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Final Report: Volume 2 – Wetland Master Plan

Technical Support for Development of Wetland Master Plan for Kigali City

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Abbreviations and Acronyms

ACNR	Association for the Conservation of Natural Resources
CoK	City of Kigali
EDCL	Energy Development Company Limited
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
ENR	Environment and Natural Resources
GDP	Gross Domestic Product
GGCRS	Green Growth and Climate Resilience Strategy
GIS	Geographic Information System
ha	hectare
IBA	Important Bird Area
IMCE	Integrated Management of Critical Ecosystems
km	kilometre
m	metre
M&E	Monitoring and Evaluation
MINAGRI	Ministry of Agriculture
MINEDUC	Ministry of Education
MINICOM	Ministry of Commerce
MINIFRA	Ministry of Infrastructure
MoE	Ministry of Environment
MP	Master Plan
NAEB	National Agriculture Export Board
OAG	Office of the Auditor General
OSC	One Stop Centre
PES	Payment for Ecosystem Services
RAB	Rwanda Agricultural Board
RDB	Rwanda Development Board

REMA	Rwanda Environment Management Authority
RHA	Rwanda Housing Authority
RTDA	Rwanda Transport Development Authority
RWCA	Rwanda Wildlife Conservation Association
SDG	Sustainable Development Goals
SEA	Strategic Environmental Assessment
STP	Sewage Treatment Plant
ToR	Terms of Reference
UNDP	United Nations Development Program
WMP	Wetlands Master Plan

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1 Introduction to the Wetlands Master Plan

1.1 Guiding Principles

The Ministry of Environment (2019) National Environment and Climate Change Policy developed guiding principles and these have been adapted for the Wetlands Master Plan: (1) Ecosystem approach to conserving environmental resources to ensure that wetlands are managed in an integrated manner while also providing benefits to the residents in Kigali; (2) Assessment of environmental risks and impacts for development projects; (3) Precautionary principle seeks to minimise activities that have the potential to damage the integrity of wetlands; (4) The principle of sustainability of environment and equal opportunities across generations; (5) Mitigation and adaptation in response to negative impacts; (6) Polluter pays principle; (7) The pollution prevention principle anticipates problems and prevents negative impacts; (8) Producer responsibility in which producers are responsible for the treatment or disposal of wastes; (9) The principle of information dissemination and community education in the conservation and protection of the environment; (10) Principle of cooperation: public institutions, international institutions, associations and private individuals are required to protect wetlands; (11) Effective involvement of women and youth in wetland management; and (12) Payment for Ecosystem Services (PES) in wetland management.

Rwanda has numerous wetlands that contribute to livelihoods, biodiversity conservation, ecosystem services and carbon sequestration. The Government of Rwanda (GoR) has sound and comprehensive legislation to manage its natural resources but, despite this legislation, wetlands in the City of Kigali (CoK) are degraded largely owing to drainage for agriculture. The GoR has required the following: (1) Develop a master plan and strategies for wetland management in Rwanda; (2) Develop guidelines for the use of wetlands; (3) Identify polluted wetlands and develop remediation plans that use environmentally-sound technologies to prevent pollution; (4) Promote and intensify wetland protection and rehabilitation of degraded wetlands; (5) Strengthen collaborative and participatory management of wetland resources; (6) Strengthen efforts in wetland research and conservation; (7) Ensure the protection of wetlands from unsustainable practices to reduce soil erosion and environmental degradation; and (8) Ensure that development within wetlands or their buffer zones conform with EIA processes and procedures.

1.2 Definition of Wetlands

Under the RAMSAR convention a wetland is defined as: “an area with marsh or water, whether artificial or naturally occurring, where the water is either flowing or stagnant, either salty or fresh and can also include marine areas where the depth of water during low tide reaches a minimum of six meters.” The wetlands include surrounding areas of the shores, riverbanks and entire watercourses.

The National Water Act (South Africa) defines wetlands as: “land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which in normal circumstances supports or would support vegetation typically adapted to life in saturated soils” (Macfarlane et al., 2008).

There are many names for land areas that temporally or permanently wet, e.g. bog, carr, fen, marsh, mire and swamp. These terms are all encompassed within the word ‘wetland’. In Rwanda, legislation should use only ‘wetland’ when seeking to describe such areas and the definition above from Macfarlane et al. (2008) should be adopted in future. However, a variety of definitions and names have been used for wetlands in Rwanda and these are summarized in Table 1.

Table 1: Wetland definitions as used in laws, policies and guidelines in Rwanda (Aurecon AMEI Limited 2017)

LAW/POLICY/GUIDELINES	TERM	WETLAND DEFINITION
Environmental Policy 2003	wetland	Not defined
Land Policy 2004	marshland	Not defined
Law N° 04/2005 determining the modalities of protection, conservation and promotion of environment in Rwanda	wetland	A wetland is a place made up of valleys, plain lands and swamps
	swamp	A flat area between mountains with much stagnant water and biodiversity, with <i>Cyperus papyrus</i> , <i>Cyperus</i> sp. or other vegetation of the same family

LAW/POLICY/GUIDELINES	TERM	WETLAND DEFINITION
Law N° 62/2008 putting in place the use, conservation, protection and management of water resources regulations No 62/2008	swamp	Alluvial bottoms of valleys, stream sides, rivers, lakes and ponds characterised by the accumulation or the water passage even during the dry season, with a soil and a specific vegetation relating to surrounding hill zones
Law No 43/2013 governing land in Rwanda	swamp	A plain area between hills or mountains with water and biodiversity, and where <i>Cyperus papyrus</i> or <i>Carex</i> sp. or plants of their species grow
Prime Minister's Order N° 006/03 of 30/01/2017 drawing up a list of swamp lands, their characteristics and boundaries and determining modalities of their use, development and management	swamp land	A flat area between mountains with much stagnant water and biodiversity, with <i>Cyperus papyrus</i> or other vegetation of the same family
Guidelines for EIA for Wetland	wetland	Areas that are seasonally or permanently flooded with characteristic soils, inhabited by flora and fauna adapted to living in waterlogged conditions; these include seasonally-flooded grassland, swamp forest, permanently flooded <i>Cyperus papyrus</i> , grass swamp and upland bog
Organic Law N°48/2018 of 13/08/2018 on environment	wetland	Areas consisting of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six (6) metres

LAW N°49/2018 OF 13/08/2018 (DETERMINING THE USE AND MANAGEMENT OF WATER RESOURCES IN RWANDA) defines a wetland as an area of marsh or water, whether natural or artificial, permanent or temporary, with water that is stagnant or flowing. The law also defines ecological flow as the quantity and quality of the water flow required to sustain the aquatic ecosystem and the human and animal lives depending upon it.

The natural water boundaries for streams, rivers and lakes are delimited by the line reached by the highest waters before overflowing. For wetlands, the boundaries are delimited by a line reached by the highest waters in normal circumstances. In Rwanda, wetlands are state-owned. The Ministry of Environment (MoE) has delineated all wetlands in the CoK and a 20 m buffer zone surrounds all wetlands.

Rwanda has mapped, using GIS, the locations and boundaries of all wetlands in the country. The Integrated Management of Critical Ecosystems (IMCE) project carried out by Rwanda Environment Management Authority (REMA) and funded by the World Bank, described the diverse range of wetlands in the country. The wetland inventory set wetland boundaries and this determines where cultivation or other human activities are allowed. This wetland inventory was gazetted in 2017 (Ministerial Order No 006/03 of 30/01/2017) and determined how these areas may be used and managed.

Many of the wetlands in the CoK are so degraded that these areas no longer fit any of the wetland definitions provided above. Therefore, this management plan uses the boundaries as set by the MoE to determine wetland extents and the areas that need to be managed through this Master Plan.

1.3 Value of Urban Wetlands

Urban wetlands have the capacity to provide the following benefits: (1) Water supply; (2) Flood mitigation; (3) Climate moderation; (4) Wastewater treatment; (5) Habitat for biodiversity; (6) Agriculture and fisheries; (7) Tourism and recreation; (8) Education and research; and (9) Human wellbeing.

The ecological services provided by wetlands are often undervalued and wetland conservation is often ignored when planning urban developments. It is vitally important that urban plans for stormwater and wastewater management in the CoK include consideration of how wetland conservation can be integrated within these plans.

The CoK has done much to ensure an integrated approach to wetland rehabilitation and conservation. Legislation to protect wetlands is in place, wetlands have been demarcated, mapped and surveyed by drone. The Wetland Master Plan (WMP) provides guidance on wetland use, rehabilitation, management and monitoring.

ARCOS (2018) undertook a survey of key stakeholders who use or protect wetlands in Rwanda and sought to identify their priorities that require the use of wetlands biodiversity data. The report also considered capacity gaps that prevent these institutions and organizations from generating these data themselves (Table 2 and Table 3). The MoE indicated that it needed more data on wetland biodiversity, wetland mapping and the valuation of ecosystem services.

Table 2: Data needs for decision-making indicated by institutions and organizations that use wetlands (ARCOS, 2018)

INSTITUTION	BIODIVERSITY DATA	UPDATED WETLANDS MAPPING	ECOSYSTEM SERVICES VALUATION DATA	PHYSICO-CHEMICAL DATA
Ministry of Infrastructure (MININFRA)	Yes		Yes	
Kabuye Sugar Factory				Soil data
Water for Growth Project			Yes	
National Agriculture Export Board (NAEB)		Yes		Soil data
Rwanda Wildlife Conservation Association (RWCA)	Yes			
Rwanda Agricultural Board (RAB)	Yes		Yes	
Ministry of Environment (MoE)	Yes	Yes	Yes	
Rwanda Transport Development Authority (RTDA)			Yes	
Energy Development Company Limited (EDCL)			Yes	
Association for the Conservation of Nature	Yes	Yes		
Rwanda Development Board (RDB)	Yes		Yes	

The stakeholders also indicated that there was a need for wetland biodiversity data that could be used to develop EIAs, environmental reports and environmental management plans (Table 3). It was also stated that there was inadequate capacity to collect and analyse biodiversity data (ARCOS, 2018).

Table 3: Synopsis of wetlands biodiversity data needs for institutions that utilize wetlands (ARCOS, 2018)

INSTITUTION	CURRENT USE OF BIODIVERSITY DATA	BIODIVERSITY DATA GAPS TO BE ADDRESSED	PLANNED USE OF WETLANDS BIODIVERSITY DATA	CAPACITY NEEDS
MININFRA	Development of energy projects; siting of new power production projects and monitoring of EMPs	EIAs done in a rushed fashion and no data to support ToRs preparation process	Preparation of the SEA for urbanization and human settlement	The Monitoring and Evaluation (M&E) and GIS officers need capacity building on biodiversity data management and use;

INSTITUTION	CURRENT USE OF BIODIVERSITY DATA	BIODIVERSITY DATA GAPS TO BE ADDRESSED	PLANNED USE OF WETLANDS BIODIVERSITY DATA	CAPACITY NEEDS
				no in-house capacity for biodiversity
Kabuye Sugar Factory	Planning for establishment of new sugar cane plantations		New 1,500 ha plantations are planned to be developed and would require biodiversity data in wetlands	No in-house capacity for biodiversity data collection, analysis and use
Water for Growth Project	Preparation of catchment management plans	Ecosystem services valuation for wetlands in key catchments	Development of PES initiatives in selected catchments	
NAEB		Need data on wetlands flood zones	Expansion of horticulture in wetlands	Need capacity on assessment of horticulture effects on wetland biodiversity and function (use of chemicals, water for irrigation)
RWCA	Assessment of grey-crowned crane habitat		Wetlands data would be used in the community education programme about protection of grey-crowned crane habitats	
RAB		Feasibility studies for new wetland development projects do not include biodiversity assessment	Ecosystem valuation data to be used to develop more convincing narratives for new investors	Need to include an ecologist in the feasibility assessment teams
MoE	Production of State of Environment Reports	Need for updated wetlands inventory	Wetlands data would be used in the preparation and implementation of a national wetlands master plan	Need capacity in biodiversity data management, analysis and use
RTDA	Feasibility studies of new roads construction	Need data on ecosystem services valuation		Establishment of a database to compile biodiversity data from EIAs
EDCL	Selection of new energy infrastructure sites	Need data on ecosystem services valuation		Need capacity on biodiversity data

INSTITUTION	CURRENT USE OF BIODIVERSITY DATA	BIODIVERSITY DATA GAPS TO BE ADDRESSED	PLANNED USE OF WETLANDS BIODIVERSITY DATA	CAPACITY NEEDS
				management and integration
ACNR			Assessment of IBAs, development of selected wetlands profiles	Need capacity in wetlands ecosystem services valuation and use of GIS for wetlands mapping
RDB	Development of management plans for protected areas	Biodiversity occurrence not prioritized in ranger-based monitoring on National Parks; no system for easy access of data on wetlands to guide potential investors	Development of avitourism; revision of National Parks management plans	Capacity in biodiversity data collection for rangers and data analysis for park managers

1.4 Purpose of the Wetland Master Plan

The Kigali Urban Wetland Master Plan has the following objectives:

1. Adopt a balanced approach, promoting conservation and rehabilitation but also with a wise use, green growth perspective;
2. Seamlessly integrate with the ongoing Kigali Master Plan, generating synergies between the wetlands and the developed urban area of the Central Business District (CBD);
3. Provide streamlined regulations and indications for all wetlands, identifying areas of particular importance for their potential conservation or sustainable use; and
4. Identify strategic projects to be implemented within the wetlands and in synergy with CoK Implementation Plan (Conservation Investment Plans).

2 The Setting

2.1 Country Setting

Rwanda is bordered to the north by Uganda, to the east by Tanzania, the south by Burundi and the west by the Democratic Republic of Congo. The CoK (capital of Rwanda) is located centrally, is the commercial capital and the largest city in Rwanda.

The watershed separating the Congo and Nile Basins runs from north to south through the country with about 80% of the country (including the CoK) draining to the Nile River. The country's longest river is the Nyabarongo which rises as the Rukarara River in the Nyungwe Forest (source of the Nile River). The Rukarara River flows into the Mwogo River which joins the Mbirurume River to form the Nyabarongo proper. The Nyabarongo River forms the southern border of the CoK and the river is joined by the Nyabugogo River that drains from Lake Muhazi on the city's northern border. The Nyabugogo watershed is the most densely populated and urbanized catchment in Rwanda. The Nyabarongo River merges with the Ruvubu River to form the Kagera River that flows into Lake Victoria. Mountains, part of the Albertine Rift, dominate central and western Rwanda with the highest peaks forming the Virunga Volcanoes. The centre of the country is hilly while lowland savannas, plains and wetlands occur in eastern Rwanda.

The human population of Rwanda in 2016 was 11.9 million and the population is young with over 40% below the age of 15. With 445 people per km², Rwanda's population density is one of the highest in Africa.

The climate of the country is tropical, moderated by altitude and there are two wet seasons. There is evidence that climate change has resulted in a reduction in the number of wet days but an increase in the frequency of heavy downpours. Rwanda has few natural resources and the economy is dominated by subsistence agriculture and ecotourism. Major crops include bananas, beans, sweet potatoes, Irish potatoes, cassava, maize, taro, yams, rice and a wide variety of vegetables. Coffee and tea are the main cash crops.

2.2 City of Kigali and Kigali City Master Plan

The environmental quality of a city depends on the extent of its green spaces and natural habitats. Natural systems such as grasslands, forests and wetlands function more effectively when connected by corridors that facilitate the movement of organisms.

The CoK covers an area of 730 km². Open spaces within the City declined from 191 to 181 km² (-5.5%) between 2013 and 2018 (Surbana Jurong and SMEC, 2019). Within this same period, natural areas declined from 124.78 to 123.61 km² (-0.9%). It has been proposed to increase protected areas from 191 km² to 235 km².

More than 60% of Kigali's population live in unplanned settlements and they lack access to integrated infrastructure including safe water, proper sanitation, electricity, health services, waste management and proper roads. Many of these unplanned areas are in or adjacent to fragile ecosystems such as steep slopes and wetlands.

In the CoK, the total agricultural land (farmland and plantations) is approximately 63% of the total land area (City of Kigali Master Plan, 2013, 2019). Farming occurs adjacent to and within wetlands. The main crops grown near or in wetlands include rice, maize, sorghum, beans, taro, sugar cane and a variety of vegetables.

Rapid population growth has led to a reduction in farm sizes and encroachment into natural habitats resulting in deforestation and wetland degradation. Intensive cultivation without suitable land husbandry has led to land degradation and there is a pressing need to conserve land resources and develop sustainable land management strategies to ensure food security. Rapid deforestation, expanding areas of cultivation and urbanization has also led to a loss of biodiversity, leading to a relatively low concentration of fauna and low diversity of flora in Kigali.

