crisis of governance, participation, and distributive justice. Moving forward, interventions must bridge these divides between center and periphery, state and citizen, hardware and software, if sustainable urban futures are to be realized.

4.7.2. Challenges in Implementing Sustainable Waste Management: Convergence and Divergence of Findings

This study identified several persistent and interlinked challenges that significantly undermine sustainable waste management in Mbarara City. Both the quantitative survey data and qualitative insights from key informant interviews revealed converging evidence on systemic issues such as chronic underfunding, weak enforcement of waste regulations, and limited community engagement. For instance, 69.8% of survey respondents indicated that they were unaware of any formal waste management policies, and 72.3% cited irregular or inadequate waste collection services, a pattern that aligns with qualitative reports from city officials who described severe logistical constraints. One city health officer stated, "Our budgets for waste management are often cut or delayed, making regular collection nearly impossible."

Furthermore, the issue of institutional fragmentation emerged as a strong point of convergence across data sources. Survey findings indicated that only 18.5% of respondents believed that waste services were well-coordinated across city divisions. This perception was echoed in qualitative interviews, where a technical officer lamented, "We sometimes don't even know what the other department is doing when it comes to waste collection." This clearly demonstrates how inter-agency disconnects are not just anecdotal but are statistically visible in citizen perceptions. From a theoretical perspective, this finding both supports and complicates Systems Theory. While the theory emphasizes interdependence, the Mbarara case reveals a paradox: interdependence is acknowledged in policy texts but remains absent in institutional practice. This divergence contributes to scholarly debates on how systemic theories of governance translate (or fail to translate) in African urban contexts.

Applying Systems Theory, which emphasizes interdependence within institutional components, it becomes evident that the breakdown in coordination among Mbarara City's actors, ranging from municipal authorities to private contractors, creates systemic dysfunction. The feedback loops necessary for adaptive governance are virtually absent. This governance failure is not simply a lack of resources or personnel; it is a deeper structural malaise, where defined roles exist in policy but remain unimplemented in practice. The divergence here is subtle but significant: while policy documents articulate multi-sectoral coordination, actual practice, as revealed by field data, points to actors working in silos, thereby undermining collective outcomes.

Another convergence point between the two strands of data is the limited community involvement in waste planning. While only 21.4% of surveyed residents reported ever participating in community meetings on waste issues, qualitative narratives provided an even richer context to this finding. One community leader noted, "People are never consulted; programs come from above, and we are expected to comply." This aligns with studies by AfDB (2019) and underscores that *token participation* without genuine engagement contributes to policy failure and citizen apathy.

Yet, a notable divergence lies in how the community perceives responsibility for poor waste outcomes. While a significant portion of survey respondents (47.2%) blamed poor enforcement on government laxity, some interviewees suggested a more nuanced view, pointing to citizen non-compliance and lack of environmental awareness. As one waste contractor put it, "Even when we place collection bins, people still dump anywhere. It's a mindset problem." This reflects a tension between structural and behavioral explanations, indicating that while institutional failures dominate the landscape, some actors locate blame in individual or community-level attitudes, creating a discord in problem framing. This divergence enriches the literature by complicating earlier studies, such as Byamukama et al. (2015), that predominantly blame governance failures. The present study shows that both institutional breakdown and citizen practices must be considered, offering a more layered interpretation of waste governance challenges

This divergence is crucial for policy because it suggests that effective solutions must address both systemic and behavioral dimensions. Community sensitization alone will not suffice if institutional accountability and coordination are not simultaneously enhanced. Conversely, focusing solely on institutional reform without cultivating community ownership risks recurring policy failures.

Ultimately, the data strongly support the researcher's argument that sustainable waste management in Mbarara City cannot emerge from isolated or reactive interventions. Rather, it demands a paradigm shift from fragmented, top-down strategies to holistic, community-driven, and systems-oriented governance. This is not merely a recommendation; it is an imperative if Mbarara is to address the urban waste crisis while pursuing environmentally and socially just development.

