



COLLEGE OF SCIENCE AND TECHNOLOGY  
SCHOOL OF ARCHITECTURE AND BUILT ENVIRONMENT

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**MASTER OF SCIENCE IN GEO-INFORMATION SCIENCES FOR ENVIRONMENT  
AND SUSTAINABLE DEVELOPMENT (MSC GI-ESD)**

**ASSESSING THE CHALLENGES OF WETLANDS MANAGEMENT  
IN EASTERN PROVINCE. Case of Rwangingo Wetland, Katabagemu  
Sector.**

This thesis submitted to the University of Rwanda, College of Science and Technology in partial fulfillment of the requirements for the award of the Degree of Master of Science in Geo-Information Science for Environment and Sustainable Development.

**Presented by:**

**NYIRAHABIMANA Seraphine**

**Reg N°: 218014508**

**Supervisors: (1) Assoc. Prof. Theophile NIYONZIMA**

**(2) Assoc. Prof. Rahman TAFAHOMI**

**Kigali, August 2024**

**DECLARATION**

I declare that this thesis is my original work and has never been submitted or examined in any university as an academic requirement for any award.

NYIRAHABIMANA Seraphine

.....

Date: ... .. / ... .. / ... ..

**APPROVAL**

It is hereby confirmed that this thesis entitled “*Assessing the Challenges of Wetlands Management in Eastern Province, Case of Rwangingo Wetland, Katabagemu Sector*” submitted by **NYIRAHABIMANA Seraphine** has been assessed and accepted by the post-graduate coordination team in the School of Architecture and Built Environment.

- **Supervisors**

**Assoc. Prof. Theophile NIYONZIMA**

Signature: .....

Date: ... .. / ... .. / ... ..

**Assoc. Prof. Rahman TAFAHOMI**

Signature: .....

Date: ... .. / ... .. / ... ..

- **Post-graduate coordinator**

**Dr. Ernest UWAYEZU**

Signature: .....

Date: ... .. / ... .. / ... ..

- **Dean of School of Architecture and Built Environment**

**Dr. Josephine MALONZA**

Signature: .....

Date: ... .. / ... .. / ... ..

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## **ABSTRACT**

This study was conducted on Rwangingo Wetland located in Eastern Province, Nyagatare District, Katabagemu Sector. Rwangingo wetland contributes to human well-being as it is used for agriculture activities while its management faces challenges due to potential gaps in policies related to wetland management. . The study assessed the challenges of Rwangingo wetland management specifically describing activities conducted in the wetland, analyzing the wetland management practices, challenges related to the management of Rwangingo Wetland, and proposing measures to enhance the effectiveness of Rwangingo Wetland . Primary Data were collected through interviews, field observations, and mapping. Google Earth images, were used to analyze the change of the wetland. These images were processed and analyzed using ArcGIS. Rwangingo Wetland was mainly developed for rice production, but the findings revealed the presence of other food crops including maize, soyabean, potatoes, greenbeans, with the average yield estimated at 4.5 Tons/ha for maize. The findings show that the rehabilitation of Rwangingo wetland increased its area from 721ha to 780ha. Land cover also changed, with native vegetation like shrubland (23.7%) and cropland increased reaching 74.9%, while some areas were used for infrastructure development including road (1.2%) and water channels (0.2%). In the study area, wetland management practices underway include maintenance and rehabilitation of the road along the main water channels and farmers' organization facilitating seasonal meetings and joint monitoring/evaluation teams with stakeholders for sustainable agricultural practices. However, there are some challenges such as those related to irrigation design, conflicting wetland usages, institutional managerial issues, and recurrent flooding. Measures were set to enhance the effectiveness of Rwangingo Wetland including the protection of the buffer zone, promotion of stakeholder engagement and awareness, improvement of infrastructures and wetland management practices, and implementation of sustainable resource use management. By implementing measures that address the identified challenges, Rwangingo Wetland management will be further strengthened to ensure its conservation, increase value for the benefit of farmers.

**Keywords:** Wetland, Effectiveness, Wetland management, Rwangingo Wetland

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## LIST OF ACRONYMS AND ABBREVIATIONS

<b>DLUP</b>	District Land Use Plan
<b>Ha</b>	Hectares
<b>Km2</b>	Kilometer square
<b>m2</b>	Meter square
<b>MINAGRI</b>	Ministry of Agriculture and Animal Resources
<b>RAB</b>	Rwanda Agricultural and Animal Resource Board
<b>NWMP</b>	National Wetland Management Framework
<b>NGO</b>	Non-Governmental Organization
<b>NISR</b>	National Institute of Statistics of Rwanda
<b>NLUDMP</b>	National Land Use and Development Master Plan
<b>UR</b>	University of Rwanda
<b>SDG</b>	Sustainable Development Goals
<b>NLUDMP</b>	National Land Use Development Masterplan
<b>LULC</b>	Land Use Land Cover
<b>REMA</b>	Rwanda Environment Management Authority

## **CHAPTER ONE: INTRODUCTION**

### **1.1. The Wetlands of Rwanda**

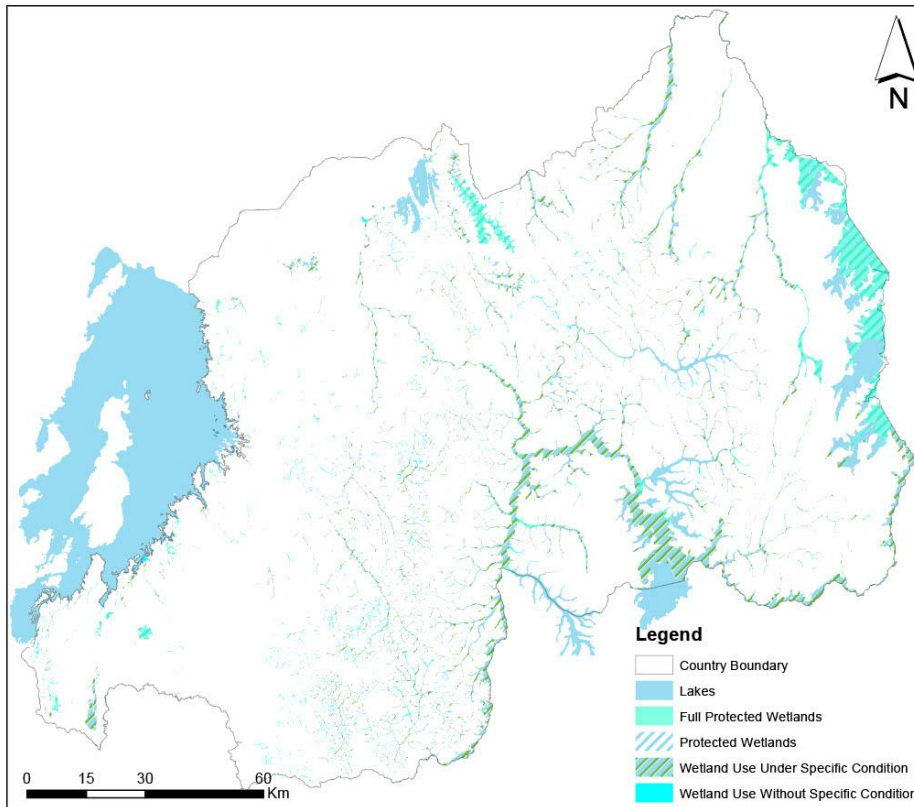
Rwanda boasts a substantial wetland cover of around 280,000 hectares, or about 11 percent of the nation's total land area. Rwanda is divided into two drainage basins: the Nile to the east, which covers 67% of the country and supplies 90% of the nation's waters, and the Congo to the west, which covers 33% of the country and supplies all of its water resources. These wetlands support important hydrologic processes that are necessary for cleaning and protecting surface and ground water, as well as key habitats for animals and biodiversity. They also provide support for a range of local livelihoods.

(Seki et al., 2018).

Despite these benefits, land use changes, resource overuse and competition, and meteorological conditions present these wetlands with a host of difficulties. Of all the habitats in Rwanda, the wetlands are the ones that are disappearing and deteriorating the fastest. Rwanda's wetlands are currently utilized for energy generation and agriculture in more than half of the country. The distribution of these and other wetlands in Rwanda is mostly influenced by the terrain of the country and the quantity of rainfall received.

(Macharia et al., 2014) these characteristics define the different types of Rwandan wetlands, including riverine, marine, estuarine, lacustrine, palustrine, and constructed wetlands. These wetlands are vital for local communities, providing essential resources like food, water, medicine, and materials for building and crafting (as documented in research by Kumar et al., 2017 and Macharia et al., 2014). Climate change is expected to significantly impact these ecosystems, threatening these resources and placing a strain on already stretched basic needs like food, water, and healthcare, especially for poorer populations (Hussain et al., 2022). This aligns with research by Turner et al. (2003) who found that climate change disrupts ecosystems, making people who rely on them more vulnerable. While traditionally used for water, grazing animals, and small-scale farming, wetlands naturally regulate water flow. However, draining wetlands for intensive agriculture disrupts this. Water quickly moves downstream, reducing the wetland's ability to control floods, store water, and trap sediment. (Kumar et al., 2017).

Wetlands in Rwanda are under pressure from activities like hydropower generation and extraction of materials like clay and sand. These actions can directly harm wetlands. Hydropower plants need a lot of water, and they often connect to wetlands. However, wetlands can't always store enough water for these plants, which can lead to problems with sediment buildup. This sediment damages the turbines and pipes in the power plants.



**Figure 1. Wetlands in Rwanda (Source: NISR & REMA, 2014)**

### **1.2. Use of Wetland**

Wetlands serve as vital ecosystems among of the worldwide highest productivity rates (Kusler, 2006). These are important components in achieving a balance between human needs and environmental health. (Martínez, 2015). Wetlands are crucial for healthy ecosystems but are sensitive to environmental changes which are Pollution from human activities and They can act as a built-in filtration system, removing pollutants from water.. In Rwanda, where most people rely on farming, land for agriculture has declined. Decades ago, each household had 3 hectares; now it's less than 1 Ha per Household (MINAGRI, 2018b; REMA, 2009).

Creating and implementing programs to sustainably manage, conserve wetlands, and help them adapt to climate change is especially difficult in low- and middle-income countries with limited resources (Bidogeza et al., 2009). In Rwanda, wetlands constitute roughly 10.6% of the country's land area with the total of 935 Wetlands (REMA, 2020). While Rwanda needs wetlands for farming to feed its growing population, it is vital to set away other areas as protected zones. These natural reserves will ensure wetlands to keep providing vital environmental benefits. (Mccartney et al., 2015).

In Rwanda, wetlands are considered as lowlands and the bottoms of valleys, regardless of how wet they are. Historically, these wetlands have been valuable for many purposes, including agriculture, resource extraction, and fishing. (REMA, 2020; Seki et al., 2018). They are significant contributors to a nation's economic by supporting agriculture, biodiversity, and ecotourism (ADB, 2018; ARCOS, 2017; MINAGRI, 2018b). Many low-income communities rely on wetlands for their survival, increasing food and getting money through agriculture (Nabahungu, 2012). In Rwanda, farming is mainly done to feed the farmer's family, Upland farmers take advantage of nearby wetlands to grow crops, they plant the same crops in both areas except for rice, which only grows in the wet ground. (Chemonics International Inc, 2008; Nabahungu & Visser, 2011). In Rwanda, Wetland farming adapts to water conditions. Traditionally, these wetland farms are small-scale and affordable. Despite being simple, they produce more than uphill farms because of the constant water supply and rich soil. The relationship between farm management and wetlands depends on how far the wetland has been changed for agricultural practices.. (MINAGRI, 2018b; Padmanaban et al., 2017) Small scale farmers, working with their families, decide what to cultivate in their reclaimed wetlands. They sometimes come together in informal groups to help each other out on their wetland and dryland fields. (Nabahungu, 2012). SDGs highlighted emphasizes that healthy wetlands are vital for clean water. Almost all freshwater comes from wetlands, either directly or after being filtered through wetlands. This highlights the need to protect, use wisely, and restore these vital ecosystems (The Ramsar Convention Secretariat, 2016), Wetlands are nature's water filters, providing clean drinking water and water for crops. They act as coastal protectors, protecting shores from These vital ecosystems also support sustainable livelihoods and contribute to our overall health.. (Seifollahi-aghmiuni et al., 2019). Wetlands used as a cost-effective solution for the environment and local communities are under pressure from increasing industries. Rwanda is leading the way in supporting their conservation and restoration. (UN Water, 2018).