Kigali has clay soils and these provide affordable local building material. However, clay mining causes environmental problems and particularly impacts wetlands. The major problem is the increase in water turbidity downstream of clay extraction sites. Clay is a vital resource that is in short supply within the CoK. Its frequent occurrence as an economic resource within wetland boundaries provides an opportunity for a private-public partnership that would see clay extraction being followed by a required programme of wetland rehabilitation. There are examples from other parts of the world where such collaborative enterprises have been very successful (e.g. Penrith Lakes, near Sydney, Australia). The granting of a license to mine clay in another wetland would only be extended to a company once rehabilitation of the first site has been satisfactorily completed. This programme can only work if, with the cessation of clay mining at a site, rehabilitation is satisfactorily completed. The linear shape of wetlands would facilitate this gradual process of sequential mining and wetland rehabilitation. The programme should be described as the ecological rehabilitation of

the wetland through the wise use of a resource. Clay removal would result in the creation of areas within the wetland of variable depth and this would serve to increase habitat diversity and provide water storage capacity during floods and water during dry periods. These basins may contain high levels of fine suspended particulate matter. Water clarity can be restored with the application of gypsum (CaSO_4).

The CoK seeks to expand through the mechanism of green growth. Green growth must be compatible with protecting the environment, reducing carbon and other unwanted emissions, improving the rational use of natural resources, dealing with climate change, securing access to clean energy and water whilst simultaneously targeting poverty reduction, job creation and social inclusion.

The CoK has an area of 730 km² and a human population of 1.3 million. In 2012, the city's population was expanding at 4% year⁻¹. Sixty-three per cent of the land within Kigali is used to grow food. This urban agriculture is significant in ensuring food security and reducing malnutrition. The GoR recognizes the need to allow this food production to occur and the Urban Planning Code permits gardening and tree nurseries within residential areas and actively promotes private food gardens. However, excess use of agrochemicals and manure can have significant impacts on wetlands and other water resources.

The CoK is located in the Albertine Rift region, forming part of the watershed for the Nile River. The surrounds are hilly, and the ridges have an average altitude of around 1,600 m asl while the intervening valleys are around 1,300 m asl. Slopes are generally steep and most roads traverse along contours to ascend the slopes. The City is ringed towards the north and west by higher hills. The highest of these is Mount Kigali, with an elevation of 1,850 m asl. The southern extent of the CoK is marked by the Nyabarongo River with its associated wetlands. Kigali Province is bordered by Rwamagana and Bugesera Districts (Eastern Province), Gakenke and Rulindo Districts (Northern Province) and Kamonyi, Ruhango and Nyanza Districts (Southern Province).

Kigali was founded in 1907 as the administrative centre of Rwanda and quickly developed as a major commercial hub because of its central location and its role as a transport route providing access to neighbouring countries. Kigali became Rwanda's capital when the country gained independence from Belgium in 1962 and since then it has become Rwanda's major economic, cultural and transport hub.

The CoK has three Districts: (1) Gasabo (15 Sectors: Bumbogo, Gatsata, Jali, Gikomero, Gisozi, Jabana, Kinyinya, Ndera, Nduba, Rusororo, Rutunga, Kacyiru, Kimihurura, Kimironko and Remera); (2) Kicukiro (10 Sectors: Gahanga, Gatenga, Gikondo, Kagarama, Kanombe, Kicukiro, Kigarama, Masaka, Niboye and Nyarugunga); and (3) Nyarugenge (10 Sectors: Gitega, Kanyinya, Kigali, Kimisagara, Mageragere, Muhima, Nyakabanda, Nyamirambo, Nyarugenge and Rwezamenyo).

Kigali's average temperature is approximately 22°C with a low temperature of about 16°C and a high temperature of about 28°C. Its equatorial climate is moderated by its altitude. The average annual precipitation is approximately 950 mm. While it rains throughout the year, wet seasons are bimodal with higher rainfall between March-April and October-November. It is drier between June-August with less than 50 mm of rain.

The CoK lies within an area with medium to high risk soil erosion and soil present on slopes greater than 5% slope are susceptible to heavy erosion. About 17% of the CoK is on land with slopes of more than 30%. Inappropriate developments including unplanned settlements on steep slopes has caused extensive soil erosion in some areas. This results in heavy sediment loads in streams and rivers and high rates of sedimentation within wetlands.

The CoK is drained by streams and rivers and the area can be delineated into twenty-five watersheds. Lake Muhazi lies along the northern border of the CoK northeast of Gasabo District. The lake is the main source of water to the Nyabugogo River. The Nyabarongo River borders Nyarugenge and Kicukiro Districts along the south western edge of the CoK and most of the rivers draining the CoK flow into this river. The Nyabarongo River flows near Lake Rweru and is part of the Nile River Basin. The Yanze, Kibumba, Rwezangoro and Ruganwa Rivers all drain into Nyabugogo River, which flows into the Nyabarongo River to the west of the City.

These rivers provide domestic water, drain stormwater and contribute to the physical beauty and character of the City. The Nyabarongo River has turbid water owing to high sediment loadings from soil erosion in its catchment and it also is polluted with sewage effluents and from stormwater runoff. Agriculture in these watersheds add sediment, pesticides, herbicides and chemical fertilizers which further degrade the water quality in these urban rivers. Urban development and landcover change are increasing the impervious surfaces in Kigali's catchments, leading to increased stormwater runoff and localized flooding. Flood risks are high in the valley and wetland areas of the city to which the catchments drain, including along the Nyabugogo, Gikondo and Nyabarongo Rivers. Preservation and restoration of

the natural drainage channels across the catchments in the CoK is an important strategy for managing flooding, especially as developed stormwater drainage infrastructure in much of the City is absent.

Private ownership of land and inadequate land suitable for housing and other development has led to escalating land prices, overcrowding of existing neighbourhoods and illegal encroachment onto steep slopes and drainage or degradation of urban wetlands. Any plans to restore urban wetlands will require a balance between wetland protection and the use of wetland resources and wetland areas for economic development activities.

The CoK seeks to become green and efficient. Major challenges that this effort faces include urban areas prone to landslides and flooding, unplanned developments on steep slopes, deforestation and encroachment into wetlands. Efforts to address these challenges include clearance of developments on steep slopes and within wetlands by acquiring land for relocation, ecological restoration of steep slopes and wetlands, conservation of remaining wetlands, reforestation of steep slopes, establishing buffer zones around lakes, rivers and wetlands and by seeking ways to exploit natural areas sustainably and create green jobs. Some wetland areas have already had buildings and other structures removed as a first stage in habitat restoration.

The concept of Green Growth has been articulated clearly by Rwandan Ministry of Infrastructure (MININFRA) and the Global Green Growth Institute (GGGI). The Government of Rwanda (2011) and Government of Rwanda and GGGI (2015) address climate change and the need for urban development through green growth.

Strategies to achieve these green goals include:

- Development of an Integrated Water Resource Management Plan that will include strategies to protect wetlands, lakes, rivers and their catchment areas and plans to manage stormwater;
- Development of an inventory of illegal activities in all urban wetlands with maps and photos detailing these activities;
- An awareness campaign and capacity-building training activities;
- Protection of wetlands while allowing for some recreational, agricultural and mining activities such as clay extraction;
- Restoration of wetlands, lakes and rivers that have been impacted by human activities;
- Relocation of people inhabiting restricted and hazardous areas including protected wetlands;
- Integration of wetlands into the design and development of green open spaces, urban parks and city trails;
- Promotion of long-term reduction in wetland areas that are currently under cultivation and their restoration as natural areas;
- Development of a wetlands management manual that includes the management of agricultural practices in wetlands;
- Development of a wetland management plan for the CoK;
- Institution of a no net loss of wetlands policy;
- Restoration of wetlands; and
- Enforcement of the buffer zone policies: 20 m for wetlands, 10 m for rivers and 50 m for lakes.

2.3 Wetlands Policies and Institutional Context

The Office of the Auditor General (2018) concluded that wetlands in Rwanda are not effectively managed and protected which leads to their degradation. The OAG noted:

1. Lack of a wetlands management policy;
2. Absence of a wetland management plan;
3. Wetlands damaged by sand and clay removal;
4. Wastes dumped in wetlands;
5. Prohibited structures in wetlands;
6. Absence of a status report on the protection of biodiversity in wetlands; and
7. Failure to determine the level of wetland pollution.

Rwanda is endowed with wetlands that contribute significantly to environmental sustainability, community livelihoods and carbon sequestration (Ministry of Environment, 2019). The GoR has legislation to manage all its natural resources, including wetlands. However, there are signs of wetland degradation due to factors including the draining of wetlands for agriculture, urban and industrial expansion and poor use of wetland catchments leading to siltation and pollution of wetlands and rivers. Therefore, the following policy actions are required:

1. Develop a master plan and implementation strategies for wetland management in Rwanda;

2. Develop guidelines for the use of wetlands;
3. Identify all polluted wetlands and develop a decontamination plan including the use of environmentally-sound technologies (phytoremediation) for pollution prevention, control and remediation;
4. Promote and intensify wetland protection, restoration and rehabilitation of degraded wetlands;
5. Strengthen collaborative and participatory management of wetland resources;
6. Strengthen existing wetland research and encourage conservation and restoration of ecosystems critically threatened by climate change;
7. Ensure the protection of wetlands, riverbanks, hilltops and slopes from unsustainable practices to prevent soil erosion and environmental degradation; and
8. Ensure that developmental activities within wetlands or in the buffer zone of wetlands conform with EIA processes and procedures.

The Biodiversity Policy presented by the Ministry of Environment (2019) considers the rehabilitation of degraded ecosystems in Rwanda as an urgent and major task that requires the commitment of significant resources from both national budgets and other sources.

The proposed goal of the Environment and Climate Change Policy is: “Rwanda is to be a nation that has a clean and healthy environment, resilient to climate variability and change that supports a high quality of life for its society.”

Primary national institutions involved in wetland protection and management include: (1) Ministry of Environment (MoE); (2) Ministry of Agriculture and Animal Resources (MINAGRI); (3) Rwanda Environment Management Authority (REMA); (4) Rwanda Development Board (RDB); (5) Rwanda Land Management and Use Authority (RLMUA); (6) Rwanda Water and Forestry Authority (RWFA); (7) City of Kigali (CoK); and (8) Local Government Authorities. The roles and responsibilities of these agencies are detailed in Table 4.

Table 4: Key government agencies and their responsibilities in wetland conservation and management

INSTITUTIONS	RESPONSIBILITIES
MoE	Wetland management, wetland identification and classification, wetland conservation.
MINAGRI	Maintenance and rehabilitation of unprotected wetlands used for agriculture; Approval of lending unprotected wetlands for agriculture.
REMA	Implementation of wetlands policies; Advise GoR on policies, strategies and legislation related to wetland management, international conventions (e.g. RAMSAR); Inspection of wetlands and their management and preparation of a report every two years; Conduct studies and research on wetland environmental issues; Monitor and assess development programmes to ensure compliance with wetland laws; Participate in the preparation of strategies designed to reduce risk that may cause wetland degradation and propose remedial measures; Provide advice and technical support on wetland conservation and management; Disseminate education materials related to wetland conservation, protection and management; Monitor the EIA process as applicable to developments in wetlands; Establish relationships with international institutions and organizations involved in wetland conservation and management.
RDB	Provide EIA advice and ensure compliance; Wildlife conservation and tourism.
RLMUA	Implement national policies, laws, strategies, regulations that apply to wetlands; Advise the GoR and monitor the implementation of strategies related to the management of wetlands; Promote activities related to the exploitation of wetland resources; Register land; Supervise land-related matters including PMO N° 006/03 of 30/01/2017 on wetlands; Initiate research on land and wetland issues; Establish guidelines on the use of land and wetlands.
RWFA	Implement policies, laws and strategies related to water resources including wetlands; Advise GoR on strategies related to the management of water resources and wetlands; Assist in programmes that reduce erosion; Advise on applications for the use of water resources; Monitor use of water resources and wetlands; Provide advice on fees to be paid for use of water resources.
LGA	Wetland management programmes.

The following laws and regulations have been enacted for the protection of wetlands in Rwanda:

1. Organic Law N°48/2018 of 13/08/2018 on environment;
2. Ministerial Order N° 004/2008 of 15/08/2008 establishing the list of works, activities and projects that require an Environmental Impact Assessment (EIA);
3. Ministerial Order N° 007/2008 of 15/08/2008 establishing a list of protected flora and fauna;
4. Ministerial Order N° 26/03 of 23/10/2008 establishing a list of prohibited chemicals and pollutants;
5. Ministerial Order N° 007/16.01 of 15/07/2010 determining the length of land on shores of lakes and rivers transferred to public property;
6. Ministerial Order N° 008/16.01 of 13/10/2010 establishes the list of wetlands and their limits and regulating their management and use; wetland use under specific conditions shall be exploited upon completion of an EIA;
7. Ministerial Order N° 004/16.01 of 24/05/2013 establishing a list of water pollutants;
8. Prime Minister Order N° 006/03 of 30/01/2017 provides a list of swamp lands, their characteristics and boundaries and determines modalities of their use, development and management;
9. The RAMSAR Convention was signed by Rwanda in April 2006. This international convention provides a framework for national activities and international cooperation for the conservation and wise use of wetlands and their wetland resources; and
10. The Convention on Biological Diversity was ratified by Rwanda in August 1996.

In 2011, the GoR approved the Green Growth and Climate Resilience Strategy (GGCRS). This strategy aims for the country to be a developed climate-resilient, low-carbon economy by 2050. Objectives of the strategy include to achieve (1) sustainable land and water utilization for food security; (2) urban development and biodiversity and ecosystem preservation; (3) social protection; and (4) improved health and disaster risk reduction. Of relevance to wetland management, the strategy seeks to support programmes leading to integrated water resource management and planning; to promote ecotourism, conservation and Payment for Ecosystem Services (PES); and to provide climate data and projections of climate change.

The National Biodiversity Strategy and Action Plan (2016) seeks: (1) to improve environmental stability for natural ecosystems and their biodiversity; (2) to restore degraded ecosystems and maintain equilibrium among biological communities; (3) to establish an appropriate framework for access to genetic resources and equitable sharing of benefits arising from biodiversity use and ecosystems services; and (4) to improve policy, legal and institutional frameworks for better management and conservation of national biodiversity.

Organic Law N°48/2018 of 13/08/2018 on environment uses the RAMSAR definition of wetlands: areas consisting of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six (6) metres. Other definitions of relevance to this project include (but see Section 1.2):

1. **Natural environment:** an environment that encompasses all living species and non-living things occurring naturally on earth, including soil and subsoil, water, air, biodiversity, and landscapes, tourist sites and monuments that affect human survival and economic activity;
2. **Swamp:** as a plain area between hills or mountains with water and biodiversity where papyrus or carex or plants of their species grow;
3. **Climate change:** a change in weather patterns attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods;
4. **Ecosystem:** a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit;
5. **Shores:** a wetland that is dominated by herbaceous rather than woody or plant species often found at the edges of lakes and streams where they form a transition between aquatic and terrestrial ecosystems;
6. **Environmental impact assessment:** a systematic process of identifying environmental, social and economic impacts of a project before a decision of its acceptance is made; and
7. **Biodiversity:** the variability of living organisms of all types including a person, animals of all species, plants of all types be it on land or underground, in water or in the atmosphere and the interactions among them.

The law requires that water resources must be protected from any source of pollution. Swamps with permanent water and full of swamp vegetation must be given special protection considering their role and importance in the preservation of the biodiversity.

Acts prohibited in wetlands and protected areas are as follows:

1. To dump any solid, liquid waste or hazardous gaseous substances in a stream, river, swamp, pond, lake and in their surroundings;
2. To damage the quality of the surface or underground water;
3. To dump, spill or deposit materials of any nature that may cause or increase water pollution;
4. To wash minerals in streams or lakes;
5. To build an agricultural and livestock installation in a distance of ten metres (10 m) away from the banks of streams and rivers and fifty metres (50 m) away from the lake banks;
6. To build a cattle kraal, slaughter house, cattle market in a distance of sixty metres (60 m) away from the banks of streams and rivers and two hundred metres (200 m) away from the lake banks;
7. To build in water sources, streams, rivers and lakes and in the buffer zone in a distance of ten metres (10 m) away from streams and fifty metres (50 m) away from lakes;
8. To pile soil and any other materials in wetlands;
9. To compact or change the nature of the wetland;
10. To build in the swamp and in the buffer zone in a distance of twenty metres (20 m) away from the swamp boundaries;
11. To drain the swamps without prior authorization of the competent authority;
12. To drain, divert or block the rivers without prior authorization of the competent authority;
13. To carry out any activity, except that related to research and science in reserved swamps;
14. To introduce plants or animal species whether alien or indigenous into wetlands without prior authorization of the competent authority;
15. To dump, make flow any hazardous waste, waste water, except after treatment in accordance with relevant instructions; and
16. To dump, make flow, dispose of and store any substance in a place where it may cause or facilitate pollution of national waters.

However, the Minister, after consultations with relevant institutions, may authorize some constructions or any other tourism-related activity as well as the use of water and underwater resources.

Rwanda's environmental regulations stipulate that buffer zones should be maintained and protected along the periphery of waterbodies, with 10 m buffer zone for rivers, 20 m buffer zone for wetlands and a 50 m buffer zone for lakes (Ministerial Order N° 007/16.01 of 15/07/2010).

The GoR's Vision 2050 seeks high standards of living for all Rwandans and focuses on five areas: (1) Quality of life; (2) Modern infrastructure and livelihoods; (3) Transformation for prosperity; (4) Values for Vision 2050; and (5) International cooperation and positioning. Additional emphasis will be put on strengthening monitoring and evaluation. High impact areas selected include implementation of: Environmental and Social Impact Assessments, biodiversity and ecosystem management, pollution and waste management.