4.7.3. Socio-Economic Implications of Poor Waste Management: Convergence and Divergence of Findings

This study provides compelling and multi-dimensional evidence that ineffective waste management practices are tightly interwoven with significant and escalating socio-economic consequences in Mbarara City. Both quantitative data and qualitative narratives converge to highlight health, livelihood, and educational disruptions, especially among vulnerable populations residing near the River Rwizi.

Quantitatively, over 60% of survey respondents reported that at least one household member had suffered from a waterborne illness, most commonly typhoid, dysentery, or cholera, within the past year. These findings correlate with World Health Organization estimates on the urban health burden linked to environmental degradation. Qualitative interviews echoed this, with a community health worker stating, "We see the same families returning with the same diseases. It's because they have no choice but to use water from River Rwizi.".

This finding extends existing WHO (2018) arguments on environmental health by situating disease not only in exposure but in systemic governance failures. Theoretically, this adds to debates on environmental justice, showing how health inequalities are produced through infrastructural exclusion, and this convergence underscores that waste-related pollution is not only visible but also measurably harmful to public health.

The implications extend beyond health. Households reported increased spending on medical treatment and reduced income due to missed workdays 56.7% of respondents indicated that illness had directly affected their ability to earn a living. Qualitative insights reinforced this with specific stories of disrupted livelihoods: one respondent from the fishing community lamented, "We used to catch fish and sell in the market, but now the water stinks, and fish are hard to find." This narrative

aligns with survey responses indicating that 48.9% of residents perceived a negative impact on their agricultural or fishing activities due to poor waste management.

Here, Systems Theory helps make sense of the negative feedback loops created by environmental degradation. Failures in waste regulation compromise water quality, which in turn harms public health, reduces income, and disrupts education as families redirect resources to healthcare or children miss school. The cycle is self-perpetuating and disproportionately affects those already in economically precarious positions. Indeed, the study found that households in informal settlements were both more exposed to waste and less likely to access protective infrastructure or services.

A subtle divergence emerged in how different actors attributed responsibility for these socio-economic harms. While the majority of survey participants (62.5%) held the local government accountable for inadequate waste enforcement, qualitative data revealed more complex perspectives. Some community leaders pointed to public apathy and illegal dumping by residents as contributing factors. This divergence contributes to scholarly debates by juxtaposing structural explanations (government failure) with behavioral explanations (citizen dumping). Rather than choosing between them, the study demonstrates that both operate simultaneously in feedback loops, thereby enriching existing debates on accountability in African waste governance. For example, a municipal environmental officer remarked, “Even when we put up warning signs or bins, people throw garbage into the river; it’s a problem of behavior, not just policy.” This indicates a discrepancy between public perception and institutional framing, revealing a gap in environmental awareness and civic responsibility. This divergence has significant policy implications: while structural reform is essential, behavioral change must also be cultivated through targeted environmental education and participatory governance models. Without addressing both dimensions, solutions may remain superficial or short-lived. Importantly, the study also revealed hidden economic costs across multiple sectors agriculture, informal trade, healthcare, and even tourism. The polluted River Rwizi, once a community asset, now represents a liability. Stakeholders from the private sector and informal trade emphasized how the aesthetic and ecological degradation reduces foot traffic to markets and deters visitors, cutting off alternative income streams. These effects are often underreported in mainstream economic assessments, reinforcing the need for integrated, cross-sector analysis of environmental policy impacts.

In conclusion, the findings strongly support integrating waste management as a key socio-economic development priority, not just a technical or environmental concern. This requires cross-sector collaboration, ongoing investment, and accountability systems that involve communities, policymakers, and private sectors. Unless these structural and behavioral factors are addressed together, Mbarara risks worsening urban inequalities amid unchecked environmental decline.

CHAPTER FIVE
SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Introduction

This chapter presents a synthesis of the study's findings in relation to the research objectives. It discusses the significance of the results, compares them with existing literature, and derives conclusions and practical recommendations for improving waste management and promoting environmental sustainability in Mbarara City, particularly around the River Rwizi.