In Rwanda, large areas of wetlands were drained to create agricultural land. However, these projects ignored the important role wetlands play in managing water flow and ecology. As a result, 5,000 Ha out of the 165,000 Ha of rehabilitated wetlands meet environmental and water management guidelines (Prosper et al., 2017). The government of Rwanda considers wetlands as a key tool to boost agriculture, aiming for food security and poverty reduction as outlined in agricultural policy of 2020. According to Vision 2050, the Government of Rwanda targets a yearly economic growth of 6.4%, with a significant decrease in less than 30% of farmers. By 2050, Rwandan agriculture is expected to be advanced with professional farmers managing large, irrigated farms covering 600,000 hectares and all irrigable land will be irrigated. (GoR, 2022)

## 1.2. Problem Statement

Wetlands act as natural filters, flood protectors, and supporting all human well-being. (Kumar et al., 2017). Fish and fiber supply, water supply, water purification, climate regulation, control of floods, recreational activities, and tourism are some of the services provided by the wetlands(Solve, 2013) .However, many of Rwanda's wetlands are not properly managed within their management plan. (Nile Basin Initiative, 2019).Wetlands are essential for preserving the global hydrological cycle, regulating the climate, conserving biological diversity, and ensuring human well-being. (Baisha Weng, 2024), Wetland ecosystems have the potential to directly benefit human well-being in addition to providing indirect benefits. (Pritchard, 2023).Improved wetland management is expected to have a potential contribution to this growth of 0.5%. The government of Rwanda supports wetland developmenti as an effort to increase crop production, increase the rural economy, and reduce poverty, (Ndayisaba et al., 2017).

The ability low-income and subsistence farmers in Eastern province to sustain their current productivity and adapt to future climate variability depends mainly on how well their natural environment, especially wetland management.(ARCOS, 2017; RWFA, 2021). However the challenge for Eastern Province lies in creating sustainable wetland management strategies adapted to local community needs. This requires understanding the impact of human activities on wetland strength and identifying limits for rehabilitation to avoid ecosystem failure (REMA, 2020).

While wetland development is given priority in Rwandan government policy to intensify agriculture, there are issues regarding the long term sustainability of this strategy. This research pertains to Rwangingo wetland located between Gatsibo and Nyagatare in Katabagemu Sector. Rwangingo wetland management faces challenges due to potential contradictions and gaps in policies related to wetland management and there is no management plan for Rwangingo. The other challenges are conflicting interest in the implementation of existing policy including unclear relations between policies promoting wetland conservation and those allowing wetland development.

Farming activities within Rwangingo Wetland resulted in the degradation of valuable ecosystems, rendering the area unsuitable for sustained agricultural practices. The encroachment of livestock and agricultural activities on adjacent hillsides further aggravated the situation. Inappropriate of wetland drainage, and the implementation of irrigated agriculture contributed to a significant environmental imbalance within the wetland and surrounding regions.The purpose of this study is to assess the challenges of Rwangingo Wetland management, with a focus on whether it achieves a balance between the well-being of the wetland

ecosystem and agricultural production, and analyze to which extent the management is fulfilled and increase knowledge of the current situation and sustainable use of wetland.

### **1.3.Objectives.**

#### **1.3.1Main objective**

The main objective of the study is to assess the challenges of Rwangingo Wetland Management, Katabagemu Sector.

#### **1.3.2.Specific objectives**

- To describe current activities conducted in Rwangingo Wetland
- To define the management practices of Rwangingo wetland.
- To analyze challenges related to the management of Rwangingo Wetland
- To propose measures to enhance the effectiveness of Rwangingo wetland management.

#### **1.3.3.Research questions**

- What are current activities conducted in Rwangingo Wetland?
- How successful are management interventions in Rwangingo wetland?
- What are the challenges related to the management of Rwangingo wetland?
- What measures could be to enhance the effectiveness of Rwangingo Wetland management?

### **1.4. Significance of the Study**

Assessing the challenges of Rwangingo Wetland management is crucial for informing future management practices and policy decisions that ensure the sustainable use of wetlands. Sharing findings will lead to improved wetland management strategies of management practices and measures to address challenges related to wetlands management and also provide information for future researchers. Furthermore, the study serves as a model for assessing the challenges of wetland management in other regions.

### **1.5. Research Matrix**

The research matrix summarizes the specific objectives and research questions, the data sources and methods, variables to be analyzed, methods, and expected data. It is a tool used during the research and writing process of a thesis. It functions as a visual guide that allows to compare different data to address research questions in assessing the effectiveness of Rwangingo Wetland Management.

<b>Research objective</b>	<b>Research question</b>	<b>Methods and data sources</b>	<b>Expected Results</b>
To describe the current activities conducted in Rwangingo wetland	What are the current activities conducted in Rwangingo Wetland?	Existing literature (scientific papers, existing reports, policies, laws, regulations on wetland management, etc.) Field observation, interview  Inventory mapping,	Types of activities conducted in the wetland, compliance of those activities with existing policies, laws, and regulations on wetland management. Overview of crop types grown in Rwangingo Wetland.
To analyze the wetland management practices of Rwangingo wetland.	How successful are management interventions in Rwangingo wetland?	Existing literature (scientific papers, existing reports, policies, laws, regulations on wetland management, etc.) Field observation,interview,Inventory mapping	-Description of existing wetland management practices,  -identify existing cooperatives in Rwangingo Wetland  -Description of land use and Land cover change in different years.
To analyze challenges related to the management of Rwangingo wetland.	What are the challenges related to the management of Rwangingo wetland?	Existing literature (scientific papers,existing reports, policies,laws,regulations on wetland management, etc.) Field observation, interview  Inventory mapping	Overview of Rwangingo Wetland management challenges.

***Table 1. Research Matrix***

## **CHAPTER TWO: LITERATURE REVIEW**

### **2.1.Introduction**

wetlands play a crucial role in providing essential services for our environment Despite their smaller land, (Seki et al., 2018). Understanding the services wetlands offer has led to a broader appreciation for the worth of natural assets (Zhang et al., 2015). The critical role of wetlands led to regulations protecting them (Zhang et al., 2015). Restoring or creating new wetlands to replace lost ones are difficult and take years to be established. Even successful mitigation efforts are not fully replicate the functions of the original wetland (Macpherson, 2013) . This chapter presents the definition of wetlands, uses of wetlands,challenges, Wetland land use and land cover changes.

### **2.2.Definition of wetlands**

Wetlands bridge the gap between dry land and aquatic environments (i.e. grasslands, forests) and water systems(Pritchard, 2023) (i.e., lakes, rivers, and oceans). there's no clear line between completely dry and completely wet environments. This diversity, along with the smooth transition between these extremes, makes it difficult to establish a universal definition that applies to all wetlands. Additionally, the scientific community faces challenges in adapting their definitions to encompass this vast range of wetland types(Council 1995: 22)there's no clear line between completely dry and completely wet environments. This diversity, along with the smooth transition between these extremes, makes it difficult to establish a universal definition that applies to all wetlands. Additionally, the scientific community faces challenges in adapting their definitions to encompass this vast range of wetland types.”(The Ramsar Convention Secretariat, 2016).It continues in The article defines wetlands in two ways. One way includes not only the core area but also nearby coastal and river zones. It also encompasses islands and deep underwater areas within the wetland boundaries. Another way to describe wetlands is as areas where land and water meet. The water table is typically close to the surface or the land may be covered in shallow water.

### **2.3.Legal Framework**

#### **2.3.1.National Wetland Management Framework**

This framework outlines a plan for wetland management, including inventory, protection, rehabilitation, and monitoring. This framework, created for the Rwanda Environment Management Authority (REMA), follows the guidelines of the Ramsar Convention on wetlands. The National Wetland Management Framework creates a unified approach to managing ecosystems.Recognizing the importance of wetlands for Rwandan biodiversity, people, and the economy, This builds upon Rwanda's existing commitment to wetland

conservation and ensures these resources are used sustainably in the future. Several Policies and Regulations have been put forward for the conservation and management of wetland ecosystems in Rwanda. These policies include The National Policy on Environment (2019), Environmental Law (2018) and Land Use Plans Zoning Regulations(2022).

**2.3.2.Environment and Climate Change Policy(2019)**

Rwanda's environment policy, adopted in 2019, aims for a healthy environment that can withstand climate change and support a good quality of life. It promotes sustainable environmental management and emphasizes building expertise and public awareness to protect the environment,for wetland management, the policy proposes restoring degraded wetland ecosystems and endangered species and implementing measures to prevent soil erosion on slopes near wetlands.

**2.3.3.Environmental Law(2018)**

This law establishes a general framework for environmental protection and management, including wetlands, and categorizes wetlands as either protected or non-protected. Protected wetlands fall within Ramsar Sites as wetlands of international importance. Non-protected wetlands can be used under specific conditions or without restrictions. This law sets that a 50meter buffer zone exists around wetlands designated as public land. This helps minimize activities that could negatively impact the wetland.

**2.3.4.Land use plans zoning Regulations(2022)**

Land use plan Zoning Regulations establish wetland zones to conserve these vital ecosystems and guide their sustainable use. This plan aims to 1) regulate activities within wetlands, 2) designate areas for conservation or use, 3) ensure surrounding development complements wetland zoning, and 4) identify projects to improve wetlands. It promotes both conservation and wise use, even allowing agriculture in 20meter buffer zones around unprotected wetlands.

**2.4. Comparison of Rwandan Wetland Management Frameworks**

NO	Policies, laws, and Regulations	Key points regarding Wetland management	Gaps in Wetland Management
1	National Wetland Management Framework (2017)	This framework outlines a plan for wetland management, including inventory, protection, rehabilitation, and monitoring.	1. determination of the extent of crop variation and agricultural

		It emphasizes following guidelines set by the Ramsar Convention on wetlands and describe sustainable agriculture in wetlands.	methods that couldn't cause damage to Wetlands 2. Unclear of implementation responsibilities and involvement of local communities in wetland management
2	Environment and Climate Change Policy(2019)	It emphasizes public awareness and capacity building for wetland protection.	1. Lack of details on wetland management and buffer zone establishment. 2.The policy doesn't mention activities and strategies for the sustainable use of wetlands.
5	Land Use Plans Zoning Regulations(2022)	Regulates activities within wetlands - Designates areas for conservation or sustainable use - Allows some activities, like agriculture, in specific zones around unprotected wetlands	1. Lack of monitoring and enforcement regulations 2. Regulations focus on wetland zoning but it doesn't mention the wetland restoration strategies
	Environmental Law(2018)	Establishes general framework for wetland protection  - Categories wetlands as totally protected or non-protected  -	Lack of a comprehensive policy focusing on wetland protection

**Table 2. Comparison of Rwandan Wetland Management Frameworks**

## **2.5. Threats to wetland**

Wetlands are the world's most valuable environmental resource but also the most vulnerable (Hudson et al., 2019). Wetlands have suffered degradation through either direct alteration or indirectly through the consequences of change especially in the hydrological input. Factors that lead to the loss of these wetlands are poverty, population pressure, sectoral demands, lack of centralized planning and perverse economic policies

### **2.5.1. Climate Change**

Climate change will disrupt the natural water flow in wetlands through rising temperatures and altered precipitation, potentially leading to significant changes in their plant and animal life. (Rene et al., 2018) .A range of human activities documented by the IPCC in 2007 are triggering biological and physical consequences across the globe. (Al-Obaid et al. 2017).

Healthy wetlands are essential for our well-being. The specific type of wetland depends on factors like climate, geography, and water flow. However, the biggest threats to wetlands come from human activities, not nature itself. Even if we stop climate change, some impacts are unavoidable. The more greenhouse gases we emit, the worse it gets for freshwater ecosystems. They could reach tipping points where dramatic changes happen suddenly. (Seifollahi-aghmiuni et al., 2019). Currently, the planet is grappling with the damaging consequences of climate change. (Erwin 2009). Climate change is causing the ground to thaw, water to freeze and flow differently, plants and animals to move to higher elevations, and some species to disappear. This is because nature can't easily adjust to these changes. (McCarthy and II 2001). The effectiveness of Hungarian nature conservation efforts is challenged by the severe degradation of wetland ecosystems (Malatinszky, 2013). Climate change, including its unpredictable swings, will disrupt ecosystems and where people live. Agriculture and water supplies will be especially hard hit. (Kebede et al. 2012). Climate change is a major driver of habitat destruction, not the other way around. Rising temperatures, altered precipitation patterns, and increasing sea levels can all destroy existing habitats (Klemas 2011A 2014 report by the IPCC found a clear link between human activities and rising greenhouse gas concentrations, which are very likely causing climate change. (IPCC 2013).

Climate change will likely affect wetlands in major ways, but exactly how is still uncertain. (Junk 2013) Our current way of using resources and the changing climate are both putting a strain on the environment. If we don't change course, this will lead to a significant loss of variety in life on Earth, more frequent flooding that will reduce some groundwater supplies, less and dirtier water overall, and disruptions to how ecosystems work,

making it harder for them to provide us with things we need (Grimm et al. 2013; Khisa et al. 2013). Africa, heavily reliant on agriculture, faces a double threat: rising temperatures exceeding the global average and a changing climate that disrupts agricultural practices (IPCC report, 2013) (Mitchell 2013). The growing demands placed on our environment will lead to continued exploitation of ecosystems. Malatinszky (2013) proposes an integrated framework for biodiversity conservation. This approach would involve evaluating vulnerabilities across different sectors and developing management plans to address them (Mitchell 2013).