2.4 Description of the Wetlands in the City of Kigali

The wetlands (by name) within the CoK and their major ecological features are shown in Figure 1 and Figure 2. Wetlands now cover approximately 10.6% (compared to 14% in 2013) of the land area of the CoK. The total area of wetlands is around 72 km² (Table 5:) and this has declined from 100 km² in 2013. The wetlands are mainly found lining the low-lying valleys and floodplains of the rivers flowing through the city. Wetlands in the CoK are classified as Central Plateau Swamps (based on REMA's 2008 wetland inventory and classification system). The wetlands have a mineralized soil substrate with the dominant vegetation, when not cultivated, includes *Polygonum pulchrum*, *P. senegalense*, *Cyperus papyrus*, *Typha* sp., *Phragmites* sp., *Commelina diffusa*, *Cynodon dactylon*, *Eichhornia crassipes* and *Pennisetum purpureum* (Figure 2 and Figure 3). These uncultivated wetlands provide significant ecosystem services that include improving water quality by sediment and nutrient removal, flood attenuation, reducing soil erosion, providing habitat for flora and fauna, moderating climate conditions, contributing to aesthetics and providing opportunities for economic, recreational, educational and research activities.

The City of Kigali Master Plan (Surbana Jurong and SMEC, 2019) has identified wetland areas for development. The Muhima Waterfront Development encompasses parts of the Nyabugogo, Rwezangoro and Rwampara Wetlands (Figure 1). This proposal seeks to create a distinct waterfront with public open spaces and recreation zones that are close to the city centre. The development will also address flooding that is an issue for the areas that lie next to these wetlands. The large wetlands to the south of the CoK are identified as the Eco-Wetland Corridor. Development of this region will provide a place to visit for ecotourists and it is proposed that a botanical garden, bird watching site,

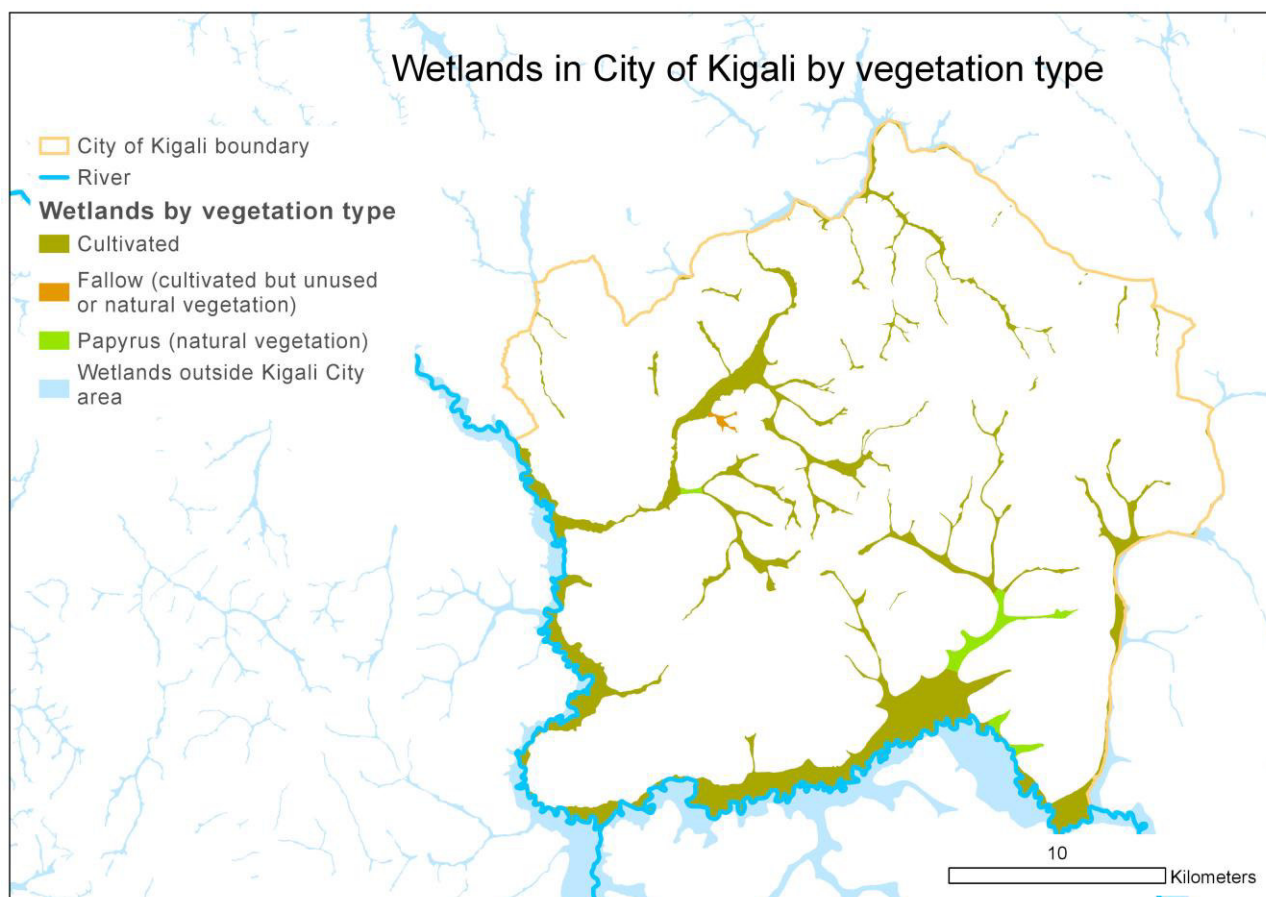


Figure 2: Wetlands in the City of Kigali showing that most of the wetland areas are under cultivation



Figure 3: Large expanse of natural vegetation dominated by *Cyperus papyrus* in Nyabarongo Aval Wetland in the City of Kigali

The CoK faces environmental challenges including land degradation, deforestation, dependence on biomass to provide cooking fuel, soil erosion and siltation of rivers and wetlands, water pollution, air pollution, degraded forests and wetlands, and inadequate solid waste and wastewater management strategies. Urbanization and subsistence farming extending into naturally vegetated and forested areas has led to deforestation, biodiversity loss and topsoil erosion. The loss of soil has significant hydrological and water quality impacts on downstream rivers and wetlands.

Drainage of wetlands (Figure 4) and river floodplains for settlement, cultivation (Figure 5) and grazing has led to a loss of wetland area, degradation of wetlands and loss of the valuable ecosystem services that wetlands provide. Wetland and river flood plains naturally experience flooding and therefore people, livestock, crops and structures within these areas are at a high risk of being impacted by flooding. The increase in the area of impervious surfaces, reduction in forest cover and alteration of natural drainage areas within the CoK has led to increased flooding and landslide risks. Many of the wetlands within the CoK have had drainage channels dug and water no longer covers much of the areas that have been designated as lying within the wetland boundaries. Over half the wetlands in the CoK are degraded and this means that the ecosystem services that they previously provided have either been impaired or are no longer delivered.

Burning vegetation to clear areas for cultivation releases carbon dioxide and cattle and rice fields release methane and these greenhouse gases drive climate change. The impact of climate change is another major environmental concern and since 1970 Rwanda has experienced an increase in annual mean temperature of 1.4°C. It is anticipated that by 2050 the increase above the 1970 level will be 2.5°C. Whilst changes in mean rainfall are less certain, the higher temperatures are likely to lead to an increase in intense rain events that will cause flooding and landslides (Ministry of Environment, 2019).



Figure 4: Raised cultivation beds leading to drainage of areas of Rwezangoro Wetland in the City of Kigali



Figure 5: Rice cultivation in Gikono Wetland in the City of Kigali

With respect to urban wetlands, the CoK Master Plan (Surbana Jurong and SMEC, 2013, 2019) identified the need for the following activities:

- Monitoring of urban wetlands using drones to establish drone-baseline imagery of wetlands and their buffer zones;
- Development of the 130 ha Nyandungu Urban Wetland Ecotourism Park lying within the Mwanana-Mulindi-Kanombe Wetland, will restore and conserve wetland ecosystems and biodiversity while also serving as a recreational park;
- Rehabilitation of the Nyandungu and Kimicanga Wetlands that are part of Rwampara Wetland;
- Waterfront development along the shores of the Muhima Wetland in the CBD that form parts of Nyabugogo, Rwezangoro and Rwampara Wetlands; and
- Development of sub-catchment management plans for the Gikondo (Rugenge) and Nyabugogo Wetlands.

Urban planning and city design must include wetlands as natural infrastructure for nature conservation and the provision of ecosystem services. These wetland systems should be included in plans to manage stormwater, water supply and the treatment of wastewaters.

The GoR seeks to develop an Urban Wetland Master Plan for the City of Kigali. The GoR through its MoE with funding from the United Nations Development Program (UNDP) seeks to transform the relevant provisions of the ORGANIC LAW into a regulatory instrument.

Wetland conservation will require greater attention to the management of stormwater and wastewaters. This will require increased efforts to:

- Manage and treat stormwater before it is discharged into rivers and wetlands and promote techniques that increase onsite infiltration of the rainwater;
- Reduce non-point source pollution from watershed sources through improved urban land-use and agricultural and forestry management practices;
- Strictly implement the environmental buffer zone laws: 10 m for rivers, 20 m for wetlands and 50 m for lakes;
- Restore these buffer zones with natural vegetation;
- Construct Sewage Treatment Plants (STP) to reduce the impact of wastewater on rivers and wetlands;

- Ensure that new developments include techniques to reduce stormwater run-off by enhancing infiltration and to improve water quality using natural techniques such as swales, detention basins and constructed wetlands.

Table 5: Wetlands by vegetation type

WETLANDS	AREA (ha)
Cultivated	7273.1
Byabagabo	36.3
Degi-Nyarufunzo	64.2
Gikono	29.4
Kajevuba	287.3
Karuruma	32.6
Kaziramuboro	8.4
Kibobo	21.2
Kiradiha	42.4
Misare	33.4
Mugasagara	2.4
Mulindi-Kanombe	121.5
Mwanana-Mulindi-Kanombe	244.0
Nyabarongo Amont	1118.5
Nyabarongo Aval	2569.4
Nyabugogo	724.0
Nyabugogo-Kabuye	229.8
Nyabuhoro	4.1
Nyabuhoro-Kiruhura	27.3
Nyacyonga-Mulindi	38.5
Nyacyonge-Rubilizi-Nyacyonga	16.9
Nyagasozi-Kigozi	19.4
Rubilizi	92.1
Rufigiza-Akagogo	142.1
Rufigiza-Nyagisenyi	322.5
Rugende-Isumo	280.6
Rugenge	140.2
Rwabashamana	194.7
Rwampara	288.9
Rwamugeni	5.2
Rwintare	79.2
Yanze	56.9
Fallow (crop and natural vegetation)	40.0
Kamusenyi	40.0
Papyrus (nat. veg.)	408.1
Kanyetabi	45.4
Kitaguzirwa	290.3
Ruhosha-Ayabaraya	48.9
Rwezangoro	23.5
Total	7721.2

Wetlands along the Nyabarongo River have been designated an Important Bird Area (IBA) because it is a hotspot for diverse species of migratory and resident birds. Table 6 summarizes the categories of wetland vegetation and their management.

Table 6: Wetlands by vegetation type and management

WETLANDS	AREA (ha)
Cultivated	7273.1
Exploitation without particular conditions	148.2
Exploitation under conditions	7124.9
Fallow (crop and natural vegetation)	40.0
Exploitation without particular conditions	40.0
Papyrus (nat. veg.)	408.1
Exploitation under conditions	408.1

2.5 Wetland Descriptions

The following descriptions of the 37 wetlands in the CoK are compiled from the reports produced by team members and more detailed information is provided in the Interim Thematic Reports and summaries are provided in Section 3 below.

2.5.1 Akanyaru Nord

This wetland (5,146 ha) is dominated by a *Cyperus papyrus* vegetation. This site has been identified for RAMSAR designation and therefore should be categorised a Conservation Wetland. This wetland has a low-medium water pollution rating. Most of this wetland lies outside the CoK boundary.

2.5.2 Byabagabo

This wetland (36 ha) has a brick factory at its northern end. Cultivation, including sugar cane fields, occurs along most of its length. There are fishponds within the wetland. A truck depot is present within the wetland boundary. There is a low human population density around the wetland. This wetland has a medium-high water pollution rating.

2.5.3 Degi-Nyarufunzo

This wetland (64ha) has a wide area of green space surrounding the boundary of the wetland. However, most of the wetland is under intense cultivation. Sugar cane cultivation occurs where the wetland abuts on Nyabarongo Amont. Roads cross the wetland in two places. This wetland has a medium-high water pollution rating.

2.5.4 Gikono

Gikono Wetland (29 ha) is divided into two areas. The southern area is under intense cultivation with a few fishponds. The northern area is 'Y'-shaped and the western arm is short and traversed by a road and a few residences occur within the boundary. This arm is almost all under cultivation with two fishponds. The other arm (eastern) has many fishponds at its western end. Some of this arm is cultivated and some is pasture. The area around the wetland is sparsely populated. A large area of the wetland is under rice cultivation with drainage channels. Other crops include sweet potato and banana. This wetland has a medium water pollution rating.

2.5.5 Kajevuba

Kajevuba Wetland (287 ha) has significant cultivation (sweet potato, beans, maize and taro) with herring-bone drainage into a central channel. There is a residential area along the western boundary at the northern end of the wetland but otherwise there is a low human population density surrounding most of this wetland. Two roads cross the wetland and there is a small reservoir that fills the wetland boundary. A *Cyperus papyrus* vegetation is at the southern end of the reservoir. A small lake surrounded by a *Cyperus papyrus* wetland is near the south-eastern end of the wetland. A degraded area (possible clay extraction) occurs towards the end of the wetland where a road crosses the wetland. This wetland has a low-medium water pollution rating.

2.5.6 Kamusenyi

Most of Kamusenyi Wetland (40 ha) is cultivated but there are degraded areas (clay mining) and poor pasture within the wetland boundary and also surrounding the wetland. A number of roads are present within the wetland boundary. This wetland has a medium water pollution rating.

2.5.7 Kanyetabi

This wetland (45 ha) is dominated by *Cyperus papyrus*. The wetland has brick-making and chicken-processing factories. This wetland has a medium water pollution rating.

2.5.8 Karuruma

Intense cultivation covers most of this wetland (33 ha) that is drained by a tree-lined stream. Some buildings within the wetland boundary. This wetland has a medium water pollution rating.

2.5.9 Kaziramuboro

Some cultivation (sugar cane, maize and banana) is present within this wetland (8 ha). Two fishponds and a few groves of trees are present. This wetland has a medium water pollution rating.

2.5.10 Kibobo

Kibobo Wetland (21 ha) drains into Lake Muhazi and is under intense cultivation with a grid of drainage channels that flow into a central stream. A road crosses the centre of the wetland. Major crops are sweet potato and rice. This wetland has a low-medium water pollution rating.

2.5.11 Kiradiha

Kiradiha Wetland (42 ha) is under intense cultivation and is surrounded by medium-density residential areas. This wetland has a medium water pollution rating.

2.5.12 Kitaguzirwa

The western end of Kitaguzirwa Wetland (290 ha) is cultivated and a main road crosses the wetland. There is an area of open water and the eastern end of the wetland is covered in *Cyperus papyrus* vegetation. There are a number of structures and buildings in an arm of the wetland to the north of the area of open water. This wetland has a medium-high water pollution rating. The Rwanda Wildlife Conservation Association has plans to establish Umusambi Village as a grey-crowned crane sanctuary and ecotourism area.

2.5.13 Misare

Misare Wetland (33 ha) is under intense cultivation for its entire area and is drained by a central channel that flows into Nyabugogo Wetland. The human population around the wetland is low. This wetland has a low-medium water pollution rating.

2.5.14 Mugasagara

Mugasagara Wetland (2.4 ha) comprises two patches. One abuts the shores of Lake Muhazi (Mugasagara North) and the other lies to the south. The shoreline of Lake Muhazi is lined with *Cyperus papyrus* and to the south are crop fields (taro, banana and sweet potato). The southern end of the northern patch appears to be uncultivated. Mugasagara South is cultivated with fish-bone drains taking water into Mugasagara Stream. The area around both wetland patches is sparsely-populated. This wetland has a low-medium water pollution rating.

2.5.15 Mulindi-Kanombe

The northern end of Mulindi-Kanombe Wetland (122 ha) is 'Y-shaped' with the western and eastern branches both under intense cultivation. The southern section of the wetland has a central drainage channel and most is under cultivation. Two roads cross the wetland. This wetland has a medium-high water pollution rating.

2.5.16 Mwanana-Mulindi-Kanombe

This wetland has an area of 244 ha. The middle section of this wetland (Nyandungu) has been proposed for development as a recreation and ecotourism park. This wetland is heavily polluted from untreated wastewater that flows from densely populated settlements and possible industrial pollutants from Matelas Dodoma (mattress manufacturer), Speranza Ltd, Minimex, Centre Umushumba Mwiza, fertiliser factory, several car garages and fuel stations as well as other factories located in the Special Economic Zone (SEZ). Further impacts come from agricultural activities.