5.2. Summary of Study Findings

This study aimed to assess the influence of waste management practices on environmental sustainability in Mbarara City, with a focus on communities located near River Rwizi. A convergent mixed-methods design was employed, combining quantitative data from structured questionnaires with qualitative insights from key informant interviews. Quantitative data were analyzed using descriptive statistics, correlation analysis, and multiple regression modeling, while qualitative responses were examined thematically to enrich interpretation and provide contextual depth.

5.2.1. Waste Management Practices.

The findings revealed that plastic (43.3%) and organic waste (39.6%) were the most commonly generated types of waste within the study area. Disposal methods were primarily limited to municipal collection (24.7%) and open dumping (23.5%), indicating an overreliance on conventional and often unsustainable methods. Notably, only 32.7% of respondents reported practicing waste segregation, pointing to low community uptake of basic sustainable waste practices. Waste collection frequency was inconsistent, with only 14.9% of households receiving daily collection, and a significant number experiencing infrequent or no collection services. This suggests gaps in service coverage and system reliability across neighborhoods.

5.2.2. Challenges to effective waste management.

Key informants highlighted several structural and institutional barriers impeding effective waste management. These included insufficient funding, limited infrastructure, and weak enforcement of existing waste management policies. Furthermore, there was a consensus on the lack of public

awareness and civic responsibility regarding proper waste handling. These challenges collectively hinder the operationalization of sustainable waste systems in Mbarara City.

5.2.3. Socio-Economic and Environmental Impacts

The study identified multiple negative consequences of poor waste management on both the environment and local livelihoods. Improper waste disposal was associated with reduced agricultural productivity, especially in peri-urban areas where waste contaminates water and soil. Additionally, health-related costs were reported to increase due to the proliferation of waste-related diseases, and environmental degradation was evident along the River Rwizi. Regression analysis confirmed a statistically significant relationship between waste management practices, stakeholder challenges, and environmental sustainability outcomes ($R^2 = 0.477$), indicating that nearly 48% of the variance in sustainability outcomes could be explained by the factors studied.

5.3. Conclusions

Based on the comprehensive analysis of both quantitative and qualitative data, this study draws a set of conclusions aligned with the specific objectives that guided the research. These conclusions underscore the multifaceted nature of waste management challenges in Mbarara City and highlight the critical link between environmental practices and community well-being

5. 3.1. Status of Waste Management Practices in Mbarara City

The study concludes that waste management practices in Mbarara City, particularly in the communities situated near River Rwizi, remain largely inadequate and unsustainable. The findings reveal that a substantial proportion of the population still engages in environmentally harmful practices such as open dumping, roadside littering, and the burning of solid waste. These practices not only contribute to land and air pollution but also lead to the contamination of water bodies, most notably the River Rwizi, thereby posing serious risks to public health.

Efforts toward sustainable waste management, such as waste segregation at the household level, recycling initiatives, and composting of organic waste, are minimal and poorly adopted. This lack of participation reflects a combination of low public awareness, limited accessibility to appropriate waste disposal facilities, and weak institutional support. The disparities in waste collection services

are stark, with central urban areas enjoying relatively better coverage compared to peri-urban and informal settlements, where service delivery is often irregular or non-existent. These spatial inequalities reflect deeper infrastructural and logistical constraints facing the city's waste management system.

Although some private sector players have entered the waste management space, their efforts are often fragmented and lack coordination with local government authorities. In summary, the study concludes that Mbarara City lacks an integrated, inclusive, and well-coordinated waste management framework capable of supporting environmental sustainability. Existing policy frameworks and bylaws have not translated into effective implementation, resulting in a gap between policy intent and practice.

5.3.2. Challenges Faced in Implementing Sustainable Waste Management

The study identifies a range of interconnected challenges that hinder the effective implementation of sustainable waste management systems within the city. Chief among these is inadequate funding, which limits the ability of the municipal authorities to invest in waste collection equipment, build modern landfill sites, or develop recycling infrastructure. Additionally, enforcement of existing waste management laws and regulations is weak due to both institutional incapacity and political interference.

Community engagement is also limited, with many residents either unaware of their responsibilities or lacking trust in the local government's ability to manage waste effectively. There is a widespread absence of behavior change communication programs, which has resulted in low levels of public cooperation and minimal efforts toward proper waste segregation and disposal at the household level.