### **2.5.2. Pollution**

Wetlands are like fussy eaters - they need clean water to thrive. Unfortunately, dirty water filled with pollutants is a major threat to these ecosystems. Common culprits include fertilizers, pesticides, sediment, metals, and air pollution. While wetlands can act as natural filters, they can only handle so much. Once overloaded, they become polluted and struggle to recover. This can lead to the collapse of entire wetland ecosystems, harming all the plants and animals that rely on them. Just look at China's polluted rivers - a sad example of how water contamination can devastate entire habitats. (An et al. 2007).

### **2.6. Pressure on Wetlands**

Human activities like building roads, farming, and cutting down trees have damaged wetlands. This disrupts how these ecosystems naturally function and reduces their benefits. (Junk 2013; Bassi et al. 2014; Khisa et al. 2013; Mitchell 2013). Several activities threaten Rwandan wetlands, including uncontrolled use of fertilizers and pesticides, soil erosion caused by human actions, extraction of peat moss, illegal mining, construction in restricted areas, and pollution from industrial waste. (Padmanaban et al., 2017). Rapid population growth puts a strain on wetlands. Especially in struggling communities, people often resort to using wetlands for immediate needs, which harms the variety of life those areas support. A study in South Africa (Junk, 2013) found a large amount of wetland being converted to farms and cities. (MEA; 2005) Population growth is driving the biggest threat to wetlands: conversion for agriculture. (Verhoeven and Setter 2010).

In simpler terms, wetlands are being drained and filled in to create mines. A study by Rooney et al (2012) found that over 29,500 hectares of peatland in Alberta, Canada, have been converted into oil sands mines. This conversion is most severe in developing countries where traditional practices that once protected wetlands are disappearing. This loss of traditional knowledge is leading to irreversible damage to wetlands (Maltby, 1991). The future of these wetlands now depends on government policies and economic pressures, rather than the natural processes and local knowledge that once ensured their sustainability.

## **2.7. Wetland Services.**

Wetlands are not only valuable for humans (flood control, recreation), but also possess inherent ecological functions (water quality, habitat) that contribute to a healthy ecosystem (Millennium Ecosystem Assessment). These benefits, regardless of human presence, showcase the multifaceted value of wetlands (Junk 2013; Erwin 2009; Ellison 1994).

### **2.7.1. Provisioning Services**

Wetlands are packed with life, offering a bounty of plants and animals. This abundance not only provides food (like fish and rice) but also creates jobs for people living nearby. Many indigenous communities depend heavily on these natural ecosystems for their basic needs, including food, clean water, medicine, fuel, and even materials for clothing. In fact, wetlands are a lifeline for many rural poor households, especially for drinking water. Studies like the one by McCartney and Van Koppen (2004) in Tanzania show that a staggering 80% of low-income families rely on wetlands for their daily water needs.

### **2.7.2. Regulation Services**

Draining wetlands for development releases stored carbon back into the atmosphere. But healthy wetlands actually help keep water clean! They act as natural filters, removing pollutants and excess nutrients that could harm aquatic life. This filtering process even helps treat polluted water.

### **2.7.3. Cultural services**

Wetlands provide cultural, spiritual and educational benefits to societies (De Groot 1992). They act as recreational places and tourist attraction areas i.e. hiking, walking, birding, and sports fishing. Wetlands provide learning opportunities like research services and educational centers. Human beings have utilized since time immemorial wetlands to bring up societies with many traditional cultures being strengthened by their relationship with wetlands like the Coburg Peninsula where the natives up to date have strong attachment to the traditions carried out within the wetland<sup>1</sup> for example hunting and gathering (WWF, 2017).

### **2.7.4. Supporting services**

Wetlands provide crucial habitats for many species, which is essential for maintaining biodiversity. (Clarkson, Ausseil, and Gerbeaux 2013) Despite covering only a small portion of the Earth, wetlands are biodiversity hotspots, boasting over 40% of the world's species and 12% of all animal species. (Siuta et al. 2016). Lake Tanganyika is a haven for biodiversity, boasting a staggering 632 species of animals found nowhere else on Earth (WWF, 2017), With a mind-blowing 2,000 fish species, the Amazon exemplifies the rich biodiversity

found in wetlands. These ecosystems are economic powerhouses, valued at US\$4.9 trillion and sustaining over a billion livelihoods through trade in wetland resources (Ramsar 2016)

## **2.8.Challenges of conservation and management of wetlands**

Millions of Africans rely on vast wetlands for survival. These areas, like the Nile floodplains and inland deltas, have supported people for centuries. Local communities have traditionally managed these wetlands wisely, without harming them. However, with growing populations and resource demands, this sustainable approach faces challenges. Experts warn that overuse can damage these wetlands beyond repair. The current challenges faced by wetland ecosystems stem from society's struggle to achieve sustainable management practices. This requires balancing the exploitation of wetland resources for economic gain with the preservation of their ecological functions and structural integrity. Finlayson proposes a community-based approach to wetland management, emphasizing the importance of understanding local needs, aspirations, and priorities to ensure sustainable livelihoods. (Finlayson 2013; Finlayson et al. 2017)

### **2.8.1.Institutional managerial issues**

Despite their historical importance, African wetlands haven't been appreciated for their economic benefits, especially for the rural poor. We need to change this to ensure healthy ecosystems for the future. (World Resource Institute 2005). Protecting wetlands is crucial, but it's vital to consider the people who depend on them for survival. The World Resources Report (2010-2011) points out the challenge for developing countries: making decisions that address the present needs of these communities, while also planning long-term policies that can handle future climate uncertainties (World Resource Institute, 2017).

### **2.8.2.Lack of information**

Wetlands are constantly shifting ecosystems, adapting to changes in water levels. However, a lack of funding has limited research into how these changes happen. The information we do have is often outdated, not relevant, or unreliable, making it hard to get a clear picture (Lynch, Kalumanga, and Ospina 2016). Wetlands are dynamic, changing size with seasons and rainfall, making them a challenge to manage sustainably. (Keddy et al. 2009) The biggest challenge to managing Africa's natural resources is the knowledge gap. (Kangalawe and Liwenga 2005).

## **2.9. Land Use and Land cover change of Wetlands**

Humans are changing the land way faster than ever before, turning forests into farms and cities at an incredible rate. This massive reshaping of the Earth's surface is having a big impact on everything from weather patterns to plant and animal life.(Thamaga, 2021) . Studying how land use and land cover changes over time is crucial for understanding the health of our environment and its impact on humans, and vice versa. (Hoque et al., 2022). Changes in land use are a major concern for ecologists, especially due to the harm they cause to aquatic environments and the diversity of species found there (Kogo et al., 2019). Land use and land cover (LULC) changes significantly impact of environment,These changes can destroy wetlands, fertile lands, and wildlife habitats. To make informed decisions about land use, we need to understand how LULC is changing.(RAJANI, 2017) . A variety of data, including LiDAR, radar, and high-resolution images, is being collected remotely to analyze wetland dynamics. This approach is becoming a powerful tool for studying wetlands systematically.(Guo et al., 2021) .

## **2.10.Concluding Remarks**

Wetlands in Rwanda are crucial for water quality, biodiversity, and livelihoods, Diverse Authors found that Wetlands are under pressure from land use changes, activities, pollution, and climate change. Further research is needed to assess the impact of managing wetlands in Rwanda. Making successful of wetland management practices and promoting community involvement are also important for sustainable wetland conservation. Rwanda has a framework for wetland management through policies. However, gaps exist in implementation and specifics. These include unclear roles for local communities, lack of details on sustainable wetland usage like agriculture activities, and missing regulations for monitoring and enforcing wetland zoning. A more comprehensive policy focusing on community involvement, sustainable use practices, and restoration strategies is needed for effective wetland management in Rwanda.

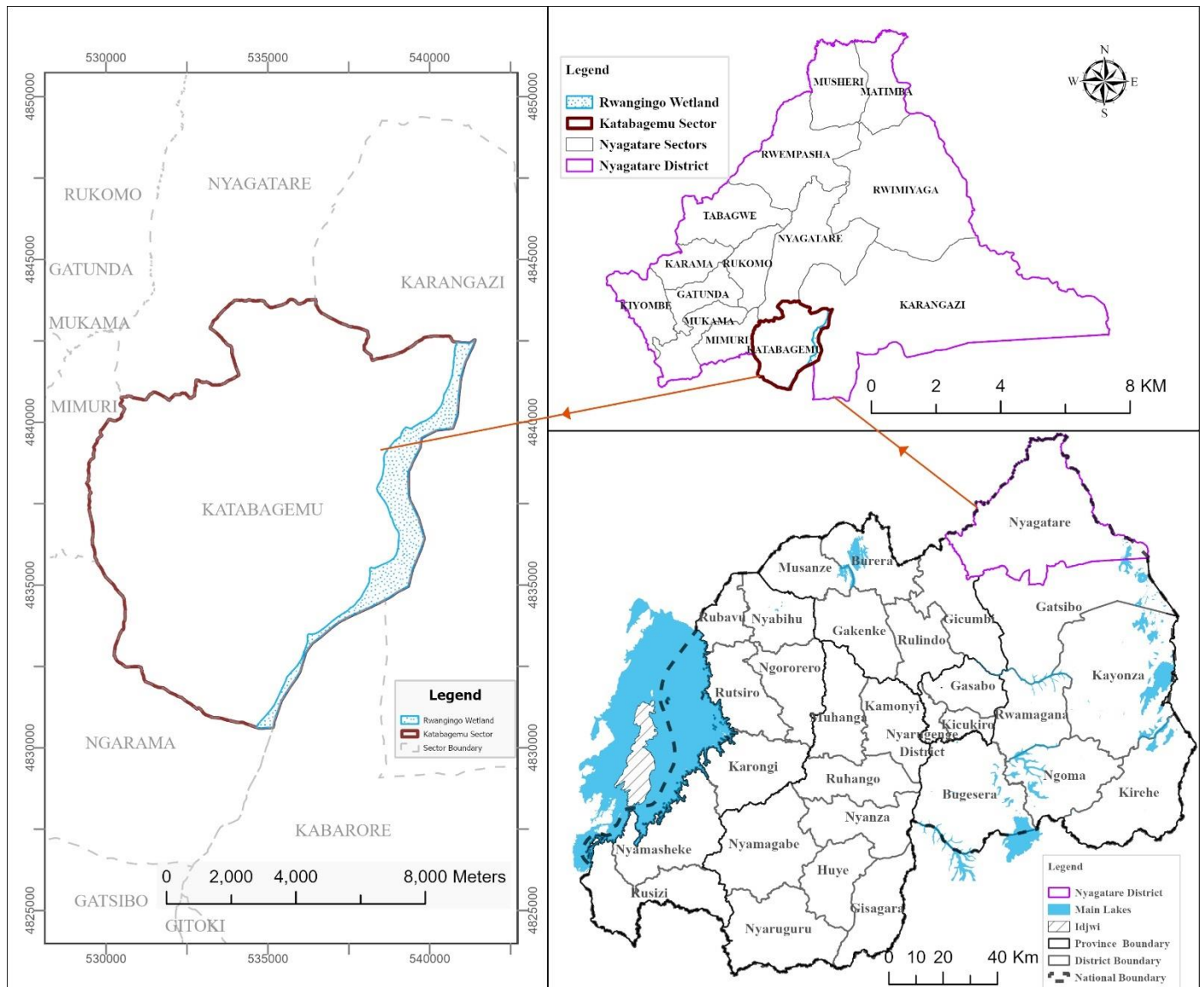
## **CHAPTER THREE: METHODOLOGY**

This chapter deals with the details of materials used and the methodology adopted for the research on Rwangingo Wetland management in Katabagemu Sector. During this study, primary and secondary sources of information were used. To Collect primary information , interviews were conducted with local leaders, farmers, administrative officials at local and national levels, and field visits and observations were conducted.