REMA has recently begun restoring the wetland as part of the 134 ha Nyandungu Urban Wetland Eco-Tourism Park project (Duhuze, 2019). The aim of the project is to create an urban wetland recreation and eco-tourism park. This wetland has a high water pollution rating.

2.5.17 Nyabarongo Amont

This large wetland (1,119 ha) straddles the Nyabarongo River and is a mix of sugar cane plantations and *Cyperus papyrus* vegetation. The site has been identified for RAMSAR designation. A number of clay brick factories are present near the wetland. This wetland has a medium-high water pollution rating.

2.5.18 Nyabarongo Aval

This large wetland (2,569 ha) straddles the Nyabarongo River and is a mix of sugar cane plantations and *Cyperus papyrus* vegetation. The site has been identified for RAMSAR designation. The wetland has medium-high water pollution owing to agricultural activities and through the impacts of clay extraction and several clay brick factories. This wetland has a medium-high water pollution rating.

2.5.19 Nyabugogo

The Nyabugogo River which flows into the Nyabarongo River drains this wetland (724 ha). Much of the wetland is under cultivation and there are a number of buildings and institutions within the wetland boundary. In places the river is lined with trees. The urban areas adjacent to this wetland are subject to flooding.

The Nyabugogo Wetland is heavily polluted from untreated wastewater the flows from the densely populated settlements that border the wetland and from industrial pollutants from the Nyabugogo taxi park (which is inside the wetland), Kabuye Sugar Factory, Jabana 1 Thermal Power Plant, Rwanda Chicken Farm, Akagera Motors, Phoenix Metals and several car garages and fuel stations including Gemeca, Kobil and Engen.

Areas within the wetland boundary are under cultivation (rice, banana, maize and sugar cane) and sewage from schools, hotels, prisons and hospitals drain into the wetland (REMA, 2009). The effluents from the Nyabugogo Wetland system pose transboundary environmental challenges. The polluted waters enter the Nyabugogo River and Wetland system which then discharges into the Nyabarongo River. The Nyabarongo River, in turn, feeds its polluted waters into the Akagera River which flows into Lake Victoria. This wetland has a high water pollution rating.

2.5.20 Nyabugogo-Kabuye

Some rice cultivation occurs within this wetland (230 ha) The central channel is lined with trees and there are some roads and structures within the wetland boundary. This wetland has a medium-high water pollution rating.

2.5.21 Nyabuhoro

This wetland (4 ha) lies in a narrow valley and is divided into three patches. The northern patch abuts Lake Muhazi and includes some *Cyperus papyrus* vegetation and much cultivation (egg plant and sweet potato). The middle patch is mostly cultivated with a few trees. The southern patch is also mostly cultivated with a few trees. This wetland has a low-medium water pollution rating.

2.5.22 Nyabuhoro-Kiruhura

This wetland (27 ha) is mostly under cultivation and is drained by a central stream that flows into the Nyabarongo Aval wetland and then into the Nyabarongo River. Major crops are sugar cane, tomato and banana. There are a few buildings within the wetland boundary and two roads cross the wetland. Some brick-making occurs within the wetland. This wetland has a low-medium water pollution rating.

2.5.23 Nyacyonga-Mulindi

Most of this wetland (39 ha) is under cultivation. A stream flows down the centre of the wetland and there are groves of trees and a plantation of fruit trees. Some buildings occur within the wetland. This wetland has a medium water pollution rating.

2.5.24 Nyacyonge-Rubilizi-Nyacyonga

This wetland (17 ha) is almost entirely under cultivation and is crossed by two roads. Crops include egg plant, banana, pumpkin and maize. This wetland has a low-medium water pollution rating.

2.5.25 Nyagasozi-Kigozi

This wetland (19 ha) has a central stream that flows into Lake Muhazi. Most of the wetland is under cultivation and there is a road that crosses the wetland. Few people live around the wetland. This wetland has a low-medium water pollution rating.

2.5.26 Rubilizi

Most of this wetland (92 ha) is under cultivation. The northern end of the wetland is lined with dense urban settlements and two small roads and one main road cross the wetland. The central area of the wetland has a wide cultivated buffer that lines the wetland boundary. Some of the wetland is pasture and the southern end is drained by a small stream that flows into the Nyabarongo Aval wetland. This wetland has a medium water pollution rating.

2.5.27 Rufigiza–Akagogo

There are two main arms to this wetland (142 ha) and a discontinuous patch to northwest. The northern arm is bifurcated at the end. The northern bifurcation has a central drain and most of the area is under cultivation. The southern bifurcation is also under cultivation (rice, taro, cassava, sweet potato and egg plant). A road crosses the wetland just to the west of where the bifurcations join. The rest of the northern arm and the entire southern arm is under cultivation. The discontinuous patch to the northwest is entirely under cultivation. Sand and clay are excavated from the wetland and there is a brick factory. This wetland has a medium water pollution rating.

2.5.28 Rufigiza–Nyagisenyi

There are many arms to the Rufigiza-Nyagisenyi Wetland (323 ha). Almost all of this wetland is cultivated and drained but there are some areas of pasture. Crops include sweet potato, maize, taro, tomato, egg plant and cassava. Some of the arms extend into densely-settled urban areas. One arm has a wide buffer zone of cultivation. An area of the wetland has been impacted by clay extraction. This wetland has a medium-high water pollution rating.

2.5.29 Rugende-Isumo

The Rugende-Isumo Wetland (281 ha) has a number of arms. The northern arm that is orientated east-west is entirely cultivated with a buffer zone of cultivation outside the wetland boundary. A main road marks the end of this arm and on either side of the road as it crosses the wetland are buildings within the wetland boundary. On the other side of the road the wetland turns south and this arm is intensively cultivated with drainage channels. Two roads cross the wetland. Another eastern arm joins the wetland and this is divided into two. Both these arms are cultivated and both have a buffer zone of cultivation outside the wetland boundary. The southern end of this wetland is covered in a *Cyperus papyrus* vegetation. This wetland has been identified as a suitable for RAMSAR site designation. There is a clay brick factory adjacent to the wetland. This wetland has a medium water pollution rating.

2.5.30 Rugenge

This wetland has an area of 140 ha. Except for a small area at the southern end of Rugenge where there is a playing field and some cultivation (cassava, banana), the wetland is almost completely covered with an industrial site. There is some green space where this wetland abuts on Rwampara Wetland. This wetland includes the area known as Gikondo. The functions of the Rugenge Wetland had been compromised by the development of an industrial site that covered most of the wetland area. The impact was further exacerbated by drainage of the wetland. The industrial park infrastructure covered between 25-33% of the Gikondo Valley Wetland (KIEM, 2006a) and a further area is occupied by lighter infrastructure and a university.

This wetland has high water pollution. Water samples collected from the Gikondo Valley Wetland indicated that pollutants were at levels such that the water is no longer suitable for human and animal consumption. BOD levels indicated high levels of organic matter and microbiological analysis further confirmed that the water was unfit for human consumption (KIEM, 2006b). Soil tests indicated high levels iron, zinc and chromium. REMA (2009) showed that factories in the CoK deposited approximately 0.12 mg L⁻¹ of metals in the tributaries of the Nyabarongo River. The Gikondo industrial park valley is being relocated to the Kigali Special Economic Zone (SEZ) and other suitable special purpose areas in the City.

2.5.31 Ruhosha-Ayabaraya

This wetland (49 ha) is dominated by *Cyperus papyrus*. There is low to medium water pollution and there is pig farm within the area.

2.5.32 Rwabashamana

This wetland (195 ha) comprises two areas: one linear area and one that is 'Y-shaped'. The linear area (to the West) is under cultivation with some pasture. The 'Y-shaped' area has a mix of cultivation, pasture, some trees and degraded areas. There is a large area of rice cultivation. Other crops include banana, egg plant and sugar cane. There are several areas showing clay extraction and there are several clay brick factories. This wetland has a medium-high water pollution rating.

2.5.33 Rwampara

This wetland has an area of 289 ha. The southern end of this wetland is surrounded by a large area of green space. Further north there is a reservoir and part of a golf course (with a water hazard) lies within the wetland boundary. Cultivation fills most of the wetland beyond the golf course but there are significant areas of industrial activity. The wetland is heavily polluted through disposal of untreated wastewater, industrial pollutants from sources such as Utexrwa textiles, industries along KG15 Road (timber yard, petroleum depot) and several car garages. The environment is further impacted by burning tyres, the presence of main roads in the wetland and agricultural activities. Crops include banana, taro, sweet potato and maize.

Given the large area of undeveloped land that surrounds this wetland, this area should be protected as an urban green space and is a site that should be considered for significant ecological rehabilitation and restoration. Within the green space an area could be set aside to develop a botanical garden. This area would also lend itself to the development of hiking and biking trails. Glory High School and La Colombiere School fall within the wetland boundary. There is a soccer field and a recreational area that are drained by a channel that runs to one side of the wetland. This wetland has a medium-high water pollution rating.

2.5.34 Rwamugeni

This wetland has an area of 5 ha. The eastern end of Rwamugeni Wetland is intensively cultivated (maize, banana, taro and sugar cane). There is an area of open water before the wetland turns north. This northern arm is also cultivated but has groves of fruit trees particularly at the northern extremity of the wetland area. This wetland has a medium water pollution rating.

2.5.35 Rwezagoro

Rwezangoro Wetland (24 ha) has a mix of cultivation, areas with *Cyperus papyrus* vegetation and open water. Intense urban development surrounds this wetland and industrial activity is occurring within the wetland boundary. The wetland has a medium water pollution rating.

2.5.36 Rwintare

This wetland (79 ha) is dominated by a *Cyperus papyrus* vegetation. Significant cultivation occurs outside the entire wetland boundary. The human population density surrounding the wetland is low. There is a clay brick factory in the wetland. This wetland has a medium water pollution rating.

2.5.37 Yanze

This wetland has an area of 57 ha and is split into three patches. The northern patch has a clear central drainage channel and is under intense cultivation. An arm at the southern end of this patch is also cultivated but has some tree cover. The middle patch has a meandering stream flowing through it and most of the area is under cultivation. The same stream flows through the southern patch and this area is also under cultivation. The human population density surrounding Yanze Wetland is low. This wetland has a medium water pollution rating.

3 Thematic Studies

3.1 Hydrology

Wetlands are vital hydrological control systems. Reducing the impact of floodwaters and providing baseline flows during periods of dry weather. This function is impaired by drainage or cultivation of wetlands. Wetland hydrology and the water quality that drains into them are inextricably linked with the management that occurs within the catchment areas in which they lie.

The hydrological study used water balance models to describe the hydrology of each wetland. These models are based on a water balance equation: the sum of precipitation, runoff and groundwater discharge (inputs) are equal in magnitude to the sum of evapotranspiration, surface outflow, and groundwater recharge (outputs), plus or minus a change in groundwater and surface water storage (Figure 6 and Figure 7).

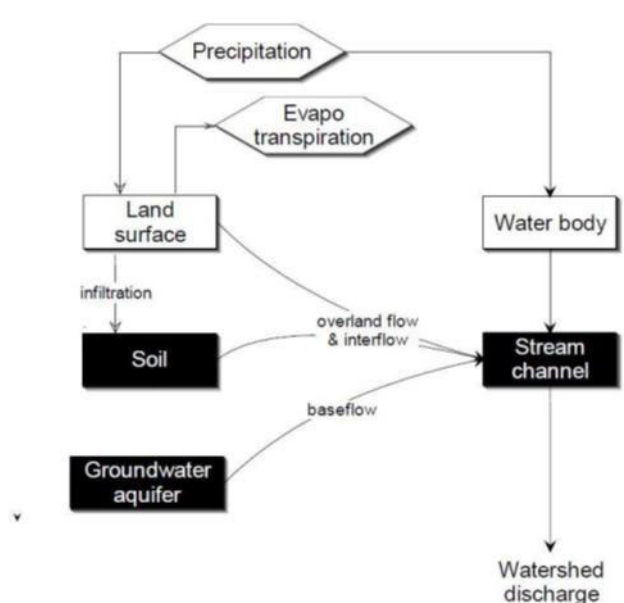


Figure 6: Typical HEC-HMS watershed runoff representation (Feldman, 2000)

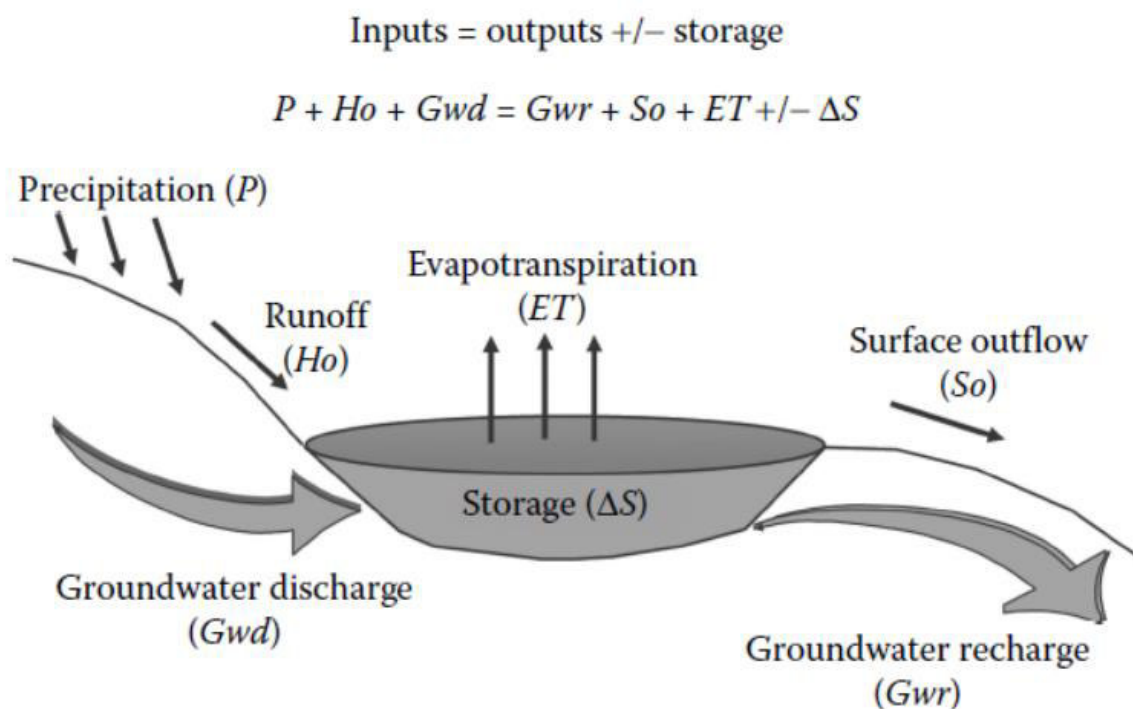


Figure 7: Water balance components of a wetland

One of the strongest controls on the water balance of a wetland is topography. Runoff is strongly controlled by topographic factors including slope gradient, slope length and contributing areas. Other soil conditions being equal (e.g., texture, moisture content and vegetative cover), for a specific point on a slope: (1) Runoff volumes and flow rates will be greater on slopes with higher gradients (gradient influences the speed of runoff and the rate at which runoff infiltrates the soil); (2) The greater the runoff volumes will be, the longer the slope above a specific point; and (3) The larger the catchment area contributing water to a specific point on the slope, the greater the volume of runoff (Figure 8).

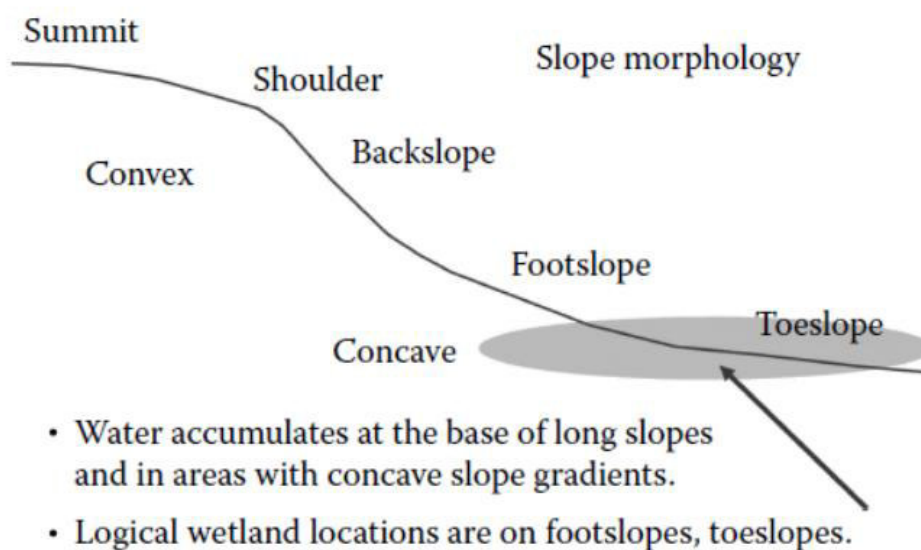


Figure 8: Hillslope profile section

It was found that the 2-year return period rainfall decreased from 2.41 mm h^{-1} to 1.86 mm h^{-1} , the 5-year rainfall from 2.97 mm h^{-1} to 2.74 mm h^{-1} , the 10-year rainfall intensity from 3.4 mm h^{-1} to 3.31 mm h^{-1} whereas the 25-yr ARI rainfall intensity increased from 3.94 mm h^{-1} to 4.04 mm h^{-1} , the 50-year ARI rainfall intensity from 4.34 mm h^{-1} to 4.39 mm h^{-1} and the 100-year return period rainfall intensity increased from 4.73 mm h^{-1} to 5.12 mm h^{-1} . This new intensity figures have been fed into the HEC-HMS event rainfall runoff model and it was found that the average increase in 10-year, 25-year, 50-year and 100-year flood were computed to be 2.6%, 12.2%, 16.5% and 20.5% on average respectively whereas the 2-year and 5-year floods decrease by about 57.3% and 14.6% respectively.