The lack of collaboration and clear roles among stakeholders, including municipal councils, private waste collectors, civil society organizations, and community leaders, has resulted in a disjointed system marked by inefficiencies and duplications. Key informant interviews further revealed that political interests often take precedence over environmental concerns, and that penalties for improper waste disposal are either rarely enforced or too lenient to serve as deterrents.

In conclusion, the study finds that the barriers to sustainable waste management in Mbarara City are not only technical or financial but are deeply rooted in systemic governance issues and behavioral patterns that require long-term strategic interventions.

5.3.3. Socio-Economic Implications of Poor Waste Management

The study establishes that the consequences of poor waste management extend well beyond environmental degradation to include serious socio-economic repercussions, particularly for communities that depend directly on natural resources. The contamination of River Rwizi, for instance, has led to a noticeable increase in the incidence of waterborne diseases such as cholera, typhoid, and dysentery, imposing both a health and economic burden on already vulnerable households. The cost of treating these preventable illnesses places additional pressure on local healthcare systems and diverts resources from other critical needs.

In addition, agricultural productivity is negatively affected due to soil and water contamination, which undermines the livelihoods of farmers who rely on clean natural inputs for successful crop yields. For fishing communities, the decline in fish populations due to polluted water sources translates into a loss of income and food insecurity. Similarly, the visual blight and foul odors caused by open dumps discourage tourism and investment in Mbarara City, thus limiting opportunities for economic growth.

Collectively, these effects illustrate the far-reaching impacts of ineffective waste management practices on the city's socio-economic development and underscore the need for urgent, coordinated action. The study concludes that waste mismanagement not only endangers the ecological health of the River Rwizi ecosystem but also threatens the economic and physical well-being of its surrounding communities, especially the poor and marginalized groups who are least equipped to cope with the consequences.

5.4. Recommendations

The study has shown that waste management in Mbarara City is hindered by limited funding, weak enforcement, poor public awareness, and uncoordinated stakeholder engagement, factors that contribute to environmental degradation and socio-economic losses, especially near River Rwizi. The following recommendations are proposed to improve waste management practices and promote environmental sustainability in Mbarara City

5.4.1. Increase Budgetary Allocation for Waste Management

To ensure sustainable and equitable waste management in Mbarara City, the City Council should formally allocate at least 10% of its annual environmental budget, specifically for solid waste infrastructure upgrades, personnel training, and regulatory enforcement. This increased funding should support the purchase of at least three additional garbage trucks to extend collection coverage to underserved peri-urban areas such as Rwemigina, Biharwe, and Kakiika. Additionally, the city should construct five decentralized waste collection points and conduct quarterly training workshops for both municipal sanitation workers and private waste contractors on effective waste segregation, safe disposal techniques, and public engagement.

To ensure transparency and accountability, a performance monitoring unit should be established within the city's environmental department to track expenditure and service outcomes, with bi-annual public reports on progress. The intended outcome of this recommendation is to reduce the city's reliance on open dumping by at least 30% and expand formal waste collection to cover 80% of households within two years. By setting specific targets, timelines, and measurable outcomes, this recommendation provides a clear roadmap for improving the waste management system in a way that is both practical and scalable.

5.4.2. Strengthen Enforcement Through Structured Protocols and Capacity Building.

To enhance regulatory compliance and improve accountability in waste management, Mbarara City should establish a well-trained and adequately resourced Environmental Enforcement Unit. This unit should be composed of at least ten officers with specialized training in environmental law, inspection procedures, and community sensitization. It should operate under a clearly defined legal mandate with operational autonomy to ensure enforcement activities are free from political interference. The unit's performance should be guided by a set of measurable indicators, such as

the number of inspections conducted, violations reported, penalties issued, and community feedback, tracked through a digital monitoring system.

All waste management bylaws and associated penalties should be publicly disseminated through awareness campaigns, radio announcements, and signage across key areas of the city. To build public trust and ensure transparency, the enforcement unit should publish quarterly reports detailing enforcement actions taken, compliance trends, and lessons learned. This structured and accountable approach is expected to increase compliance with waste disposal regulations by at least 50% over the next two years, reduce illegal dumping, and promote a culture of environmental responsibility.