### **3.1. Study area Description**

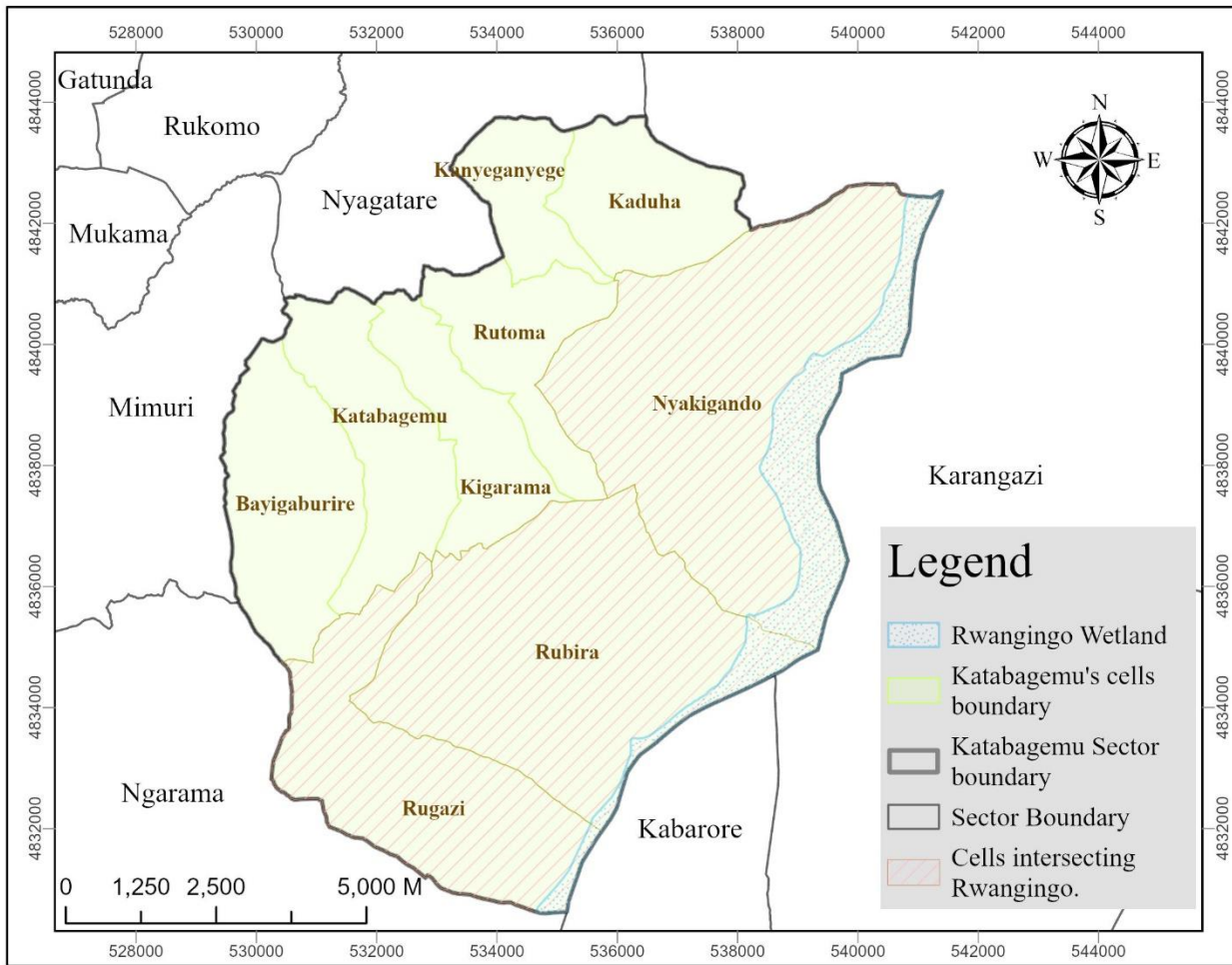
Rwangingo Wetland is Located in the Eastern Province of Rwanda, between the districts of Nyagatare (Karangazi Sector, Katabagemu Sector) and Gatsibo Districts (Ngarama, Kabarore, and Gatsibo Sectors); latitude: -1°33'0" longitude: 30°18'20.16" (Bigagaza, 2013). It may be accessed via the paved National Road Kigali-Kayonza, which travels approximately 69 km east, and the paved Road Kayonza-Kagitumba, which travels approximately 59 km north to Gabiro.

Rwangingo Wetland was developed on 930ha of area in 2016-2017 mainly for rice production. The wetland is endowed with an irrigation dam of 10m in height and 3,750,000 m<sup>3</sup> of capacity, the main irrigation canal on the left side long of 29km with various hydraulic structures, secondary and tertiary irrigation and drainage network. Currently, the wetland is being used for rice growing on 245 ha while 677 ha have been dedicated to maize and other crops production.



**Figure 2. Spatial Location of the Study area, (Source of data : NISR, NLA 2022)**

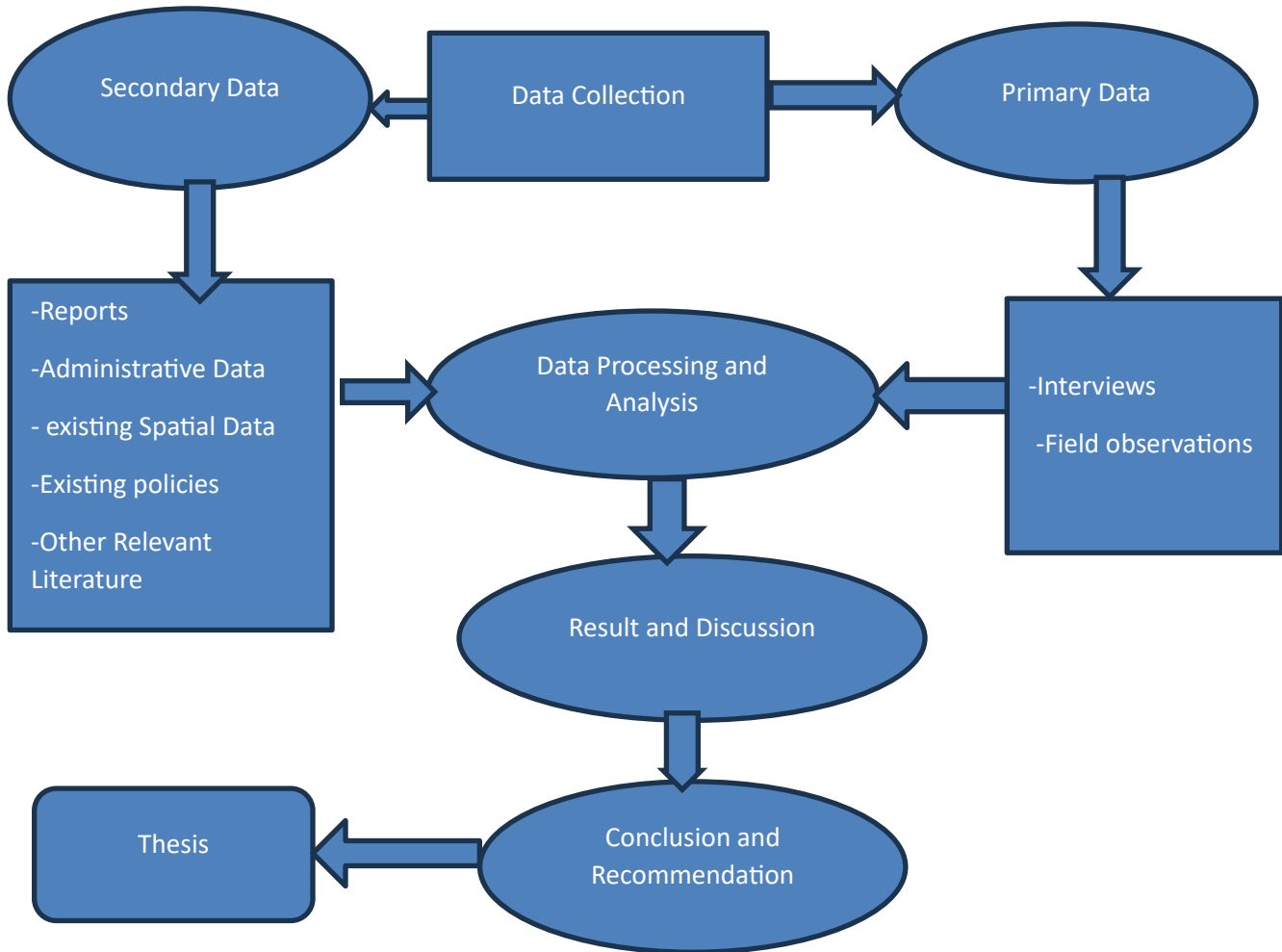
Katabagemu sector was chosen as the study area's boundary because it has three cells (Rubira, Rugazi, and Nyagando) that are close to the Rwangingo Wetland where crop and livestock production are the major sources of livelihood of the community in the study area. Rwangingo Wetland is surrounded by agricultural land and grazing area for livestock. Figure3 shows cells intersecting with Rwangingo Wetland.



**Figure 3. Location of study area at cell level (Source of data: NLA, NISR 2022)**

### 3.2. Research Design

The following Figure shows the research design of this study



*Figure 4. Research Design*

### **3.3. Data Collection Methods**

Several methods for collecting data were used to collect the information required for the purpose of the study. Primary data was collected through field observation and interview; secondary data were obtained through literature, on wetland management from NGOs and public institutions, Google Earth image, and GIS Datas.

#### **3.3.1. Secondary data collection**

Secondary sources of information were collected through literature review, administrative boundaries, land cover and land use data, Google Earth imagery, government reports, existing wetland management plans, and studies on wetland initiatives and their impact on dependent communities. Analyzing this information provided valuable insights into the history of wetland management, current management challenges, and the overall challenges of wetland management.

#### **3.3.2. Primary Data Collection**

In primary data collection, I used an interview guide to conduct interviews, and field observations. I also used various data collection tools including GPS and Camera to take geographical coordinates and photos.

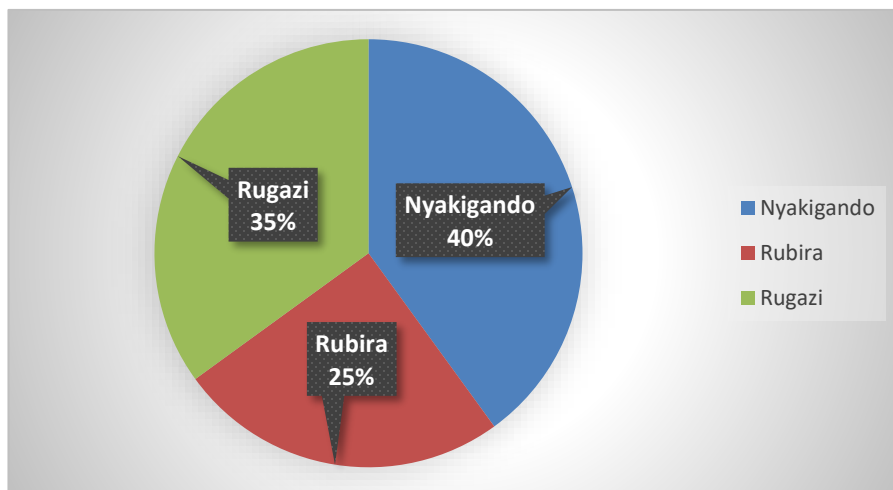
##### ***3.3.2.1 Interview***

I conducted an interview with the community and Local leaders around the wetland (Nyakigando, Rubira, and Rugazi cells) staff at sector and District levels, experts from RAB and REMA, NGOs with Environmental practitioners. Respondents from the community included those who have the knowledge and ability to provide useful insights about challenges of Rwangingo Wetland management. Responses from the interview provided information about Rwangingo wetland management, existing challenges related to sustainable livelihood, and wetland policy implementation. The interview guide used is attached as appendix.

NO	CATEGORY	Numberof Respondents
1	Farmers	20
2	Local readers	9
3	People Who settle around the Wetland	4
4	Katabagemu Sector Staffs	2
5	Nyagatare District Staff	2
6	NGOs and public institutions	6
<b>Total</b>		<b>43</b>

**Table 3. Number and categories of respondents**

The farmers interviewed to describe current activities conducted in Rwangingo Wetland, analyze wetland management practices, and investigate challenges related to Rwangingo Wetland management came from three different cells. Respondents in Nyakigando cell were 8 respondents, while in Rubira and Rugazi cells were 5 and 7 respondents respectively.



**Figure 5. Distribution of Farmers respondents in Cells (Source: Field work, 2024)**

### **3.3.2.2. Field Observations**

During the period of interviews with farmers, the field observations were also made. Observations related to wetland area, ongoing activities in Rwangingo wetland, existing infrastructures, and existing crops. This provided insight into the current wetland status, wetland management practices, and challenges related to Rwangingo wetland management.

### **3.3.2.3. Mapping**

Fieldwork involved mapping existing infrastructure like the irrigation canal and road giving access to the wetland. Data collection was conducted on the ground to validate the current land use and land cover classification of the Rwangingo Wetland using satellite image. To assess changes in the wetland's extent and land cover, we analyzed Google Earth images of 2011 and 2024, along with land cover maps for those years. This spatial mapping proved invaluable in evaluating and understanding the significant changes that have taken place in the Rwangingo Wetland, offering a clear comparison of its status before and after its rehabilitation.