From the analysis on land-use change and related rainfall-flood modelling, it could be concluded that Kamusenye, Rugenge, Rwampara, Degi-Nyarufunzo, Nyabuhoro-Kiruhura, Rubilizi, Nyacyonga-Mulindi, Mulindi-Kanombe, Kiradiha, Kitaguzirwa, Rwintare, Kanyetabi, Ruhosha-Ayabaraya, Rwabashamana and Nyabarongo Aval Wetlands are highly flood prone.

3.1.1 Climate in the City of Kigali

The rainfall station at Kigali Airport is representative of the 37 of the wetland catchments and hence selected for further analysis (Figure 9). The monthly rainfall varies from zero to a maximum of 317 mm recorded in April 1985. The mean monthly rainfall amounts to 83.5 mm with a standard deviation of 58.7 mm.

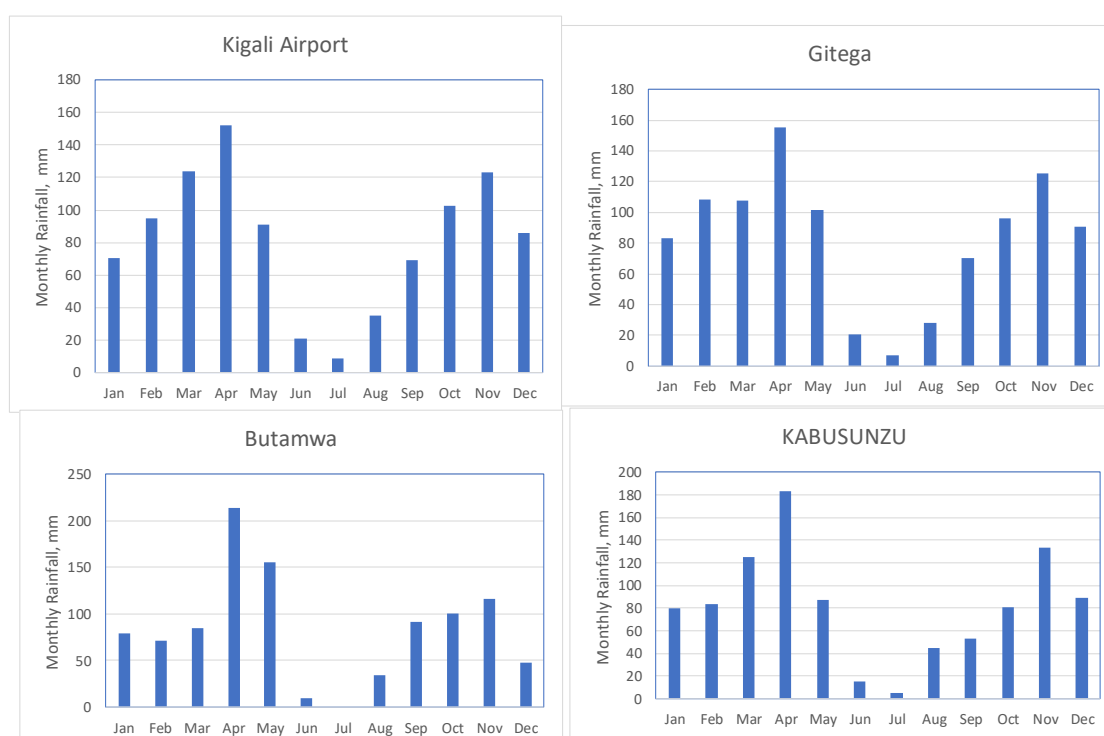


Figure 9: Monthly rainfall at key rainfall stations

The mean annual rainfall is 980 mm (1966 to 2018) with a standard deviation of 162 mm. The minimum annual rainfall was recorded in 1992 with value of 683 mm whereas the maximum annual rainfall rises to 1387 mm recorded in 2013 (Figure 10).

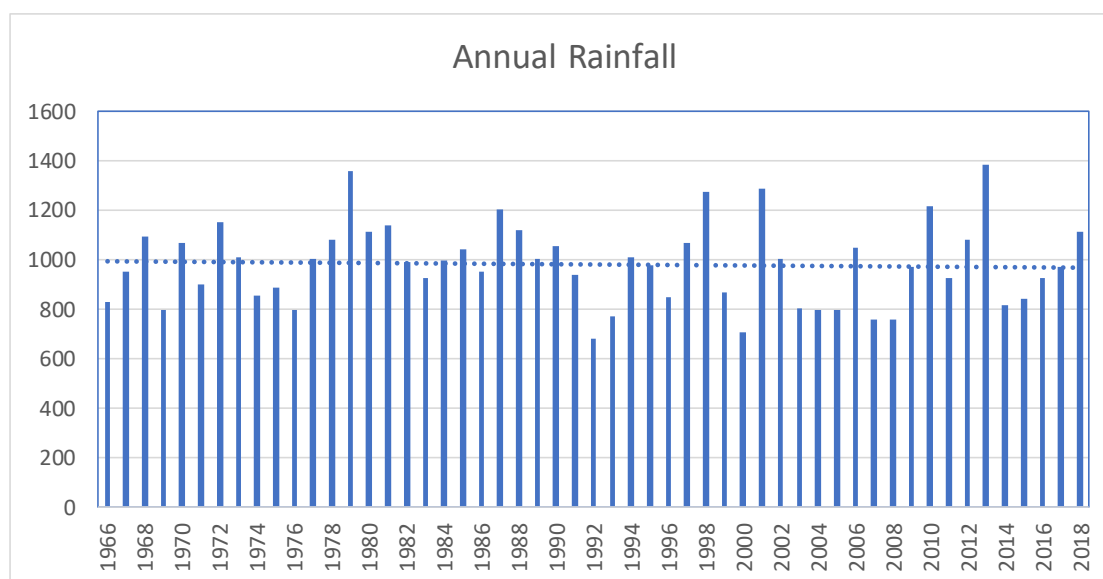


Figure 10: Annual rainfall at Kigali Airport (mm)

Monthly variation of maximum temperature and minimum temperature is shown in Figure 11.

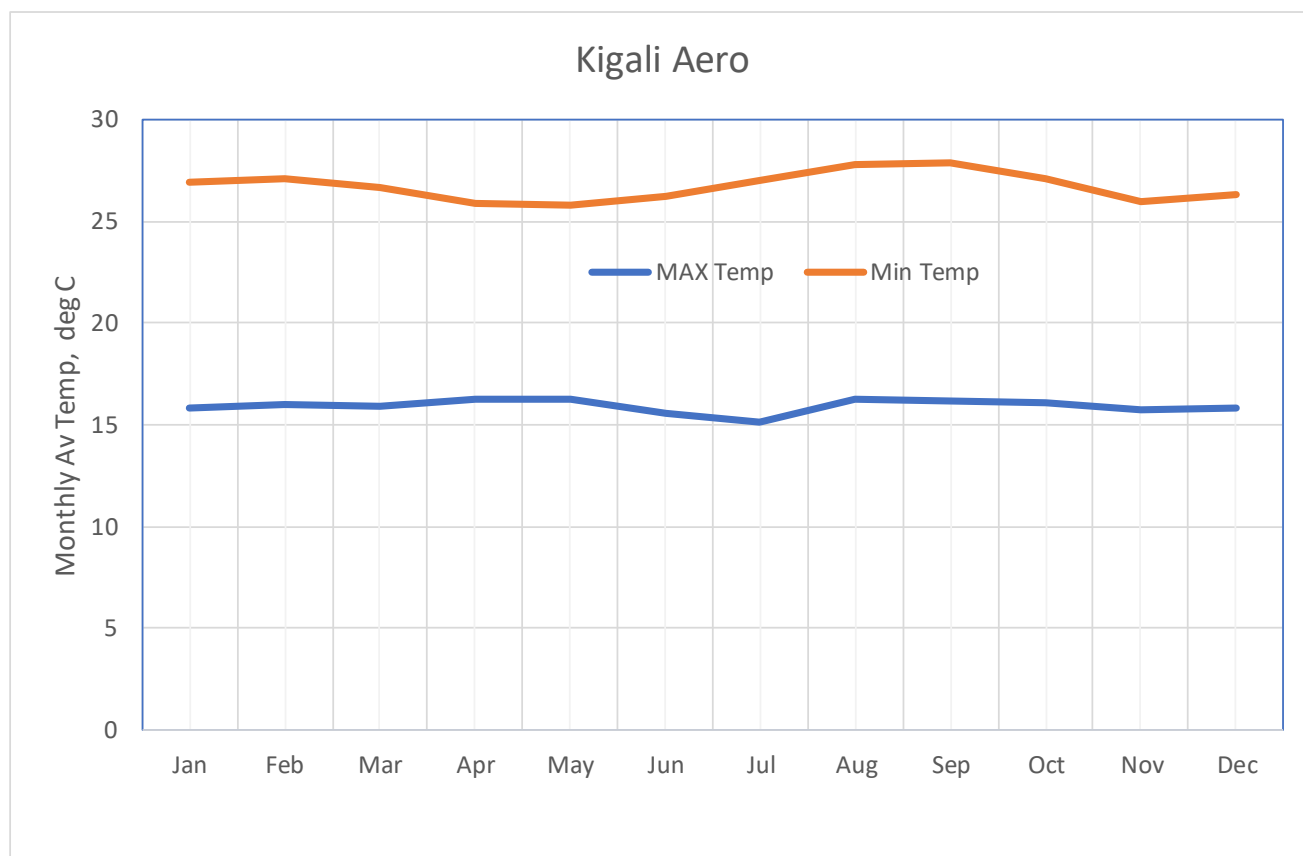


Figure 11: Monthly maximum and minimum temperature (°C)

The daily pan evaporation data were aggregated into monthly data and found to vary from a minimum of 88 mm in May to a maximum of 144 mm in August (Figure 12).

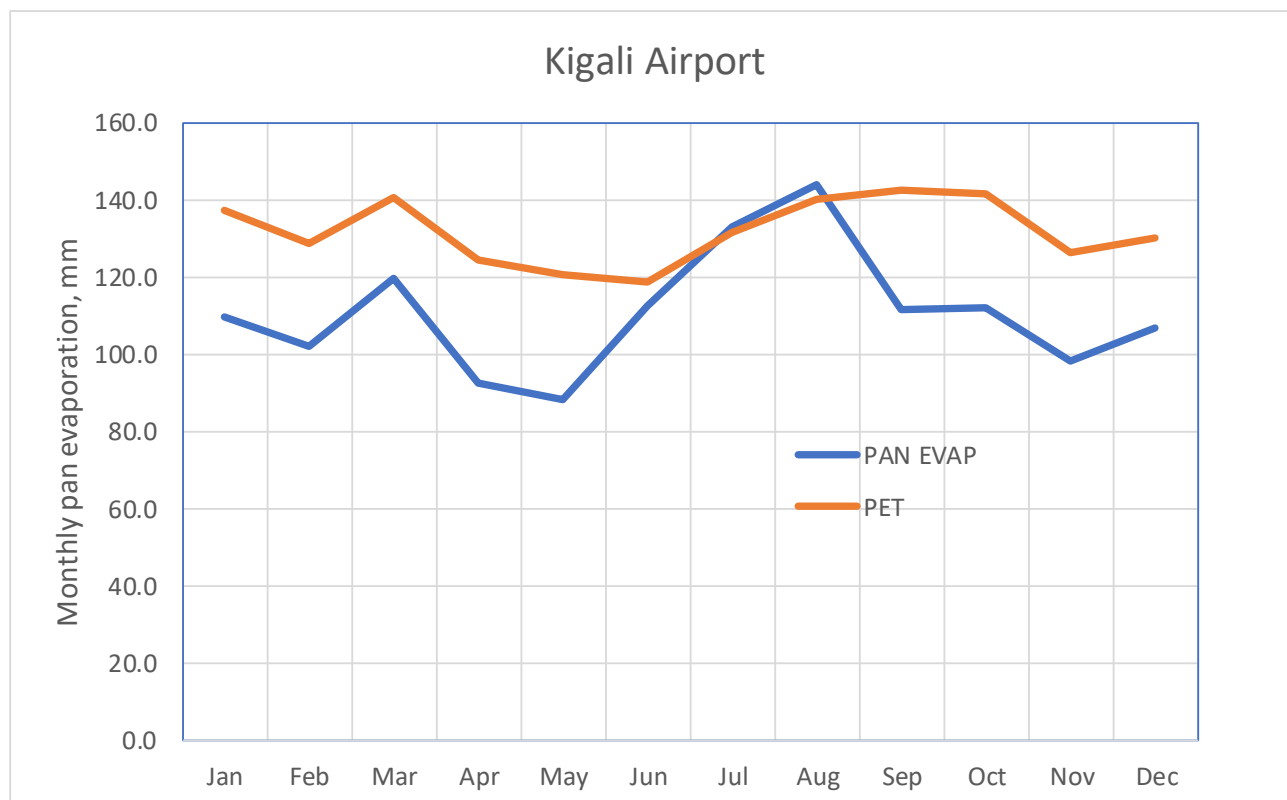


Figure 12: Monthly variation of pan evaporation and PET (mm)

3.1.2 The Catchments

The catchment areas of each of the 37 wetlands in the CoK were delineated and a short description of the hydrological landscape provided. Figure 13 provides the example of Rwampara Wetland. This wetland drains a catchment area of 34.7 km² and drains to the Nyabugogo River. The land-use is mainly agricultural. However, 20% more area of the land may be developed and hence it may become flood prone. FRu is the dominant soil type. The soil is a loam to sandy clay composed of 25% sand, 15% silt and 60% clay. The wetland is 7.9 km long with an estimated longitudinal slope of 12.3 m km⁻¹. The relief of the catchment is characterised by plain to rolling terrain.

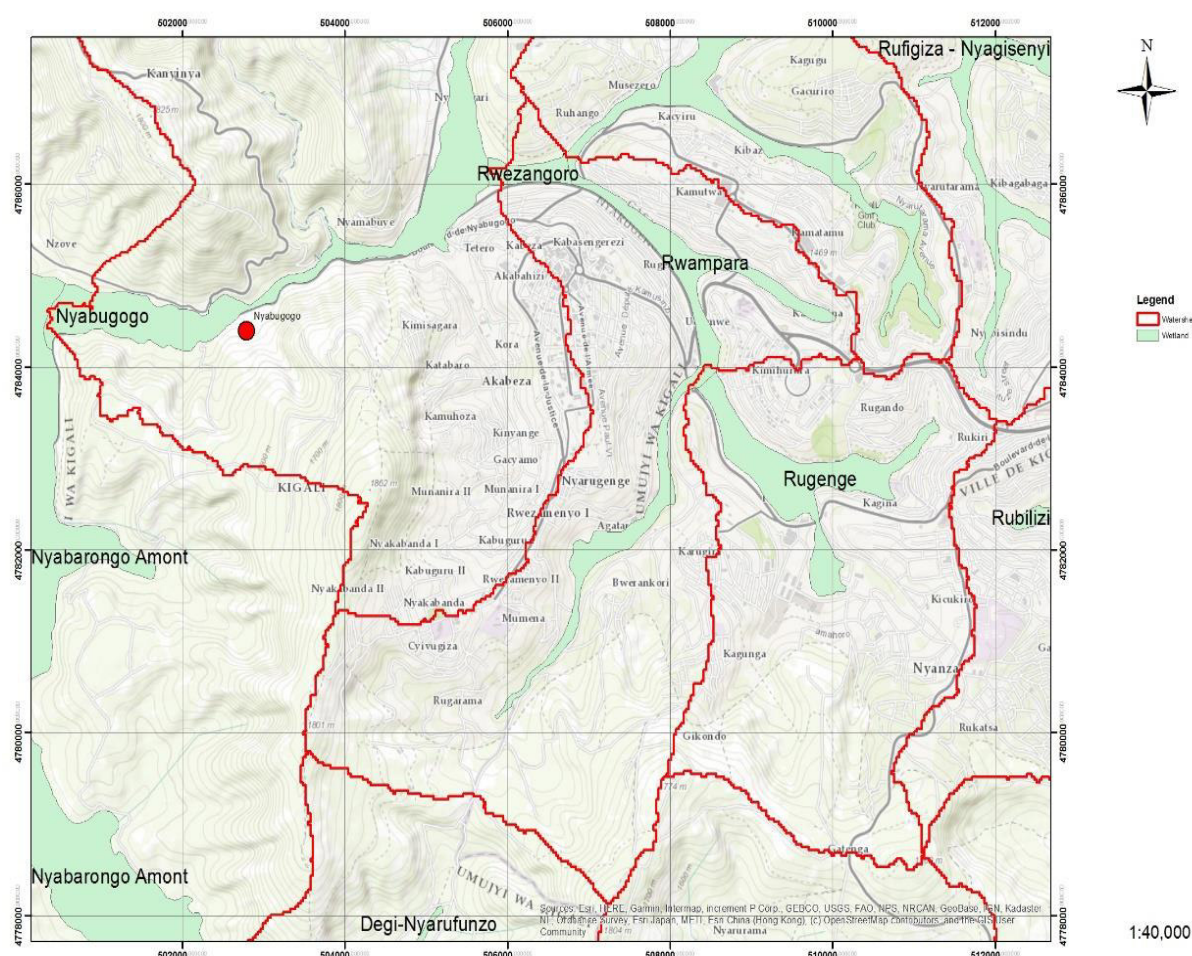


Figure 13: Rwampara Wetland catchment area

3.1.3 Geology and Groundwater

The lithology of Nyabugogo is dominated by quartzite and schist/shale basement aquifers with other lithology classes including shale, granite, pegmatite and alluvial material in valley bottoms. Aquifers associated with quartzite and schist have average storage and transmission properties, hence groundwater recharge rates, baseflow and recession behaviour are expected to exhibit average values.