5.4.3. Foster Multi-Stakeholder Partnerships for Innovation and Outreach.

To promote innovation and expand the reach of sustainable waste management, Mbarara City should foster formal multi-stakeholder partnerships with private waste management firms, non-governmental organizations (NGOs), and academic institutions. These partnerships should be guided by clear Memoranda of Understanding (MoUs) outlining shared objectives, roles, deliverables, and timelines. A key focus of these collaborations should be the piloting of at least two community-based recycling hubs in waste hotspot areas along River Rwizi, as well as the co-design and implementation of quarterly public awareness campaigns on waste reduction, segregation, and environmental stewardship.

Universities can contribute through student-led innovation projects and impact assessments, while NGOs can mobilize community participation and training. Each partnership should be evaluated biannually using performance metrics such as participation rates, quantity of waste diverted from landfills, and levels of community engagement. The aim is to create a collaborative ecosystem that leverages diverse expertise and resources to address local waste challenges innovatively, build public awareness, and stimulate a shift toward circular economy practices within the city.

5.4.4. Adopt Community-Based Waste Management Models.

To build sustainable and inclusive waste management systems, Mbarara City should implement community-based waste management pilot programs in at least two peri-urban communities, such as Nyamitanga and Kakoba. These programs should actively engage residents by providing training on household waste sorting, small-scale composting techniques, and organizing regular neighborhood clean-up campaigns. To support effective implementation, the city should supply each pilot community with essential start-up materials, including household bins, gloves, compost

kits, and signage, along with modest seed funding of approximately UGX 3 million per community to facilitate local coordination and logistics.

Local leaders and environmental committees should be involved in the design and monitoring of these initiatives to ensure community ownership and sustainability. Monthly clean-up days should be held with participation tracked through attendance records and visual documentation. Progress should be evaluated every quarter using indicators such as waste volume reduction, compost output, and household participation rates. By embedding waste practices at the community level, this model is expected to increase local accountability, reduce illegal dumping, and strengthen the culture of environmental stewardship in underserved areas.

5.4.5. Protect the River Rwizi Catchment Through Targeted Intervention.

To safeguard the ecological integrity of River Rwizi and reduce pollution from solid waste, Mbarara City should formally designate the river and its surrounding buffer zone as a high-priority environmental conservation area. This designation should be codified into city bylaws, accompanied by the enforcement of strict no-dumping regulations along the riverbanks. To support restoration efforts, the city should collaborate with environmental bodies, schools, and local communities to implement riparian reforestation activities, targeting the planting of at least 5,000 indigenous trees along vulnerable sections of the river.

Additionally, monthly clean-up events should be scheduled, with active participation from schools, youth groups, and NGOs, documented through reports and media coverage. Warning signage should be installed at 500-meter intervals along the river to deter illegal dumping, and a team of at least ten trained community environmental monitors should be deployed to report and respond to violations. These efforts should be evaluated through biannual impact assessments measuring improvements in water quality, biodiversity restoration, and community engagement levels. This targeted and participatory approach will help restore the health of River Rwizi, enhance public awareness of environmental protection, and contribute to long-term water security for Mbarara City and its surrounding communities.

5.4.6. Integrate Waste Management into Urban Planning Frameworks.

To ensure long-term sustainability in Mbarara City's growth, waste management must be fully integrated into the city's urban planning and land use frameworks. The City Council should amend existing physical planning regulations to legally require that all new urban developments, including

residential estates, commercial centers, and industrial parks, include comprehensive waste management plans as part of their development approval process. These plans should detail provisions for on-site waste segregation, adequate waste collection points, sanitation infrastructure, and environmental impact mitigation strategies.

Compliance should be verified through pre-approval reviews conducted by a multidisciplinary planning committee and followed up with periodic site inspections during and after construction. Developers who fail to comply should face conditional withholding of occupancy permits or financial penalties. In rapidly urbanizing zones such as Kakiika and Biharwe, special planning overlays should be introduced to mandate higher environmental standards, including stormwater management and proximity-based waste services. Integrating waste considerations at the planning stage will reduce future burdens on municipal systems, prevent illegal dumping, and promote environmentally conscious urban design that supports public health and resource conservation.