## **3.4. Data Analysis and Processing**

Data analysis was conducted using interview, field observation, mapping and Google Earth images were used to supplement data collection through fieldwork, and ArcGISPro software was used to make spatial analysis and mapping of the wetland. ArcGISpro software helped to interpret changes detected on different land cover for the comparison on the real ground. Qualitative data such from the respondents and different values of wetland was analyzed and conducted qualitatively through text analysis and verbal description. Rwangingo wetland management practices and the challenges were highlighted during the interview results.

### **3.4.1. Digitization based on Google Earth Imagery**

High resolution Google Earth images of 2011 and 2024 were used for mapping different Land Use and Land Cover classes found in Rwangingo wetland. Google Earth images were acquired and georeferenced in ArcGIS pro software and then different land cover classes were mapped by delineating the boundaries of those classes directly on the imagery.

## **CHAPTER FOUR: RESULTS AND DISCUSSION**

This chapter presents the findings of the research conducted on Rwangingo wetland located in Katabagemu Sector. This chapter helps to understand the findings derived from data collection, analysis, and interpretation. This was accomplished using interviews and field observations as well as mapping. It shows results, their meaning, and Result discussions related to the activities conducted in Rwangingo Wetland, Wetland management practices, challenges related to wetland management, and recommendations to enhance the Wetland management.

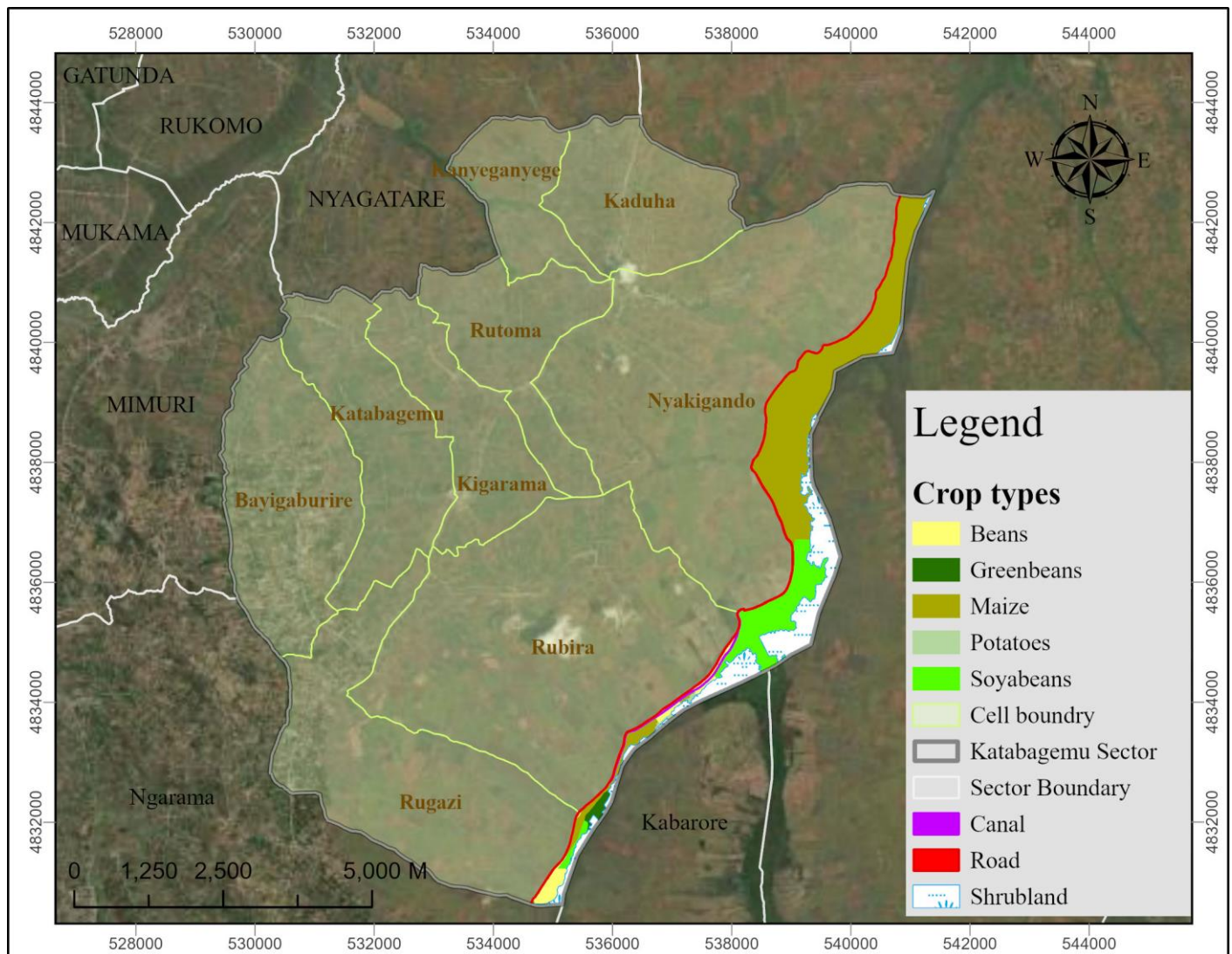
### **4.1. Current activities conducted in Rwangingo Wetland**

This study surveys the current activities conducted within the wetland and assess their success in wetland management. By evaluating these activities findings revealed that This research showed that agriculture is the main activity in the wetland, while livestock grazing is confined to the hillsides surrounding it.

#### **4.1.1.Crop Grown**

The field observations revealed a wider variety of crops cultivated, including maize, soybean, beans, potatoes, and vegetables.

Figure 6.were created using 2024 Google Earth imagery and field collected polygon samples, effectively visualizes the spatial distribution of existing crops within the wetland.



**Figure 6. Crop types in Rwangingo Wetland, katabagemu sector (Source: Field survey, NISR, 2022)**

Respondents to the interview said: *“We do not cultivate rice in this part because it was not well leveled which makes rice irrigation impossible, There is a rotation of maize, soybeans, beans, and vegetables depending on the season”*

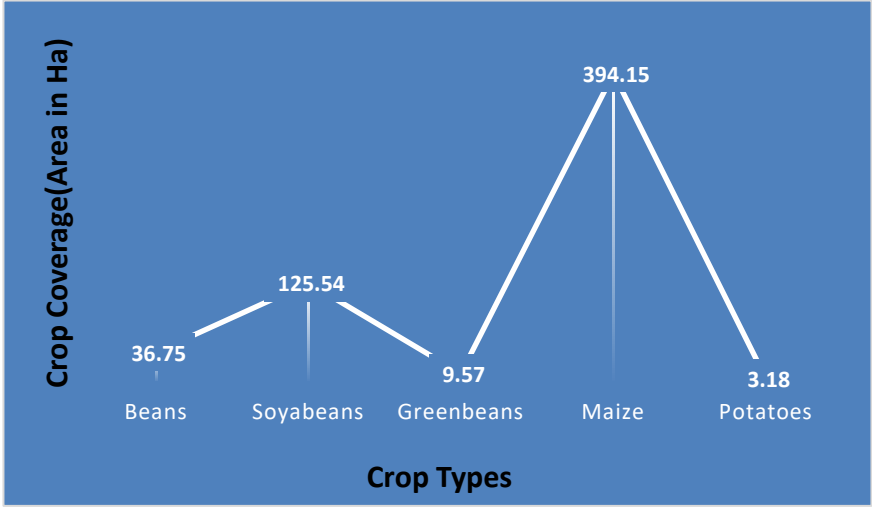
#### **4.1.2. Crop Yields**

Considering current activities limited maize yields indicate areas for improvement, and implementing various interventions has the potential to significantly increase crop yields across the wetland. The identification of beans and maize as crops with market potential is a positive sign and promoting their cultivation could greatly improve farmer livelihoods.

“There is a part of the Wetland not exploited or sometimes partially exploited because of floods. The average yields are estimated at 4.5 Tons/ha for maize”.Farmer’s response.

The consideration of yield obtained suggests several interventions that could significantly improve the overall productivity of Rwangingo Wetland: introducing small scale irrigation systems to optimize water management for both rice and high-value crops, improving access to fertilizers and other essential inputs to enhance yields, and expanding educational programs to equip farmers with wetland agriculture best practices, empowering them to make informed decisions and achieve greater productivity

The analysis of existing crops shows that maize is the most common crop grown in Rwangingo wetland with a coverage area of 394.15Ha. This is followed by soybeans 125.54Ha, beans 36.75Ha, green beans 9.57Ha, and lastly potatoes 3.18Ha. This depends on the suitability of different crops to the wetland’s specific growing conditions, including soil type ,water availability and market demand for different crops. Farmers plant crops that are in high demand and have good prices in the market.



**Figure 7. Crop types and their land coverage (Source: Field survey, NISR, 2022)**

Field observations, interviews, and mapping give a comprehensive image of current activities conducted in the Rwangingo wetland. While agriculture brings income to local communities consistent with the wetland's purpose and seasonal variations in crop production are evident as highlighted in interviews, there are some discrepancies. The observed crops deviate from the intended purpose of rice production, Agricultural activities in the buffer zone damage the main irrigation canal, contradicting land use zoning regulations.

## **4.2. Wetland management practices of Rwangingo wetland.**

This study discovered wetland management practices in Rwangingo, focusing on infrastructure development, spatial change monitoring, and farmer's organization. These approaches offer valuable tools for the sustainable management of Rwangingo wetland.

### **4.2.1. Infrastructure development**

The development of infrastructure has played an important part in enhancing the management of Rwangingo Wetland. The rehabilitation of the road network has granted easier access to most areas within the wetland. This improved accessibility is crucial for various wetland management activities, including transportation of agricultural products cultivated within the wetland, the main irrigation canal equipped with water control structures forms the backbone of managed cultivation within the wetland. This system ensures efficient water distribution and promotes sustainable agricultural practices. The findings from interview highlight the need for proper maintenance of the irrigation canal system and some road sections require repairs. A farmer, responding about how he participates in Rwangingo Wetland management:” *I planted dictator grass along my parcel to protect the main canal from Erosion and I actively involved in community works by participating in road rehabilitation, ensuring continued accessibility within the wetland.*”

Addressing these maintenance needs will ensure optimal water flow and prevent potential water loss or damage to the canals and road maintenance is essential to keeping accessibility within the wetland. Furthermore, active involvement in community works for road rehabilitation underlines the understanding of the importance of accessible infrastructure within the wetland. The collaborative effort between the community and relevant authorities is vital for the long term success of Rwangingo Wetland management.

(1) Access road is essential by providing access for farmers and others to the wetland



(2) Irrigation canal which is essential to deliver water to crops in the wetland.



**Figure 8. Infrastructure development in Rwangingo Wetland (Source: Field survey)**

Figure 8 showcases the road and canal infrastructure created during the rehabilitation of the wetland. However, field observations show that these infrastructures are not being adequately maintained.

**4.2.2. The Spatial Changes of Rwangingo Wetland**

To examine spatial changes within Rwangingo wetland, spatial data was analyzed by comparing Google Earth images of two years: 2011 and 2024. Land Use and Land Cover Classes found in Rwangingo wetland are cropland, shrubland, and Water. The table 4 shows Land Use/Land Cover class and their definitions.