The most extensive soil types, located within the eastern upstream section of the catchment, are ferralsols. These are derived from deeply weathered siliceous rocks and thus have low fertility, are acidic and have increased aluminium toxicity. These ferralsols are generally deep, easy to work and less erodible than deeply weathered soils. On steep slopes in the north-western uplands, complexes of nitisol, acrisol, alisol and lixisol are found; as well as large patches of cambisols. The cambisols are moderately deep and more fertile than ferralsols since they possess a higher cation exchange capacity (CEC). Being located on steep slopes, however, they are susceptible to erosion. Clay soils, of moderate fertility and low infiltration capacity, are located along valley bottoms and associated with floodplains and wetland areas.

The wetlands serve as a source of recharge area for the aquifers. Over pumping of groundwater will definitely affect the water depths in the wetlands.

3.1.4 Wetland Hydrology

The hydrological models used calculated the annual net inflows ($\text{m}^3 \text{s}^{-1}$, MCM) and the water depth and seasonal inflows for each wetland and, as an example, results for Rwampara Wetland are presented in Figure 14 and Figure 15.

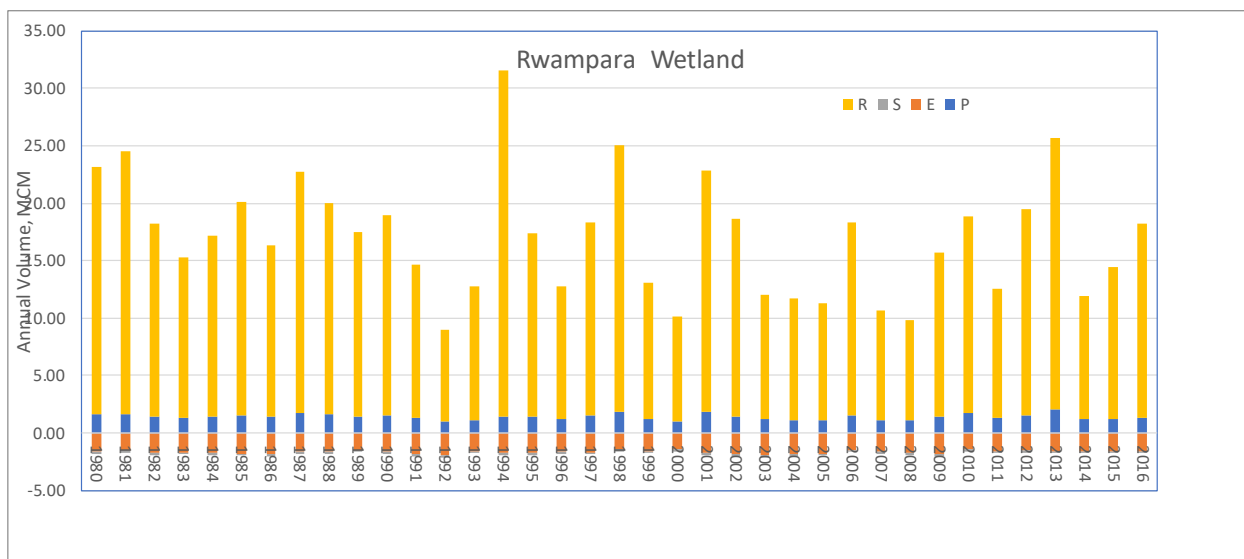


Figure 14: Rwampara Wetland annual net inflows (MCM)

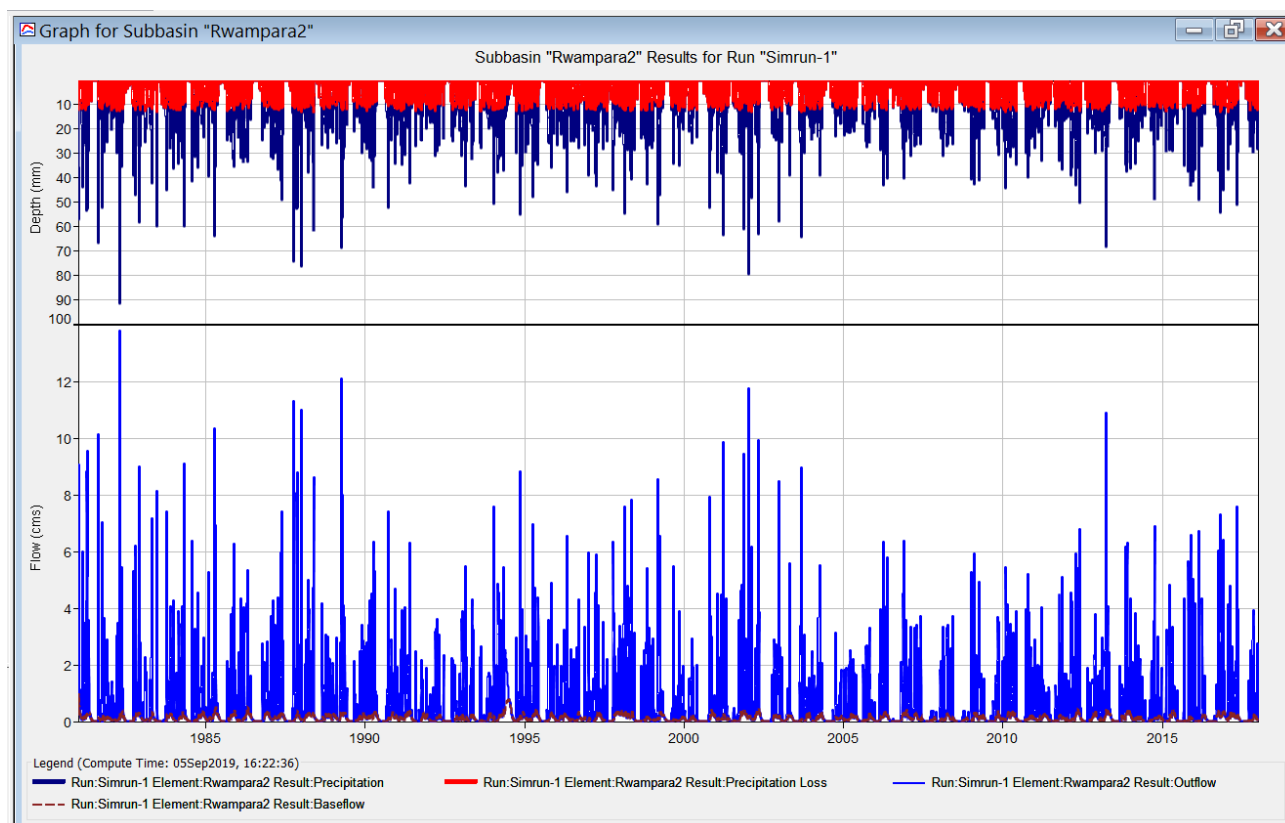


Figure 15: Rwampara-2 Wetland watershed outflow ($\text{m}^3 \text{s}^{-1}$)

3.1.5 Land-use Change Scenarios

The land-use projection map (Figure 16) shows that the percentage of residential and industrial areas will increase in the future. Hence, the percentage of paved areas or impervious areas will increase in the watersheds of the some of the wetlands.

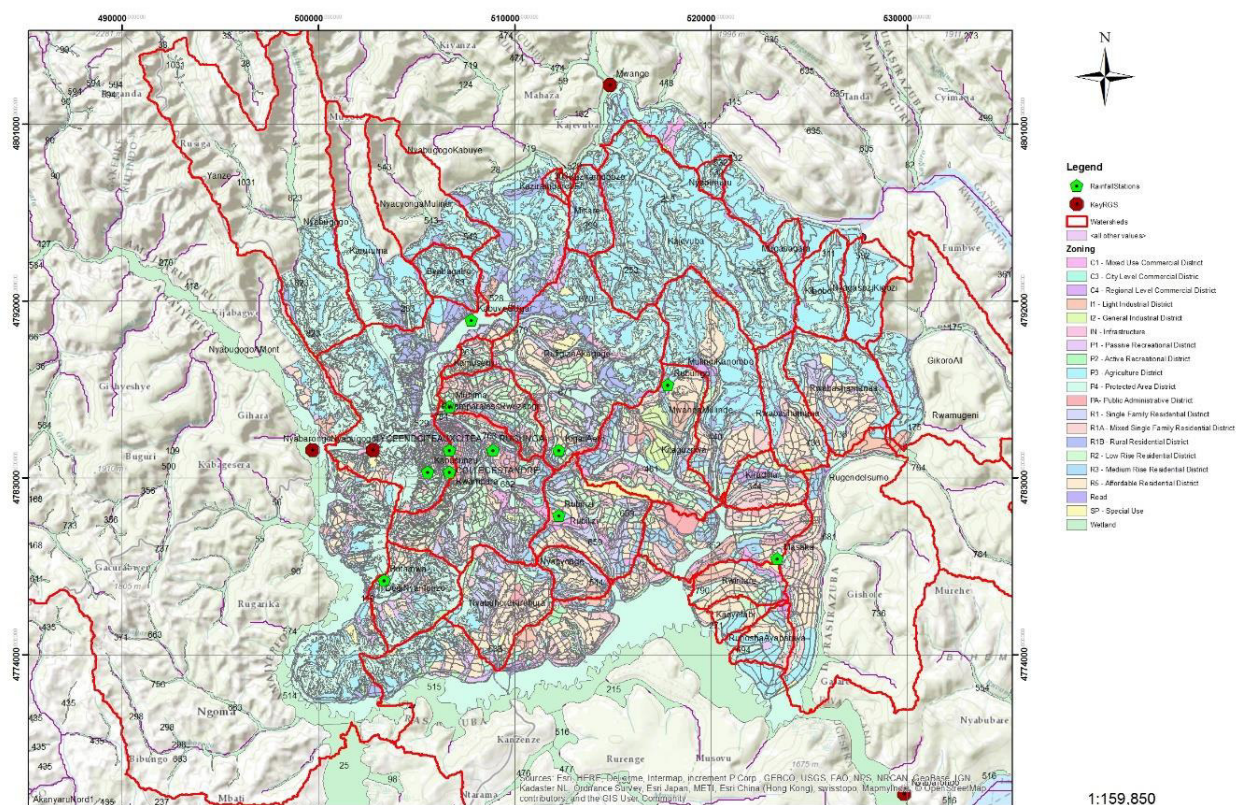


Figure 16: Future LU and LC of Kigali city

The changes in impervious area percentage will be significant for Misare, Rwampara, Rugenge, Degi-Nyarufunzo, Nyabuhoro-Kiruhura, Rubilizi, Rwabashamana, Nyacyonge-Rubilizi-Nyacyonga, Mwanana-Mulindi-Kanombe, Kiradiha, Kanyetabi, Rwintare, Kitaguzirwa and Kamusenyei catchment areas. The hydrological modelling shows that there will be changes in peak floods generated in those watersheds subject to land-use change. The 2-year, 5-year, 10-year, 25-year, 50-year and 100-year return period peak flow generated increase as high as 28.3%, 26.75%, 25.25%, 23.9%, 22.5% and 21.3% times respectively on average as a function of the extent of impervious area introduced.

From the analysis on land-use change and related rainfall-flood modelling, it could be concluded that Kamusenyei, Rugenge, Rwampara, Degi-Nyarufunzo, Nyabuhoro-Kiruhura, Rubilizi, Nyacyonga, Mulindi-Kanombe, Kiradiha, Kitaguzirwa, Rwintare, Kanyetabi, Ruhosha-Ayabaraya, Rwabashamana, Nyabarongo Aval wetlands are highly flood prone.

3.1.6 Climate Change Scenarios

The time series (1966 to 2018) of rainfall, minimum temperature and maximum temperature at Kigali meteorological station are plotted in Figure 17, Figure 18 and Figure 19. The data show an increment of the extreme events with higher peaks of precipitation during the wet season and with long periods of drought. Maximum temperature data do not reveal particular differences throughout the period although minimum temperature data show a decreasing trend.