5.4.7. Promote Livelihood Diversification Through Green Enterprises

To promote inclusive economic empowerment and sustainable environmental practices, Mbarara City should implement a livelihood diversification initiative focused on supporting green enterprises. This program should specifically target youth and vulnerable community groups in waste-intensive areas, offering technical training and micro-grants to launch small-scale ventures in plastic recycling, compost production, and aquaponics. Each selected participant or enterprise group should receive three weeks of hands-on training in enterprise development, waste-to-resource technologies, and market access strategies, followed by a startup grant of approximately UGX 1.5 million.

The program should be managed in collaboration with local NGOs and business development service providers to ensure mentorship, monitoring, and sustainability. Key performance indicators, such as enterprise survival rates, monthly income generated, volume of waste processed, and number of community members employed, should be tracked over 12 months. Additionally, an annual Green Expo should be organized to showcase successful enterprises, attract investors, and foster peer learning. By building capacity for environmental entrepreneurship, this strategy aims to reduce reliance on high-risk informal work, create green jobs, and increase community ownership and participation in sustainable waste solutions.

5.5. Areas for Further Studies

While this study has provided valuable insights into the influence of waste management practices on environmental sustainability in Mbarara City, particularly in communities surrounding River Rwizi, it has also identified important areas that warrant further investigation. Future studies could possibly focus on the following areas to interrogate them further.

1. Longitudinal Assessment of Waste Management Interventions and Environmental Outcomes in Mbarara City.
2. Economic Cost-Benefit Analysis of Sustainable Waste Disposal Technologies in Ugandan Urban Settings.
3. Social and Behavioral Determinants of Community Waste Management Practices in Mbarara City.

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APPENDIX 1: QUESTIONNAIRE

We are conducting a study on waste management practices and their implications for environmental sustainability and natural resource management in River Rwizi, Mbarara City (Remind the participant how the details of the intervention were explained in the consent form). Before we start, do you have any questions?

Section A: Demographic Information

1. Age:
   - ☐ Below 18
   - ☐ 18–25
   - ☐ 26–35
   - ☐ 36–45
   - ☐ Above 45
2. Gender:
   - ☐ Male
   - ☐ Female
   - ☐ Other
3. Education Level:
   - ☐ No formal education
   - ☐ Primary school
   - ☐ Secondary school
   - ☐ Tertiary/University
4. Occupation:
   - ☐ Farmer

- Trader
- Government employee
- Student
- Other (specify): _____

Section B: Waste Management Practices

5. What type of waste do you generate the most? (Select all that apply):
   - Organic waste (food/plant matter)
   - Plastic waste
   - Paper/cardboard
   - Hazardous waste (batteries, chemicals)
   - Other (specify): _____
6. How do you dispose of your waste?
   - Open dumping
   - Burning
   - Municipal collection
   - Recycling/reuse
   - Composting
   - Other (specify): _____
7. Who is responsible for waste collection in your area?
   - ☐ Municipal authority
   - ☐ Private companies

- ☐ Community initiatives
- ☐ Individuals
- ☐ Other (specify): _____

8. Are there public waste bins in your area?

- Yes
- No

9. How often is waste collected in your area?

- Daily
- Weekly
- Rarely
- Never

10. Do you practice any form of waste segregation?

- Yes
- No

11. If yes, what categories do you segregate waste into?

- Organic and inorganic
- Recyclables and non-recyclables
- Other (specify): _____

12. To what extent do you agree or disagree with the following statements about waste management in your area?

a) "I have sufficient knowledge about proper waste disposal methods."

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

b) "The current waste management system in Mbarara City is effective."

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

c) "Improper waste management significantly affects the health of River Rwizi."