No	Classes	Definitions
1.	Cropland	Cultivated area
2.	Shrubland	Open Shrubland including Grasses and bushes
3.	Water	Irrigation canal

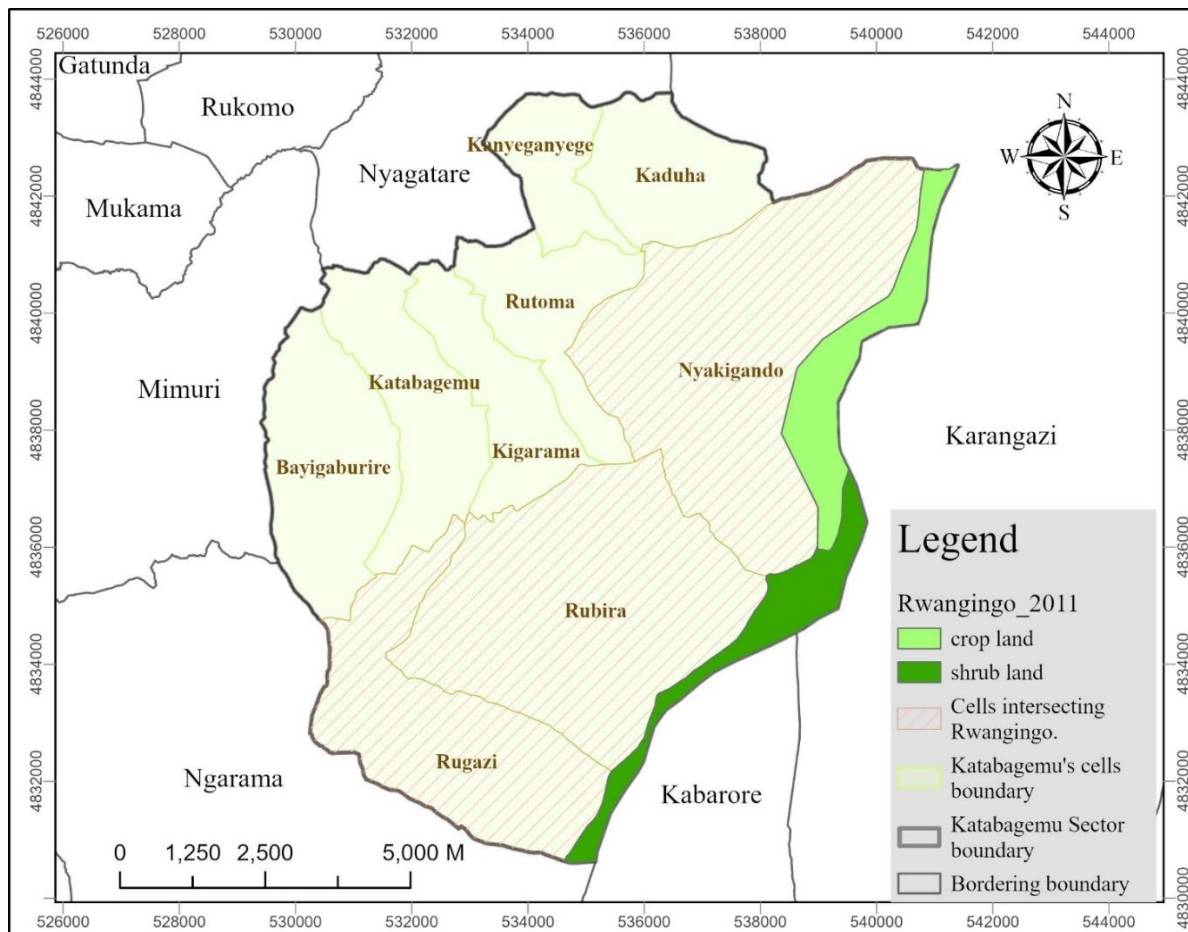
**Table 4. Land Use/Land Cover classes ,(Source: Field Survey)**

**Year (2011):** The digitization of Google Earth imagery of 2011 image was conducted to identify two primary land cover classes within the study area before the rehabilitation of Rwangingo wetland in 2016. The identified classes are cropland and shrubland. The total wetland area in 2011 was 721 hectares (ha). Cropland occupied the bigger space (58.5%), while shrubland covered the remaining 41.5% according to local leaders familiar with the area.

<b>Name</b>	<b>Shape Area in m<sup>2</sup></b>	<b>Shape Area in Ha</b>	<b>Percentage</b>
<b>Shrub land</b>	299689.7368	299.6897368	41.5148
<b>Cropland</b>	422196.8748	422.1968748	58.4852
<b>TOTAL</b>		721.8866116	100

***Table 5. Land cover classes of the study area in 2011 (Source: Google Earth image of 2011)***

The map of the Rwangingo Wetland in 2011 reveals that shrubland was the dominant land cover type, superior cropland in extent. According to local experts, a portion of the 120 hectares (16.6%) shrubland area was historically used for livestock grazing, while the remaining area consisted of natural papyrus. The map also indicates that cropland was primarily located in the Nyakigando cell.



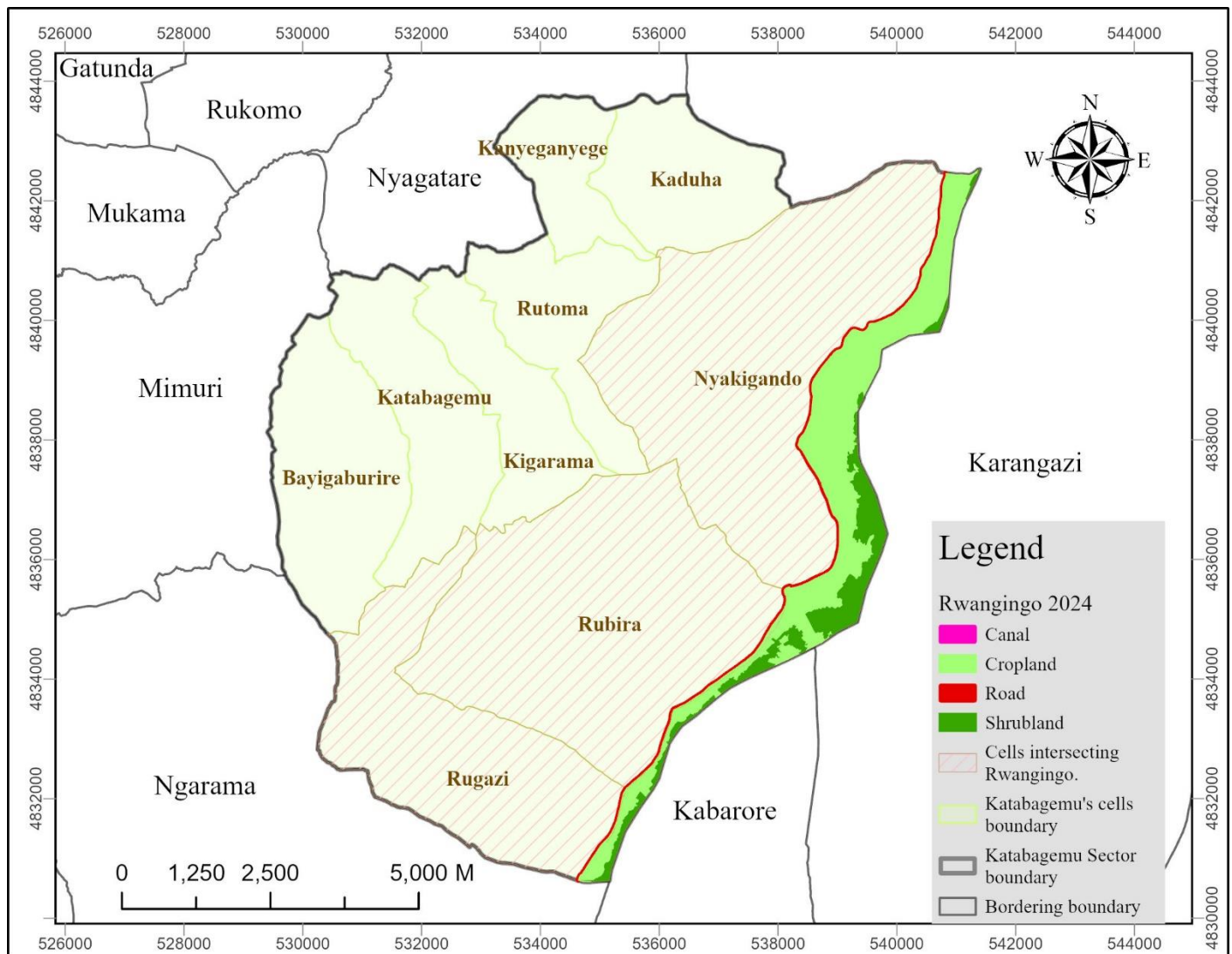
**Figure 9. land cover classes in the study area in 2011 (Source: NISR2012, Google Earth image of 2011)**

**Year (2024):** To realize the assessment of the effectiveness of the wetland management, we conducted an analysis of recent data (2024). This included Google Earth imagery alongside field data collected using the GPS, SW map tool and field observations. This more comprehensive approach provides a more accurate picture of the current land cover within the wetland. The analysis for 2024 revealed four distinct land cover classes: roads, canals, cropland, and shrubland. The total wetland area showed a slight increase to 780 ha. Cropland remained the dominant class (74.9%), and its extent increased compared to 2011. The Shrubland area decreased to 23.7%, Papyrus shrubland acts as natural plants in Rwangingo wetland, saturated up and storing water during the wet season, which helps to prevent the wetland from drying out completely during the dry season cropland. The analysis also identified new land cover types: roads (1.2%) and canals (0.2%), which were constructed as part of effective implementation of the wetland management practices.

<b>Name</b>	<b>Shape_Area in m<sup>2</sup></b>	<b>Area_in_Ha</b>	<b>Percentage</b>
<b>Canal</b>	14314.1610586	1.43141610586	0.18361447063
<b>Road</b>	90649.6545463	9.06496545463	1.16280571835
<b>Shrubland</b>	1847608.23106	184.76082310600	23.70013903648
<b>Cropland</b>	5843197.54024	584.31975402400	74.95344077454
Total		779.57695869049	100

***Table 6. Landcover classes of the study area in 2024 (Source: Google Earth imagery of 2024)***

Figure 10 showing the land cover of Rwangingo Wetland in 2024 reveals that cropland dominates the area compared to shrubland. It also shows cropland distribution across all cells intersecting the wetland. By comparing data from 2011 and 2024, we assess the impact of wetland management practices on land cover composition within Rwangingo Wetland. This comparison is crucial for ensuring the long-term success of these management efforts.



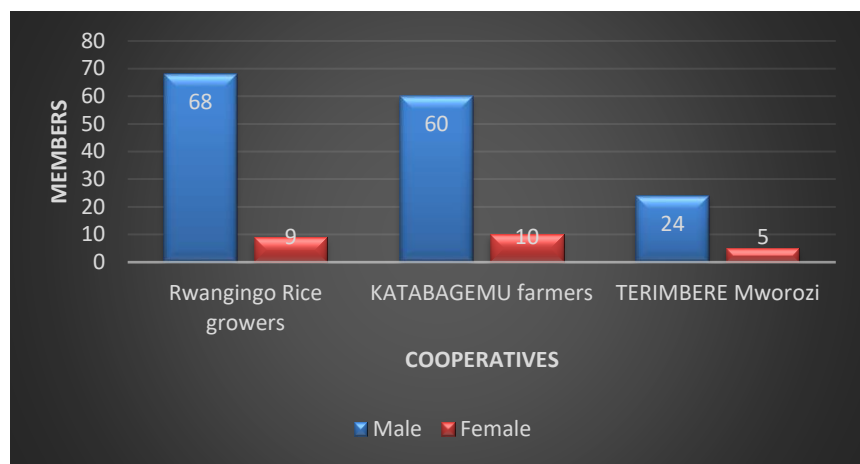
**Figure 10. Land cover 2024, (Source: Google Earth imagery of 2024, Field survey)**

#### **4.2.3. Farmers’ organization in the management of Rwangingo wetland**

In Rwanda, all developed wetlands are supposed to be managed by cooperatives or another more organized setting to ensure the wetland is managed in a coherent manner, The same applies to Rwangingo wetland. According to Katabagemu Sector Agronomist: *“There are 3 cooperatives. (1) Rwangingo Rice growers: by their name, the cooperative was founded to grow rice but they mainly grow maize in rotation with soybean because rice was not possible in their wetland parts. 2) KATABAGEMU farmers ‘cooperative: the cooperative of cow breeders; (3) TERIMBERE Mworozzi: the cooperative of cow breeders .”* These cooperatives have the responsibilities to organize a seasonal meetings with beneficiaries/Farmers, organize joint teams for monitoring and evaluation of agriculture activities with stakeholders to avoid bad practices in Wetland and

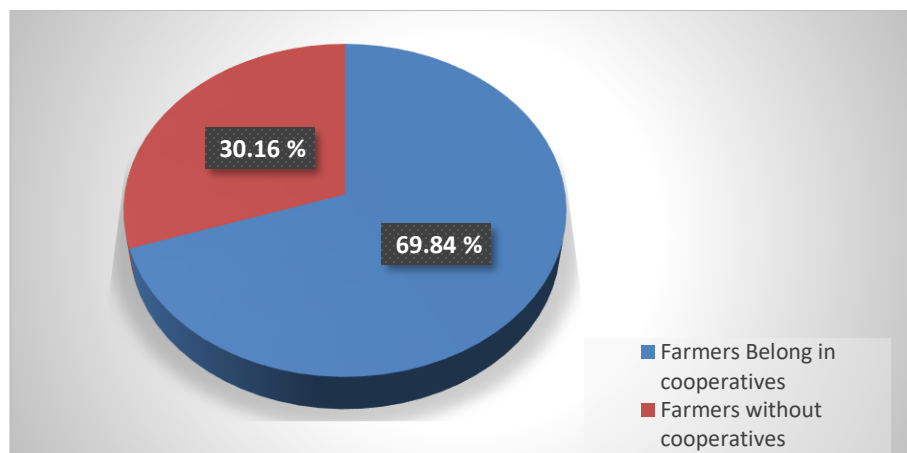
manage post-harvesting facilities. Water user representative responding on the responsibility of water user committee”*We are in charge of collecting water fees that are used in daily maintenance of irrigation infrastructures*” The total number of farmers in Rwangingo Wetland in Katabagemu Sectors are 156, while farmers participating

The Figure 11 shows the membership data by cooperative in Rwangingo Wetland Management.