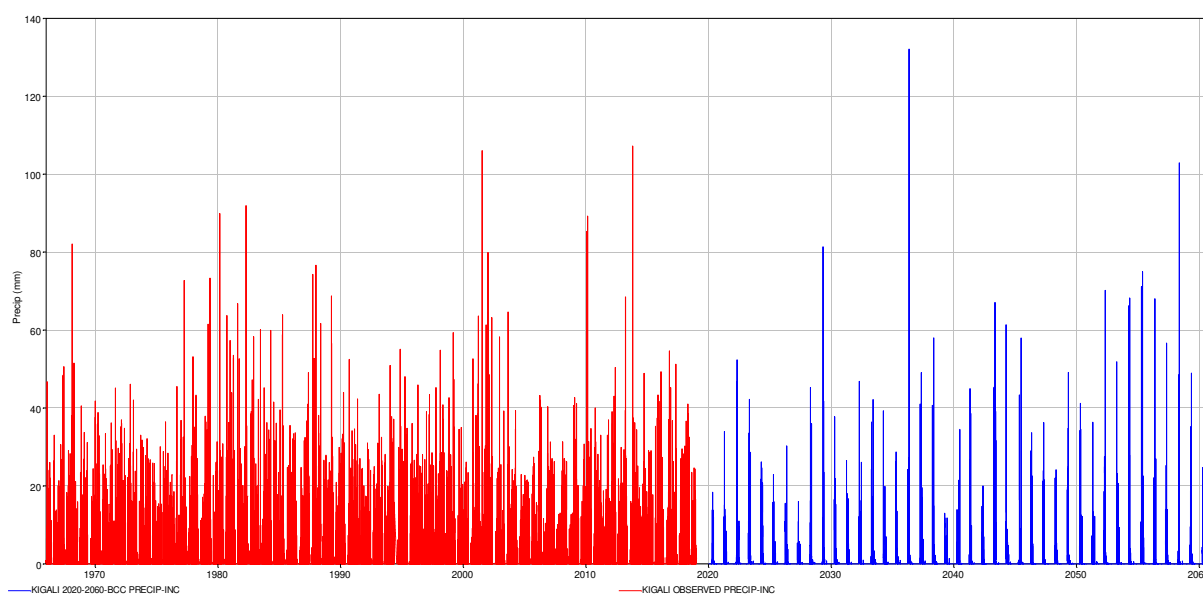


Figure 17: Daily Rainfall forecast under climate change

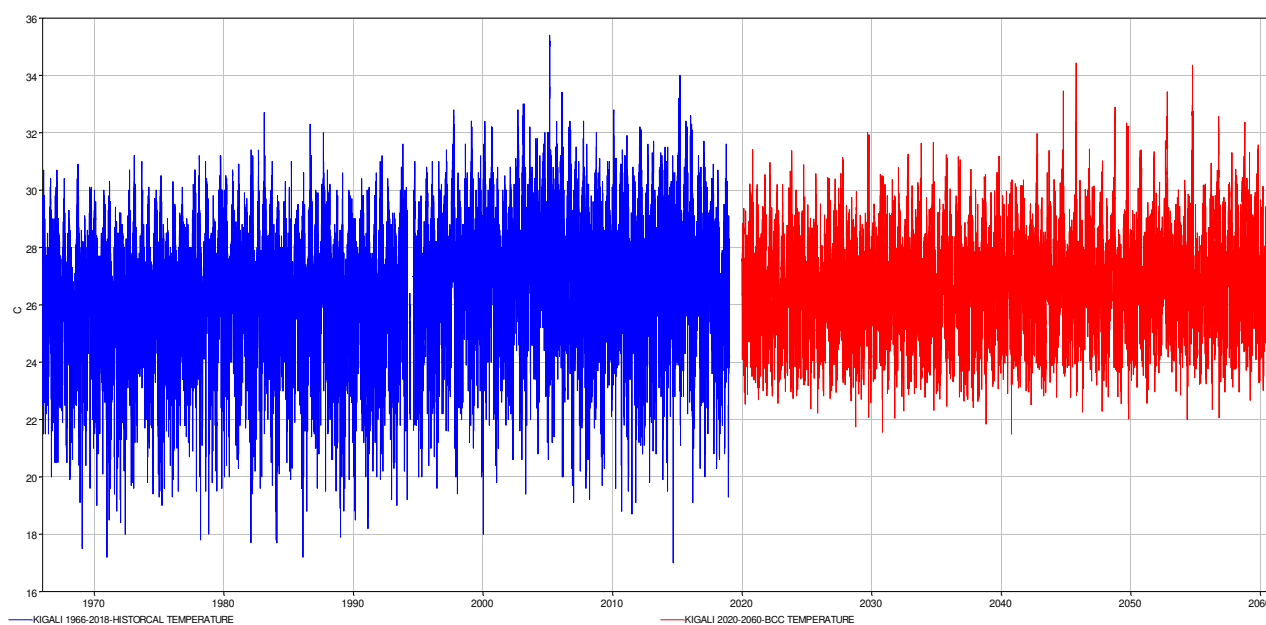


Figure 18: Daily Maximum Temperature forecast under climate change

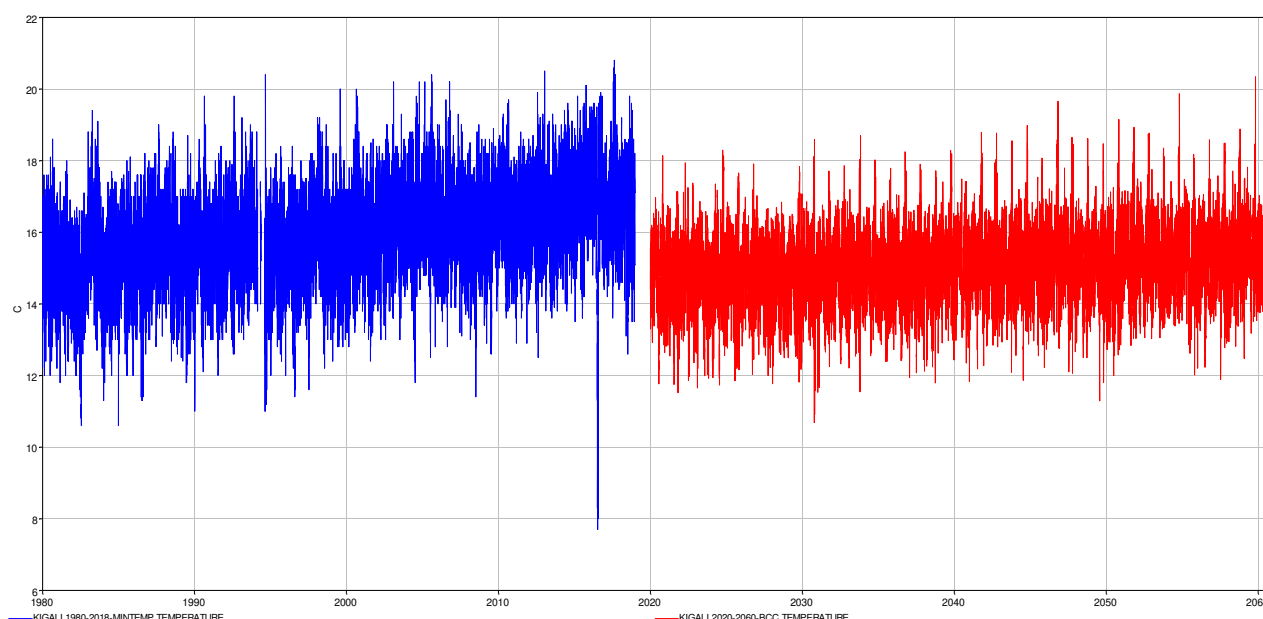


Figure 19: Daily Minimum Temperature forecast under climate change

3.1.7 Wetland Hydrology Issues

The major wetland hydrology issues are the quantity of water delivered to wetlands and the retention of the water within the wetlands. Many of the wetlands in the CoK have been drained for agriculture and this has served to reduce the water retention times. Rehabilitation efforts will focus on plugging drains that will slow down the movement of water through the wetland. Longer water retention times will increase the chance of flooding and some wetlands are probably already flood-prone. Therefore, rehabilitation efforts should also seek to reduce flood events by creating water detention basins within those wetlands likely to cause damage from high water levels or high flow rates.

3.2 Water Quality

The CoK faces environmental challenges including land degradation, deforestation, dependence on biomass to provide cooking fuel, soil erosion and siltation of rivers and wetlands, water pollution, air pollution, degraded forests and wetlands, and inadequate solid waste and wastewater management strategies. Urbanization and subsistence farming extending into naturally vegetated and forested areas has led to deforestation, biodiversity loss and topsoil erosion. The loss of soil has significant hydrological and water quality impacts on downstream rivers and wetlands.

The following methodology was used for the water pollution and water quality assessment: (1) Identification of the Kigali Wetlands and their boundaries; (2) Gathering secondary data and information on water quality, sanitation practices, pollution sources from industry and mines, domestic sewage, solid waste dumps, irrigation and agriculture including livestock grazing, stormwater drainage, siltation; (3) conducting a water pollution field survey at all 37 wetlands in the CoK; and (4) comparison of collected water quality results against relevant Rwanda national water quality guidelines.

3.2.1 Water Quality Status

Based on the field survey and water pollution checklists a pollution rating was calculated (Figure 20).

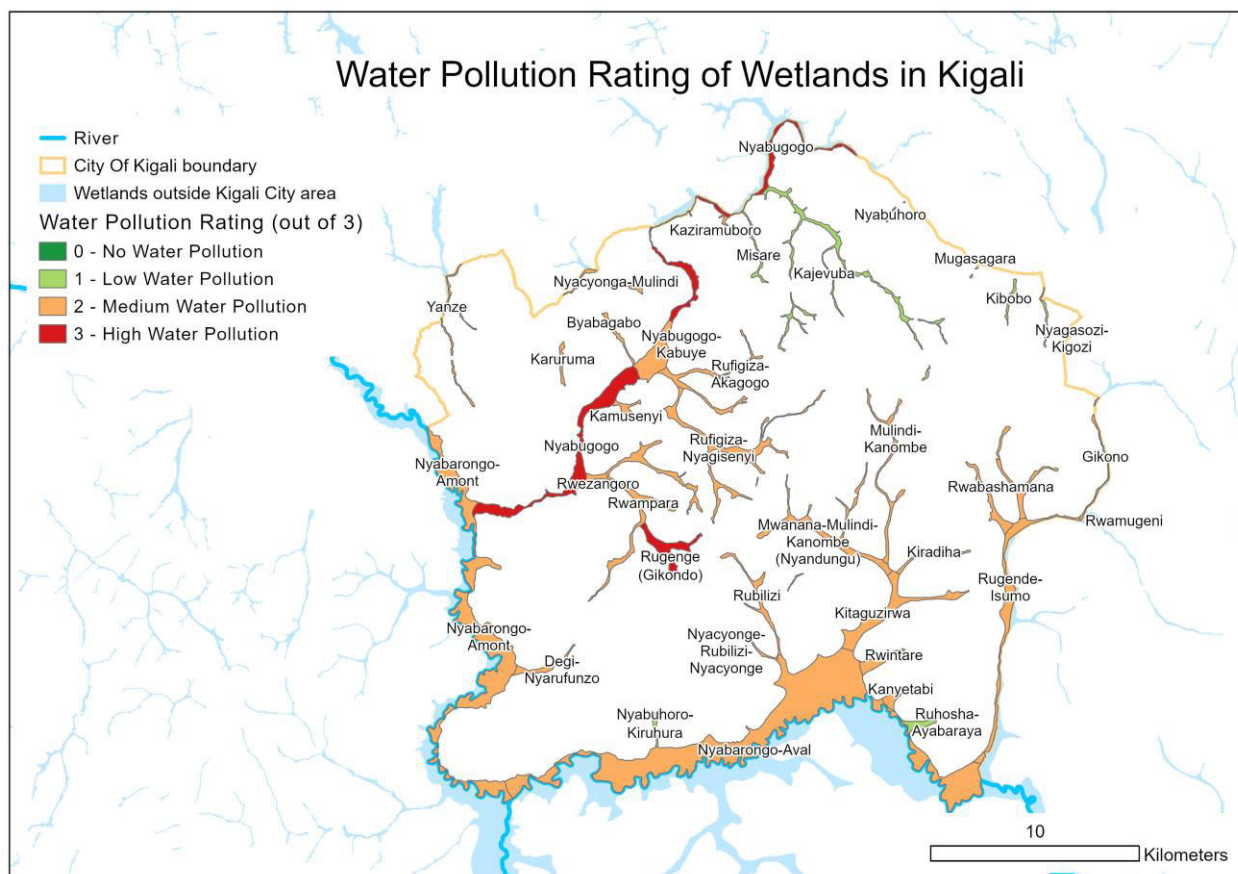


Figure 20: Map showing water pollution rating of wetlands in the City of Kigali

From the pollution survey, non-point sources for all 37 wetlands are: (1) Agriculture and irrigation; (2) domestic wastewater from settlements; and (3) stormwater and erosion. The main point sources of pollution were: (1) industries and commercial operations with a discrete waste pipe; (2) mines; (3) power plants; and (4) sewage treatment plants (Figure 21).

3.2.2 Pollution and Water Quality Issues

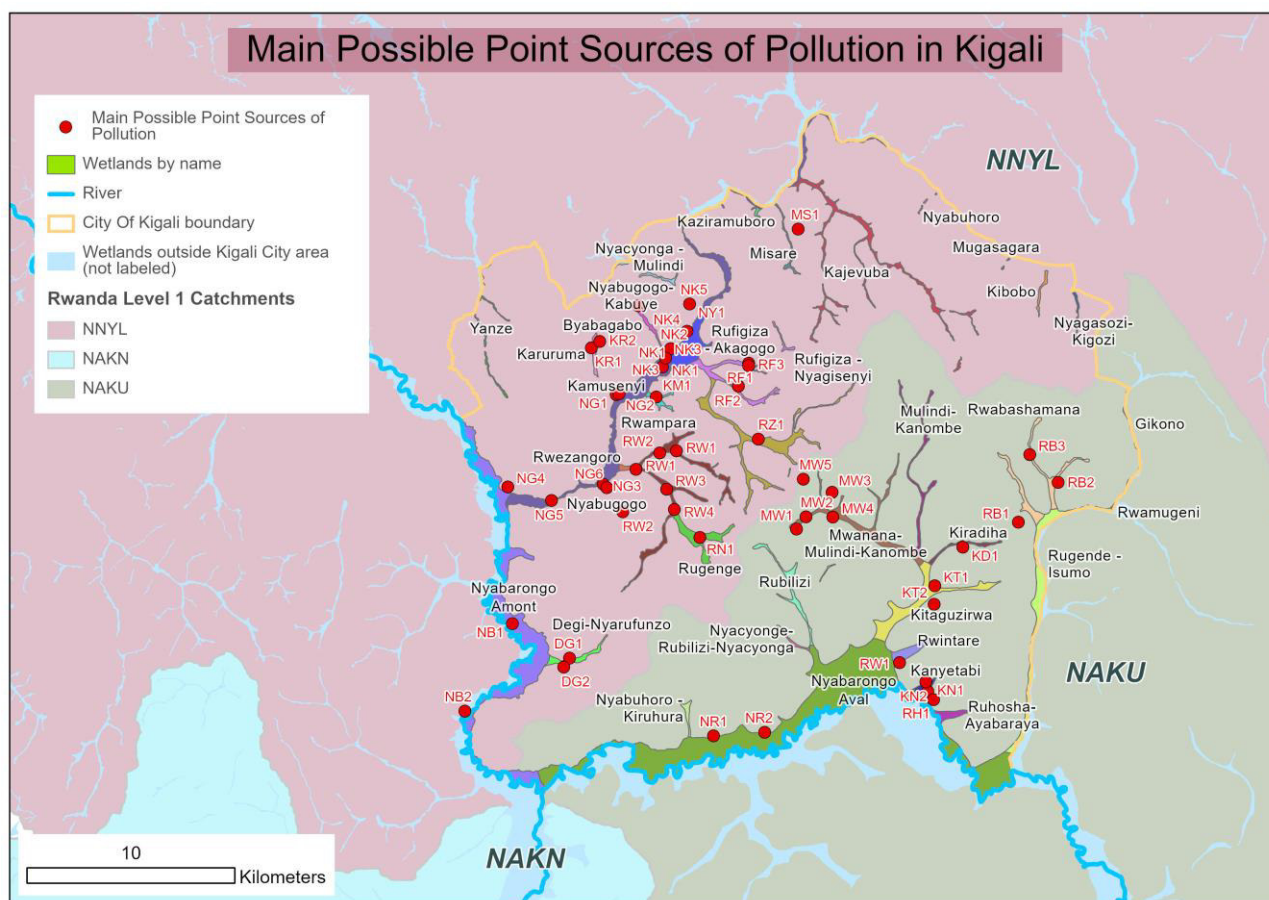


Figure 21: Main possible point sources of pollution in Kigali

Five wetlands in the CoK with the highest levels of pollution were identified as critically polluted: (1) Rugenge (Gikondo); (2) Nyabugogo; (3) Nyabarongo Aval; (4) Nyabugogo-Kabuye; and (5) Rwampara. Mwanana-Mulindi-Kanombe (Nyandungu) Wetland was regarded to be heavily polluted.

3.3 Wetland Ecology

Wetland plants require water and this may be present permanently or seasonally. Wetlands are characterised as having a water table that is close to or above the soil surface for most of the time. Wetland soils are often anoxic and wetland plants are adapted to low-oxygen sediments. Wetlands are ecotones, occurring between truly aquatic ecosystems and truly terrestrial ecosystems.

The communities of plants and animals that are found in a wetland are largely determined by the duration and depth of flooding. The most diverse wetland systems are those that are found where there is variation in the hydrological conditions that exist within the system. These conditions are determined by the topography of the wetland (i.e. water depth variations) and whether water is present permanently, seasonally or intermittently. Most of the wetland areas in the CoK have been significantly disturbed to the point that they no longer have the biological characteristics of what is regarded as a wetland ecosystem.

This wetland ecology study was carried out to collect the following ecological information: (1) Vegetation associations and their roles as shelters for different species; (2) Habitat utilization by wetland animals for feeding and breeding; (3) Identification, distributions and conservation status of wetland fauna groups: birds, reptiles, amphibians, mammals and macro-invertebrates; and (4) Fauna utilizing agro-ecosystems within wetlands. The wetland survey produced species lists found in different wetlands and habitats.

3.3.1 Flora and Fauna

The wetland vegetation found depended on how much human disturbance has occurred within the wetland. Wetlands (e.g. Nyandungu (part of Gikono Wetland), Inyange, Rubiba, Kajevuba, Rubilizi and Gahanga) that have some

natural areas have vegetation dominated by *Polygonum senegalense*, *Cyperus papyrus*, *Cyperus latifolius* and *Typha domingensis*.

Amphibians are indicators of ecological health as most species require access to clean water to lay their eggs and for the tadpoles to hatch and also require terrestrial habitat for their adult lives. Fourteen species of anuran in six families were recorded in wetlands in the CoK. Nineteen amphibian species and 9 species of reptiles were recorded in the CoK wetlands.

The ornithological survey recorded 163 birds (82 species) in the wetlands surveyed in the CoK. Species diversity was high at Nyandungu Wetland with 15.9% of the total birds recorded followed by Bumbogo, Gikondo Carlos and Kimihurura-Nyabugogo–Gitikinyoni Wetlands with 10.4%. Rwampara and Rugende-Kabuga Wetlands had the lowest bird count, respectively with just 6.7% and 5.5% respectively of all the birds recorded.

Mammals play a vital role in ecosystems as herbivores, predators and prey. They provide ecological services as seed dispersers. Few mammals were observed alive, but their presence was inferred from faecal pellets and spoor.

One hundred and ten invertebrate species belonging to 39 families were recorded from fourteen wetlands.

3.3.2 Species of Conservation Significance

The following plant species are exploited from wetlands: *Cyperus papyrus*, *Cyperus latifolius* and *Vossia cuspidata* (roofing material); *Cyperus papyrus* and *Cyperus latifolius* (making mats); and *Cyperus denudatus* (making rope).

Two important wetlands, Nyandungu and Bumbogo, are colonized by an endangered bird species, the grey-crowned crane, *Balearica regulorum*, while the wetland from Inyange factory towards Kiradiha and Kitaguzirwa Wetlands and onto the Nyabarongo River harbours a globally threatened species, *Laniarius mufumbiri* (papyrus gonolek), which appeared on the CITES protected list.

The Nile crocodile (*Crocodylus niloticus*) is internationally protected by CITES.

3.3.3 Exotic and Invasive Species

Exotic weeds such as *Lantana camara* (native to the American tropics), *Mimosa pudica*, *M. pigra* (natives to South America), *Centella asiatica* (Asiatic pennywort) and *Eichhornia crassipes* (native to South America) are found in many of the wetlands and, in particular areas that have suffered from human disturbance.