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

13. Have there been any recent improvements in waste management in your area?

☐ Yes

☐ No

☐ Not sure

14. If yes, what improvements have been made?

☐ More frequent waste collection

☐ Installation of waste bins

☐ Awareness campaigns

☐ Stricter enforcement of waste regulations

☐ Other (specify): _____

Section C: Environmental Sustainability & Challenges

13. Do you believe current waste management practices are affecting River Rwizi?

- Yes
- No

14. If yes, in what way?

- Water pollution
- Habitat destruction
- Reduced biodiversity
- Other (specify): _____

15. Are you aware of any community initiatives for improving waste management?

- Yes
- No

16. How do you rate the overall effectiveness of waste management practices in your area?

- Very effective
- Moderately effective

- Ineffective

17. What challenges do you face in proper waste management?

- Lack of infrastructure
- Poor enforcement of laws
- Lack of awareness
- High cost of alternatives
- Other (specify): _____

18. What challenges do local authorities face in managing waste effectively? (Select all that apply)

☐ Inadequate funding

☐ Weak enforcement of waste regulations

☐ Lack of public cooperation

☐ Insufficient waste collection infrastructure

☐ Other (specify): _____

19. What challenges do businesses face in managing waste? (Select all that apply)

☐ High costs of waste disposal services

☐ Limited access to recycling programs

☐ Lack of government incentives for sustainable waste management

☐ Other (specify): _____

20. What challenges do community members face in adopting better waste management practices? (Select all that apply)

☐ Limited knowledge about proper waste disposal

☐ Inconvenience/lack of waste disposal facilities

☐ Cultural attitudes towards waste disposal

☐ Other (specify): _____

Section D: Socio-Economic Implications

21. How has poor waste management affected your economic activities? (Select all that apply)

☐ Reduced fish catch due to water pollution

☐ Decline in tourism due to pollution

☐ Increased health expenses due to pollution-related diseases

☐ Decreased agricultural productivity due to soil contamination

☐ Other (specify): _____

22. Have you or your household experienced any health issues due to poor waste management near River Rwizi?

☐ Yes

☐ No

23. If yes, what health problems have you encountered? (Select all that apply)

☐ Waterborne diseases (e.g., cholera, typhoid)

☐ Respiratory problems (due to burning of waste)

☐ Skin infections

☐ Other (specify): _____

24. In your opinion, how does poor waste management impact the livelihoods of people dependent on River Rwizi?

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25. What improvements would you suggest for better waste management?

- Increase awareness campaigns
- Provide more public waste bins
- Enforce stricter regulations
- Promote recycling programs

APPENDIX 2: INTERVIEW GUIDE

Introduction:

- Thank the participant for their time.
- Briefly explain the purpose of the interview.
- Assure confidentiality and obtain consent to record responses.

Section 1: Background Information

1. Can you describe your daily activities and how they relate to waste generation?

2. How would you describe the waste management practices in your community?

3. Who is responsible for waste collection in your area, and how efficient is the service?

4. Have there been any recent changes or improvements in waste management practices?

Section 2: Community Practices and Challenges

5. What methods of waste disposal are commonly practiced in your area?

6. Are there any local systems for waste segregation or recycling? If yes, how effective are they?

7. What challenges do individuals, businesses, and local authorities face in managing waste effectively?

8. How would you describe the level of enforcement of waste management regulations in your area?

9. Do you think businesses and institutions comply with proper waste disposal practices? Why or why not?

Section 3: Environmental Impact

10. How do you think the current waste management practices impact River Rwizi?

11. Are there noticeable changes in the river's ecosystem or resources due to waste?

12. In what ways does poor waste management affect people's health and livelihoods in your community?

13. Are certain groups (e.g., farmers, fishermen, traders) more affected than others by poor waste disposal practices? If so, how?

Section 4: Governance and Policy (Role of Authorities and Sustainability Efforts

13. Are you aware of any programs or campaigns promoting environmental sustainability in your area?

14. What role do local authorities play in waste management and environmental conservation?

15. Do you feel that waste management laws and regulations are effectively enforced? If not, what are the major gaps?

Section 5: Recommendations

16. What solutions do you suggest for improving waste management around River Rwizi?

17. How can individuals and communities contribute to sustainable practices?