**Figure 11. Membership of wetland users’ cooperative (source: Katabagemu Sector)**

Site visits allowed to identify different post-harvest facilities including drying grounds for maize shelling and drying grounds/hangar, and the stores/warehouse for farm commodities. It is certainly worth noting that the improved farmers’ organization and their capacity building help in establishing profitable market linkages and avoid big variations of prices most of the time, which leads to the loss of farmers.



**Figure 12. Participation of Farmers in cooperatives (source: Katabagemu Sector)**

Many farmers aren't currently in cooperatives. Encouraging them to join could improve water management in the wetland, along with the usual benefits of cooperatives.

### **4.3.Challenges related to the use and management of Rwangingo Wetland**

This study investigated the challenges associated with the management of Rwangingo Wetland. The findings revealed several key challenges, including those related to the irrigation design, conflicting usages, flooding, and institutional managerial issues.

#### **4.3.1 Challenge Related to the Irrigation Design.**

The field observation revealed challenges that are faced in farming activity and wetland management. Most of challenges are related to the status of the current irrigation design and degraded infrastructures. The issue of water losses along the main canal that is porous in different sections and has lost its initial designed dimensions due to poor maintenance which causes a lot of water losses and the majority of irrigation networks that were initially developed have been damaged since the cultivation of other crops was adopted. The only existing irrigation canal does not allow for rational management of the available water resources.

Some structures including canal, road, and bridges were damaged and require rehabilitation. The poor maintenance is observed and the limited number of crossing bridges for pedestrians on the main canal and the existing ones are in poor condition.

#### **4.3.2.Conflicting Wetland users**

Our study found that farmers utilize Rwangingo wetland for two purposes agricultural and livestock keeping activities. This joint usage creates conflicts between farmers and local communities that rely on the wetland. In this regards, a respondent working for Kabagemu sector explained: *“There are water users that were not sufficiently taken into consideration during the initial design while they use important quantities of water on a regular basis, especially in the dry season.This is the case for vegetable farmers and cattle farmers on hillsides. Some take and use water directly near the main canal while others bring water trucks to fetch it from the canal and use it far from the canal”*.

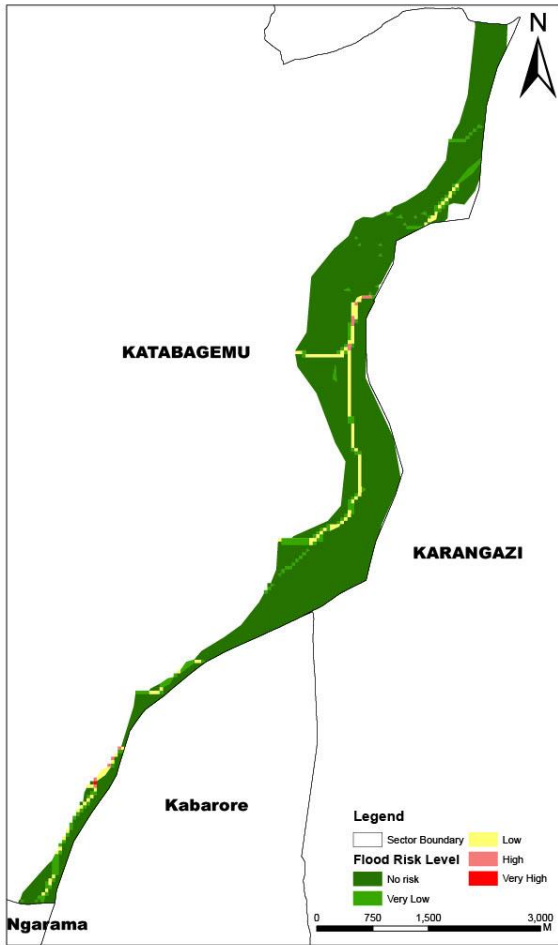
The identified conflicting usages in Rwangingo wetland pose a significant challenge to its sustainable management. Finding a way to balance these competing interests is crucial for a sustainable wetland ecosystem and the well-being of the communities that depend on Wetland and has an impact on water resource management and it contributes to the destruction of canal and other irrigation structures. The limited involvement of majority of farmers and big land owners who are not regularly based in the area delays the

implementation of some measures related to wetland management as their representatives are sometimes not the ones making decisions in conflict resolutions with livestock farming.

### **4.3.3. Flooding**

Flooding is another major challenge in the study area, two distinct flood types were analysed. The first is the inundation of lowland which consists in flooding affecting lowland with maize fields, impacting an estimated 100 hectares in season B or 40 hectares during season A and leading to significant crop loss. The second type is regular seasonal flooding which occurs almost every year but does not cause substantial damage to crops. Some measures are needed to reduce the impact of flooding. According to a Staff working for Nyagatare District” *priorities for managing flooding in Rwangingo, wetland are road maintenance, irrigation infrastructure rehabilitation, and plantation of different varieties of grasses for animal feeds around the main canal and in the buffer zone area*”

Maintaining roadsides ensures proper drainage, upgrading and repairing irrigation systems improve water management within the wetland by regulating water flow and preventing lowland areas from becoming inundated. Planting species and different varieties of grasses for animal feed serves a dual purpose. This vegetation cover stabilizes the soil and potentially reduces floodwater runoff, and also provides additional benefits like improved soil health and a source of animal feed.



**Figure 13. Flooding Risk in Rwangingo Wetland (Source of data: NISR 2012,**

The observed risk zone for flooding around the Rwangingo wetland strongly suggests the need to improve wetland management practices. One possible alternative is the use wetland areas for agricultural purposes. This can reduce the buffer zone and destroys the main canal causing a reduction of water storage during heavy rains. The increased flooding events have consequences for the farmers and community residents near Rwangingo wetland. The floodwater causes crop losses and damages infrastructures such as road and bridges, troubling transportation and agriculture activities. Implementing land use regulations around the Buffer zone in the wetland periphery could prevent further encroachment and preserve the natural floodwater storage capacity. Furthermore, community based flood management initiatives can raise awareness of residents about flood risks.

#### 4.3.4. Institutional Managerial issues

one of the significant challenges identified in the management of Rwangingo Wetland is institutional managerial issues. This refers to limitations within the organizations of authorities responsible for overseeing sustainable wetland management. Farmers could get advice from Agriculture and environmentalist technicians in the management of Rwangingo wetland.

*“Authorities visit Rwangingo at the beginning of planting season, agricultural staff from Katabagemu sector focuses on monitoring crop yields and always come here for the follow up of agriculture yields and resolving conflicts between livestock farmers whose cows graze in the wetland and crop farmers..”* response from farmers.

This situation suggests a gap in providing technical advice to farmers on sustainable wetland management practices empowering farmers with the knowledge they need in wetland management. Institutional managerial issues impact the effectiveness of Rwangingo Wetland management due to the roles and responsibilities of institutions and authorities which are unclear as there is no one institution in charge of wetland management. *A local leader in Kamutara Village, Nyakigando Cell said ” I’m a 5 year farmer in this wetland, I always see conflict arise during the dry season between wetland farmers and hillside farmers who rely on the wetland's water for irrigation and livestock. I appreciate the district's focus on providing fertilizers and improved seeds, but there is an issue that requires attention in establishing a framework for resolving water conflicts within the wetland.”*

The wetland management problem in Rwangingo and its surroundings highlights a gap in the effectiveness of relevant institutions. While local government at the district and sector levels are involved in wetland management activities like infrastructure maintenance, water resource management, and cooperative coordination, their efforts are insufficient. Defining the roles and responsibilities of each institution involved and ensuring adequate staff at each level and expertise within the responsible authorities is crucial for improving the effectiveness of Rwangingo Wetland Management.

#### **4.4.Measures to Enhance Rwangingo Wetland management**

Through field visits and discussions with farmers local leaders and staff in charge of Rwangingo wetland management, five critical challenges for Rwangingo wetland management were identified,

The following are measures to enhance Rwangingo Wetland management.

##### **4.4.1. protection of the buffer zone**

Implementing Land Use plan regulations to protect the buffer zone area.including restrictions on activities like agriculture within 20 m and development of any project from the main canal and Papyrus shrub land acts as natural plants in Rwangingo wetland. Shrubs saturated up and storing water during the wet season, which helps to prevent the wetland from drying out completely during the dry season.Additionally, promoting activities that protect the buffer zone like native plant restoration can further enhance the buffer's effectiveness.

##### **4.4.2. Promote Stakeholder Engagement and Awareness**

Creating and implementing the framework for mobilization and involvement of the big land holding farmers who are not regularly based in the area for their active involvement in the wetland. To enhance Rwangingo wetland management, Nyagatare District should prioritize collaboration with large, non-resident landowners. This will be achieved by creating a comprehensive list with relevant farmers and communities, followed by establishing clear communication channels. Joint management committees with representatives from the district, local communities, and landowners can be formed to foster shared responsibility. Engaging these landowners leads to more sustainable agricultural practices, strengthens enforcement within the buffer zone, and raises a sense of shared responsibility for the wetland management, promoting continuing commitment from all stakeholders.

##### **4.4.3. Improvement of Infrastructure and Management Practices**

Prioritize the rehabilitation of identified damaged infrastructure within the Rwangingo Wetland, to enhance Rwangingo wetland management, Nyagatare District should prioritize improving infrastructure and management practices. This could involve: identifying and rehabilitating damaged infrastructure which are the main canal, Road, and bridges. Additionally, allocating resources for regular maintenance is crucial for long-term functionality. Furthermore, developing and implementing sustainable practices including responsible water use for livestock through boreholes outside the wetland will reduce water conflict and associated degradation of the wetland. Investing in infrastructure and promoting responsible practices, will ensure the sustainability of the Rwangingo Wetland.

#### **4.4.4. Implement Sustainable Resource Use Practices**

There is need to promote sustainable agriculture practices to protect and enhance Rwangingo wetland management by Nyagatare District. This includes techniques that minimize water use, such as improved irrigation methods, and reduce pollution runoff through the use of cover crops and organic fertilizers. Promoting . Sustainable agriculture practices not only protect our environment, particularly vital wetlands, but also safeguard the livelihoods of those who depend on them.

#### **4.4.5. Implications of Measures to Enhance Rwangingo Wetland management**

Enhancing Rwangingo wetland management offers benefits to both agricultural practices and environmental wellbeing. Government institutions including REMA and RAB Implementing these measures will strengthen Environmental protection through improved land use regulations and buffer zone restoration. This will lead to reduced soil erosion and improved agricultural activities. By encouraging sustainable agricultural practices, the government will minimize water usage and responsible land use. Effectively managing Rwangingo Wetland will bring benefits to Nyagatare District. Achieving buffer zone protection, stakeholder engagement, infrastructure improvements, and sustainable practices, will lead to reduced flood risks. This can lead to thriving agriculture, and sustainable livelihoods, while improving collaboration and enforcement strengthen governance.

The measures for improved Rwangingo wetland management have the potential to significantly benefit local communities. Sustainable agricultural practices lead to increased crop yields and improved livelihoods for farmers. Better infrastructure and promoting responsible water use will reduce competition for water resources and potential conflicts. Buffer zone protection leads to flood risk reduction. Stakeholder engagement gives local communities a greater voice in managing the wetland, fostering a sense of ownership and responsibility.

#### **4.4.6. Actors in Implementation of Measures to Enhance Rwangingo wetland management**

##### ***Government Authorities***

Government institutions play a critical role in Rwangingo wetland management. The Rwanda Environment Management Authority (REMA) should prioritize developing and enforcing regulations to address harmful livestock activities encroachment. REMA allocates resources for infrastructure rehabilitation and establishes a long-term maintenance plan. The Ministry in charge of of agriculture and animal resources (MINAGRI) and its Government institution(REMA) can significantly contribute by developing a framework for involving large, non-resident landholders in wetland management. MINAGRI can further promote sustainable practices

by developing incentive programs for responsible livestock watering and collaborating with stakeholders for implementation. Clear communication strategies and incentive programs are crucial for encouraging community participation. The collaboration between REMA, MINAGRI, RAB, research institutions, and stakeholders is essential for securing funding and resources for capacity building in Wetland management..

#### ***Local Government (District)***

To enhance Rwangingo wetland management, Nyagatare District should prioritize a multipronged approach to wetland management. This includes developing a comprehensive plan with REMA, MINAGRI, and communities, enforcing strategies, and stakeholder responsibilities. Collaboration with these Authorities, NGOs, and research institutions is essential to access technical expertise, financial resources, and research support. collaborating with external partners can ease the burden aof improving the effectiveness of wetland management and addressing conflicts Training local communities and District staff on sustainable agricultural practices requires collaboration in building capacity for wetland management.

#### ***Local communities.***

*Local communities* have an important role in implementing measuresfor enhancing Rwangingo Wetland management. This will be achieved through participation in good practices for Rwangingo wetland management. For instance, communities engage in planning and restoration projects for the buffer zone; actively participate in stakeholder committees, and contribute to improving infrastructure through community work and adopting sustainable practices. Sharing sustainable agricultural techniques and reporting any unsustainable activities observed within the wetland. By working collaboratively, local communities contribute to Rwangingo Wetland management.

### **4.5. Summary of Research Findings**

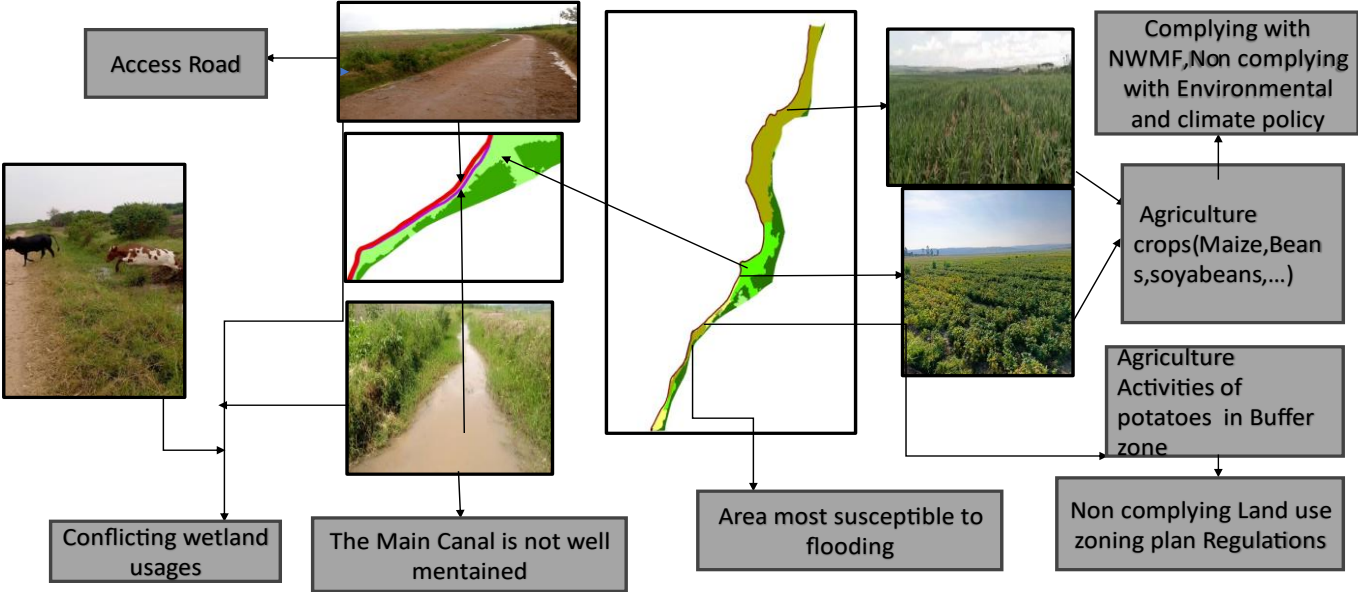
During the assessment of the challenges of Rwangingo Wetland management, the specific objectiveswas to describe Current activities conducted in Rwangingo Wetland; to analyze the management practices of Rwangingo Wetland; to analyze challenges related to the management of Rwangingo Wetland, and propose measures to enhance the Effectiveness of Rwangingo wetland management.

the following findings were highlighted :

1. The Current activities conducted in Rwangingo wetland are cropping activities for different food crops(Maize, Beans, soybeans...) These activities comply with the National Wetland management

framework promoting the wellbeing of farmers. But agriculture is not doing sustainably because farmers use organic fertilizers that cause pollution contradicting the environmental and climate policy. Agricultural activities conducted in the buffer zone are not complying with the land use zoning regulations.

2. The wetland contains infrastructure such as roads for accessibility and a main canal for irrigation, however these structures are not well maintained.
3. Challenges that hinder the Effectiveness of Rwangingo Wetland management include those related to irrigation design, conflicting wetland usages, and flooding.



**Figure 14. Key Findings of The Research (Source: Field survey)**

## **V.CONCLUSION AND RECOMMENDATIONS**

Following the data collection and analysis methods outlined in assessing the effectiveness of Rwangingo Wetland management, this chapter provide a concise overview of the results, drawn conclusion based on those findings, and offer recommendations for future research and potential application in Wetland management.

### **5.1.Conclusion**

This study aimed to assess the effectiveness of Rwangingo wetland management. To achieve this, the research investigated the activities conducted within the wetland, wetland management practices, challenges related to wetland management, and propose measures to enhance its effectiveness.

In line with the first objective which was to Describe the activities conducted within Rwangingo Wetland we found that activities conducted in Rwangingo Wetland are agriculture for Maize, Beans, and other food crops including beans, soya beans, green beansgreen beans, and potatoes. The Wetland was developed mainly for rice production, but this is impossible because it was not well leveled.

In relation to the second objective of analyze Rwangingo wetland management practices we found that The rehabilitation of Rwangingo Wetland has a positive impact on wetland management practices which are Infrastructure development, including road rehabilitation and irrigation canal. The total wetland area has been increased and there has been a change of some shrubland to cropland, Farmer organization through cooperatives facilitating knowledge sharing, joint monitoring, and market linkages.

The third objective is to analyze Challenges related to Rwangingo wetland management the findings show several challenges. The current irrigation design suffers from water loss due to a porous canal and damaged infrastructures and Poor infrastructure maintenance, and conflicting land use practices like livestock grazing damaging the canal and crops. Flooding causes significant crop loss in some areas and institutional weaknesses in communication and coordination among stakeholders hinder effective wetland management.

The last objective of this study is to propose measures to enhance the effectiveness of Rwangingo Wetland management While Rwangingo wetland has significantly challenges related to wetland management it is imperative to implement measures for enhancing the effectiveness of Wetland management including the protection of the buffer zone by Implementing Land Use plan regulations to protect the buffer zone area; Promote Stakeholder Engagement and awareness by Creating and implementing the framework for

mobilization and involvement of the big land holding farmers who are not regularly based in the area for their active involvement in the wetland. Prioritize the rehabilitation of identified damaged infrastructure within the Rwangingo Wetland promote sustainable agriculture practices including techniques that minimize water use, such as improved irrigation methods.

In conclusion, this study investigated the effectiveness of wetland management in Rwangingo Wetland, Rwanda. The research identified agriculture as the primary activity conducted within the wetland. However, this activity, along the cropland including the buffer zone, shows that current management practices are not effective because the implemented activities are different from planned activities and do not comply with some policies, and regulations related to wetland management. Challenges including conflicting usage and flooding hinder successful management. The study found that Rwangingo Wetland management is not effective.

By implementing measures that address the identified challenges, Rwangingo Wetland management will be further strengthened to ensure its conservation, and increase value for the benefit of farmers.

While the study in Rwangingo wetland provided valuable insights, it's important to acknowledge that the research area was limited to Katabagemu Sector, which doesn't cover the entire wetland. This limits the generalizability of the findings to the whole wetland ecosystem. To develop more comprehensive wetland management plans, future research should consider how local communities view wetland management practices is crucial for developing strategies that are both effective and meet community needs.

## 5.2. Recommendations

The research using the assessment of Rwangingo, we evaluate the current management practices of the Rwangingo wetland. To ensure the improvement of the Wetland management practices, this section provides recommendations based on the findings of the assessment. These recommendations aim to the improvement of the effectiveness of the wetland's management for the benefit of the ecosystem and surrounding communities. To significantly enhance the effectiveness of Rwangingo wetland management, I recommend :

1. conducting a comprehensive environmental study. This depth analysis would identify the most persistent pressures on the wetland's delicate balance, allowing for targeted conservation efforts to address issues of Flooding, invasive species, and unsustainable water usage patterns.
2. Development of a comprehensive plan that incorporates all stakeholders. This inclusive approach would involve identifying and engaging with everyone with an interest in the wetland, from local communities to government agencies and conservation organizations..
3. Conducting technical studies to assess the feasibility of controlled land conversion within specific wetland areas for sustainable rice production. This approach will balance agricultural needs with wetland needs and conservation efforts.
4. Lining the main canal to enhance water conservation and irrigation efficiency within Rwangingo Wetland, will reduce losses of Water from the canal, ensuring more water reaches its intended fields . This will provide more consistent watering for existing crops, improving wetland management.

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# VII.APPENDICES

## Appendix 1:Recommendation letter

 UNIVERSITY of RWANDA

COLLEGE OF SCIENCE AND TECHNOLOGY (CST)  
SCHOOL OF ARCHITECTURE AND BUILT ENVIRONMENT (SABE)  
Office of the Dean

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**TO WHOM IT MAY CONCERN**

Dear Sir, Kigali, 05 January 2024  
Dear Madam,

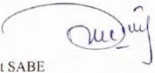
**Data Collection for MSc Dissertation by Ms. Nyirahabimana Seraphine**

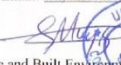
Through this letter, we would like to confirm that **Ms. Nyirahabimana Seraphine** is a final year student in the MSc of Geo-Information Science for Environment and Sustainable Development (GI-ESD) under the School of Architecture and Built Environment (SABE), College of Science and Technology (CST), at the University of Rwanda (UR). She is currently working on the MSc dissertation, with the topic "**Assessing the effectiveness of Wetlands Management in Eastern Province Case of Rwangingo Wetland, Katabagemu Sector**", under the supervision of Associate Professor Theophile Niyonzima (+250 788 450 488).


From January up to April 2024, she will be collecting data which are relevant to that topic in Nyagatare District, Katabagemu Sector, Rwangingo Wetland and surrounding cells. Data collection will include the household surveys and interviews with local leaders, and various government officials. In addition, she will need access to various spatial datasets and documents that are held by both public and private organizations. We would therefore like to request for your support so that she can get access to those data and documents. For any question related to his research, do not hesitate to contact her supervisor (tel. above) or any of us on the tel. or email below.

We do appreciate your support to that UR Student in her academic journey.

Sincerely yours.

  
**Dr. Ernest Uwayezu**  
Post Graduate Coordinator at SABE  
MSc - GI-ESD program coordinator  
Mobile: +250 783 022 510 ; Email: [wawayez Ernest@ur.ac.rw](mailto:wawayez Ernest@ur.ac.rw)

**For**   
**Dr. Josephine Malonza**  
Dean, School of Architecture and Built Environment (SABE)  
College of Science and Technology, University of Rwanda  
Mobile: + 250 7 88 625 651; E-mail: [josemwongc Malonza@ur.ac.rw](mailto:josemwongc Malonza@ur.ac.rw)



P.O Box 3900 Kigali, Rwanda      dean.sabe@ur.ac.rw      www.ur.ac.rw

## **Appendix 2: Interview Guide**

**THE INTERVIEW GUIDE- People living near the wetland (farmers, leaders, and non-farmers in Rwangingo area)**

**The purpose of this study is to assess the effectiveness of Wetlands Management in Eastern Province Case of Rwangingo Wetland, Katabagemu Sector.**

I am a Master's Research student at the University of Rwanda-School of Architecture and Built Environment, College of Science and Technology.

My research aims to assess the effectiveness of Wetlands Management in Eastern Province Case of Rwangingo Wetland, Katabagemu Sector.

I would like to ask you to participate in this interview to obtain the necessary data. Your participation is voluntary; All your answers will be handled confidentially and anonymously. Please do not give your name. Responses are needed for research purposes only and will be presented in aggregate form. If you choose to take part in this study, please answer the questions as honestly as possible.

The interview survey should take about 20 minutes to complete.

We would like to thank you for your participation.

If you would like to have further information or have any specific concerns about this survey, please contact me by e-mail: [seraphinen02@gmail.com](mailto:seraphinen02@gmail.com)

1. Where do you live? Village: .....Cell:.....Sector:.....
2. Do you have any other activity conducted in the wetland? .....If yes, Which one?
3. How do you practice that activity?
4. How do you participate in Rwangingo Wetland management?
5. How do you use the wetland as a farmer who involved in modern agriculture system that focus on wetland management?
6. Do you usually get support and advice from Agriculture and environmentalist technicians and advisors to protect Rwangingo wetland?

- Yes
- No

7. As farmer what do you do, to avoid bad practices in Rwangingo wetland?

8. What is your problem to adapt to the new system, and other aspect from perspective as a farmer of Rwangingo wetland?

**INTERVIEW GUIDE: REMA, MINAGRI, District & Environmental Practitioners**

1. Institution employing you .....
2. Your Responsibility .....
3. Is Rwangingo Wetland Management Plan being implemented as planned?  
 . How Local Leaders, stakeholders, and farmers participate in avoiding bad practices in Rwangingo wetland?
4. What are the priorities and plans for Rwangingo wetland?
5. From your point of view, what constraints and challenges related to Rwangingo wetland management in Katabagemu sector?
6. What can be done to sustainably solve all of the above challenges?
7. What are the effects of the poor implementation of the wetland policies towards Rwangingo wetland management?