Several fish species have been introduced to Rwanda and now occur in many wetlands: the African sharp-toothed catfish (*Clarias gariepinus*), the eel *Protopterus aethiopicus*, *Bagrus docmac* and *Schilbe intermedius*. *Clarias gariepinus* has impacted native fish species such as *Enteromius kerstenii* (redspot barb), *Clarias liocephalus* (smooth head catfish), *Mastacembelus frenatus* (East African spiny eel) and *Oreochromis macrochir* (long-finned tilapia).

These introduced fish species have quickly adapted to their new environment and have spread to many lakes, rivers and wetlands in the country. They have decimated native species by predation and through competition for feeding and breeding grounds. As a consequence, fishing yields have decreased and unfortunately it will be very difficult to reverse the situation.

3.3.4 Ecological Health Issues

Most of the wetlands in the CoK have been so effectively drained and converted to agriculture that they no longer support a diverse wetland flora or fauna. Therefore, the ecological health of these wetlands must be rated as poor. Furthermore, some wetland areas have been impacted by industrialization (e.g. Gikondo) or intensive rice, vegetable and sugar cane plantations.

Before a wetland can undergo ecological restoration, the cause of the degradation needs to be determined. This cause may extend into the wetland's catchment area. For restoration to succeed, any causes of degradation need to be addressed. Clear goals need to be established and this may require some investigation into the past ecological state of the wetland.

Many of the wetlands in the CoK, while having a different name, are intimately interconnected. Rugenge Wetland flows sequentially into Rwampara Wetland, Rwezangoro Wetland, Nyabugogo Wetland and Nyabarongo Amtong Wetland (Figure 22). Therefore, any activity in Rugenge Wetland could impact the four wetlands which lie downstream. This interconnectivity enables mobile wetland organisms to move through the landscape providing that the habitats are suitable.

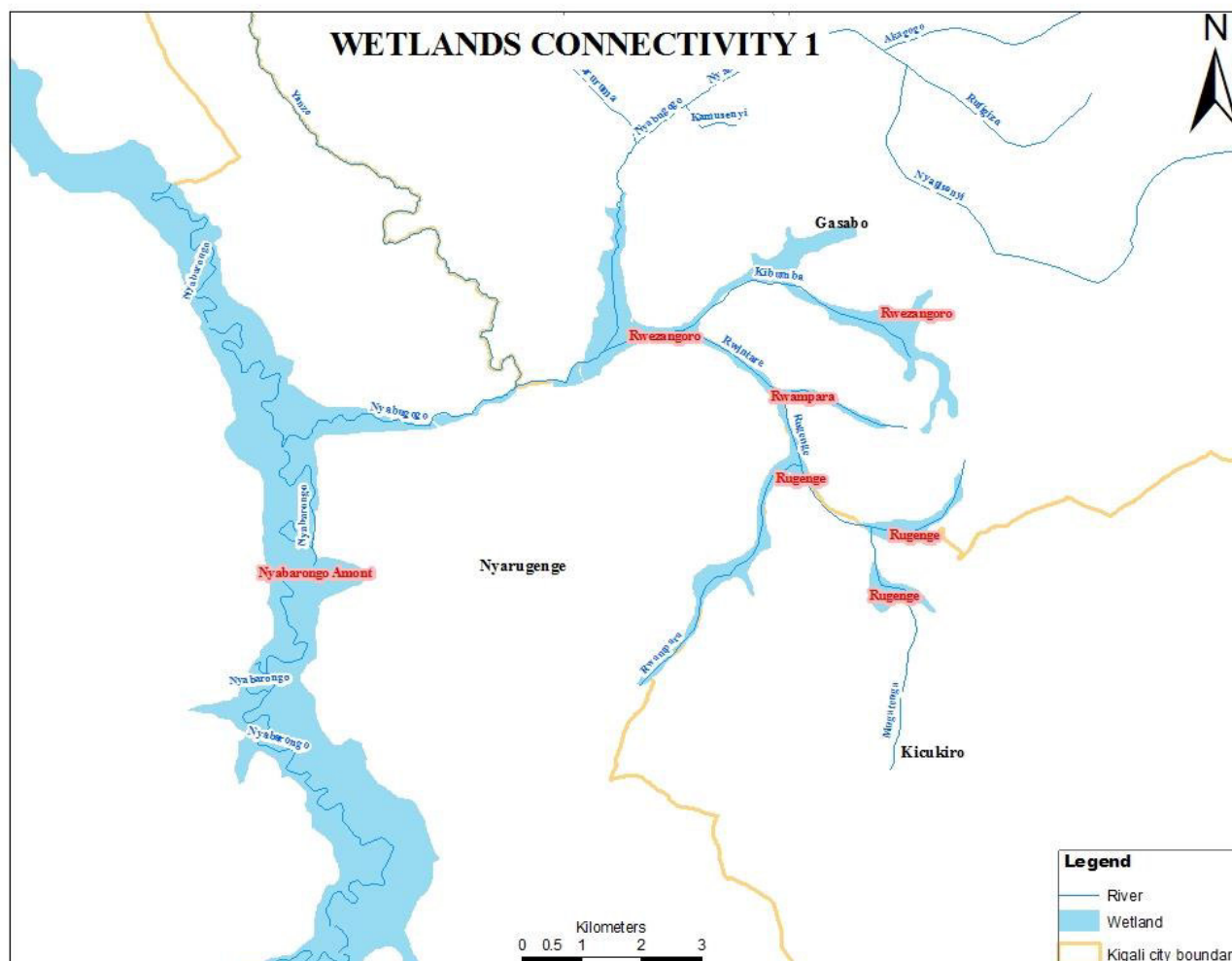


Figure 22: Interconnectivity between Rwampara-Rwezangoro-Nyabugogo to Nyabarongo Amont Wetlands

3.4 GIS Mapping, Land-Use and Urban Planning

3.4.1 Wetland Mapping

From the Ministry of Environment, a shape file with the current status of wetlands in Rwanda was received (SwamLayer_PMO_2016V_FINAL.shp) which was clipped to the extent of the Province of City of Kigali as provided by Surbana Jurong. A ground-truthing exercise was undertaken to check images produced by the drone survey.

Field data collection was performed to identify current land-use within the wetlands: at regular distances around the wetlands the status and photographs were recorded. 280 locations were selected (Figure 23) and each site visited. Data collection was done with Survey123 for ArcGIS which allows to collect coordinates, record information and take photographs. Data collected are shown in Table 7.

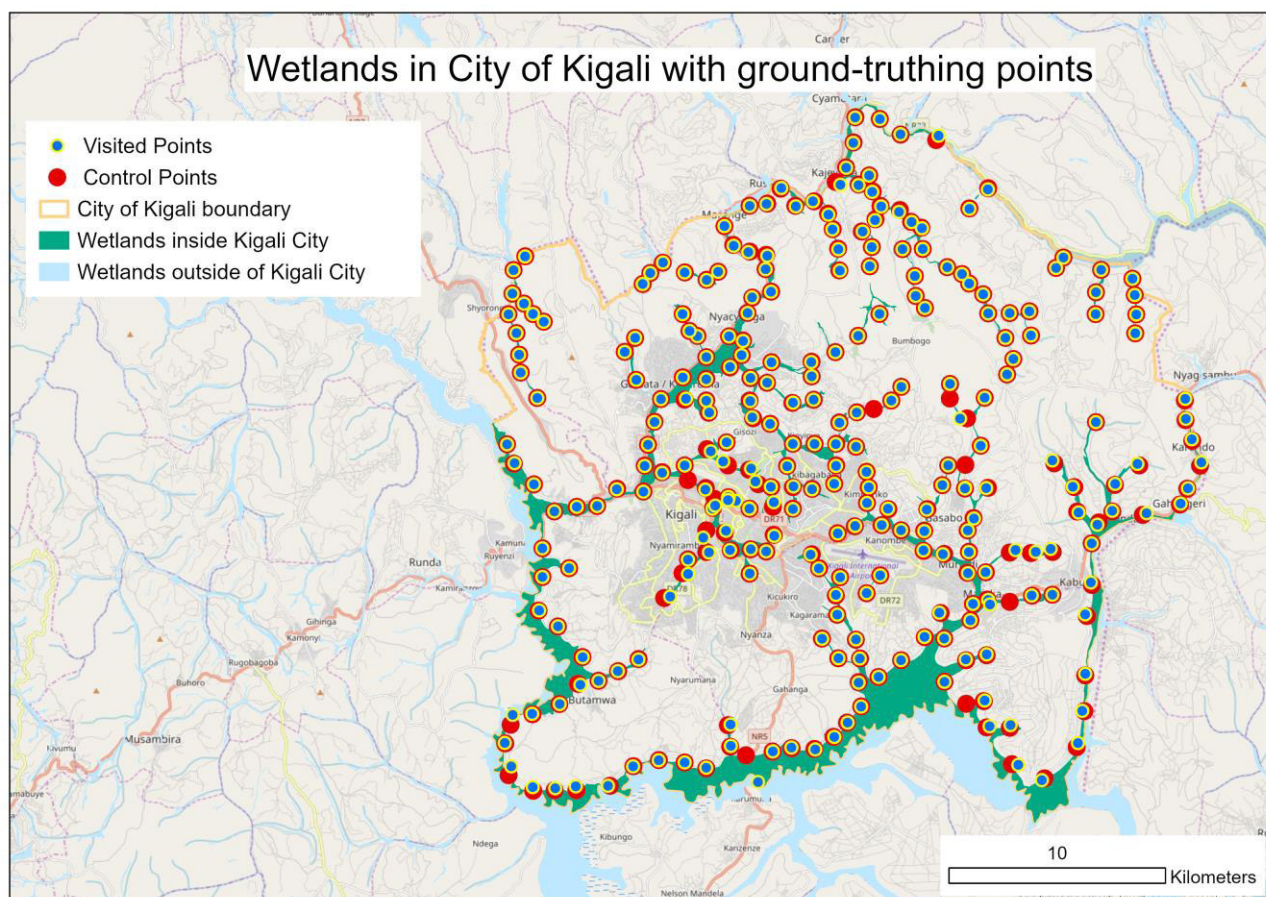


Figure 23: Wetlands with ground truthing points

Table 7: Crops, livestock and vegetation observed at field data collection points within each wetland in the City of Kigali

WETLAND	CROPS OBSERVED	LIVESTOCK	LANDUSE
Byabagabo	Banana, Cassava, Sugar Cane, Sweet Potatoes		Forest, Settlement, Agriculture, Commercial
Degi-Nyarufunzo	Banana, Maize, Vegetables	Cattle, Goat	Forest, Lakes, Marshland, Agriculture, Natural vegetation, Livestock
Gikono	Banana, Cassava, Maize, Rice, Sweet Potatoes, Vegetables, Yams	Cattle	Marshland, Agriculture, Livestock
Kajevuba	Banana, Cassava, Irish Potatoes, Maize, Sorghum, Sugar Cane, Sweet Potatoes, Tomatoes, Vegetables, Yams	Fish	Forest, Lakes, Marshland, Agriculture, Commercial, Livestock
Kamusenyi	Cassava, Maize, Sweet Potatoes, Vegetables		Marshland, Settlement, Agriculture
Kanyetabi	Banana, Cassava, Vegetables		Marshland, Agriculture
Karuruma	Banana, Cassava, Maize, Rice, Sweet Potatoes, Vegetables		Industry, Settlement, Agriculture, Natural vegetation

WETLAND	CROPS OBSERVED	LIVESTOCK	LANDUSE
Kaziramuboro	Maize, Sweet Potatoes		Forest, Agriculture
Kibobo	Banana, Rice		Lakes, Agriculture
Kiradiha	Banana, Maize, Sorghum, Vegetables	Cattle	Marshland, Settlement, Agriculture, Livestock
Kitaguzirwa	Banana, Cassava, Maize, Sugar Cane, Sweet Potatoes, Vegetables		Lakes, Marshland, Industry, Settlement, Agriculture, Natural vegetation
Misare	Banana, Maize, Sweet Potatoes, Vegetables	Goat, Cattle, Chicken, Sheep	Agriculture, Livestock
Mugasagara	Banana, Sugar Cane, Sweet Potatoes, Vegetables		Agriculture
Mulindi-Kanombe	Banana, Beans, Cassava, Maize, Sugar Cane, Sweet Potatoes, Tomatoes, Vegetables, Yams		Settlement, Agriculture, Natural vegetation
Mwanana-Mulindi-Kanombe (Nyandungu)	Banana, Cassava, Fruit, Macadamia, Maize, Sugar Cane, Sweet Potatoes, Vegetables, Yams	Cattle, Rabbit, Chicken, Fish	Marshland, Settlement, Agriculture, Natural vegetation, Commercial, Residential, Livestock
Nyabarongo-Amont	Banana, Cassava, Sorghum, Sugar Cane, Sweet Potatoes, Vegetables, Yams	Cattle	Forest, Lakes, Marshland, Settlement, Agriculture, Natural vegetation, Livestock
Nyabarongo-Aval	Banana, Cassava, Sugar Cane, Sweet Potatoes, Vegetables		Forest, Lakes, Marshland, Agriculture, Natural vegetation
Nyabugogo	Banana, Cassava, Horticulture, Irish Potatoes, Maize, Rice, Sorghum, Sugar Cane, Sweet Potatoes, Vegetables, Yams	Cattle, Goat	Forest, Lakes, Marshland, Industry, Settlement, Agriculture, Natural vegetation, Residential, Livestock
Nyabugogo-Kabuye	Banana, Cassava, Maize, Rice, Sweet Potatoes, Tomatoes, Vegetables	Cattle	Marshland, Agriculture, Livestock
Nyabuhoro	Banana, Maize, Sugar Cane, Sweet Potatoes, Vegetables		Lakes, Agriculture
Nyabuhoro Kiruhura	Banana, Sweet Potatoes, Tomatoes, Vegetables		Forest, Agriculture
Nyacyonga-Mulindi	Banana, Maize, Rice, Sorghum, Sugar Cane, Sweet Potatoes, Tomatoes, Vegetables	Cattle	Marshland, Settlement, Agriculture, Livestock
Nyacyonge-Rubilizi-Nyacyonge	Banana, Sugar Cane, Vegetables	Cattle, Goat	Settlement, Agriculture, Livestock

WETLAND	CROPS OBSERVED	LIVESTOCK	LANDUSE
Nyagasozi-Kigozi	Banana, Rice, Sorghum, Vegetables		Lakes, Agriculture
Rubilizi	Banana, Cassava, Maize, Sugar Cane, Sweet Potatoes, Vegetables	Cattle	Marshland, Settlement, Agriculture, Natural vegetation, Livestock
Rufigiza-Akagogo	Amaranth, Banana, Brinjal, Cassava, Taro, Horticulture, Irish Potatoes, Maize, Rice, Sorghum, Sweet Potatoes, Vegetables, Yams		Forest, Marshland, Settlement, Agriculture, Natural vegetation
Rufigiza-Nyagisenyi	Amaranth, Banana, Beans, Brinjal, Cassava, Taro, Fruit, Green Beans, Maize, Rice, Sorghum, Sugar Cane, Sweet Potatoes, Tomatoes, Vegetables, Yams	Cattle, Fish, Rabbits	Forest, Lakes, Marshland, Settlement, Agriculture, Natural vegetation, Residential, Livestock
Rugende-Isumo	Banana, Cassava, Maize, Rice, Sorghum, Sweet Potatoes, Vegetables	Pig	Marshland, Agriculture, Livestock
Rugenge (Gikondo)	Amaranth, Banana, Brinjal, Cassava, Taro, Horticulture, Maize, Vegetables, Yams		Forest, Constructed, Marshland, Industry, Settlement, Agriculture, Natural vegetation, Commercial, Residential
Ruhosha-Ayabaraya	Banana, Cassava, Sorghum, Sweet Potatoes, Vegetables		Forest, Marshland, Agriculture, Natural vegetation
Rwabashamana	Banana, Cassava, Maize, Sweet Potatoes, Vegetables	Pig	Marshland, Agriculture, Commercial, Livestock
Rwampara	Amaranth, Apple, Banana, Cassava, Taro, Horticulture, Irish Potatoes, Maize, Sorghum, Sugar Cane, Sweet Potatoes, Vegetables, Yams	Goat, Cattle, Chicken, Sheep	Forest, Constructed, Lakes, Marshland, Industry, Settlement, Agriculture, Natural vegetation, Commercial, Residential, Livestock
Rwamugeni			
Rwezangoro	Banana		Constructed, Agriculture
Rwintare	Sorghum, Sweet Potatoes		Forest, Marshland, Agriculture, Natural vegetation
Yanze	Banana, Cassava, Irish Potatoes, Maize, Sorghum, Sugar Cane, Sweet Potatoes, Vegetables, Yams		Forest, Marshland, Agriculture, Natural vegetation

3.4.2 Land-Use and Land Cover

Available imagery in ArcGIS, drone imagery and the collected images from the data collection were used to identify areas of land-use. The following categories were defined as broad land-use types: Agriculture, Nature Area, Industries, Water Bodies, Public Administrative, Institutional and Services, Residential, Commercial, Special Use, Open Space and Infrastructure (see examples in Figure 24 and Figure 25).

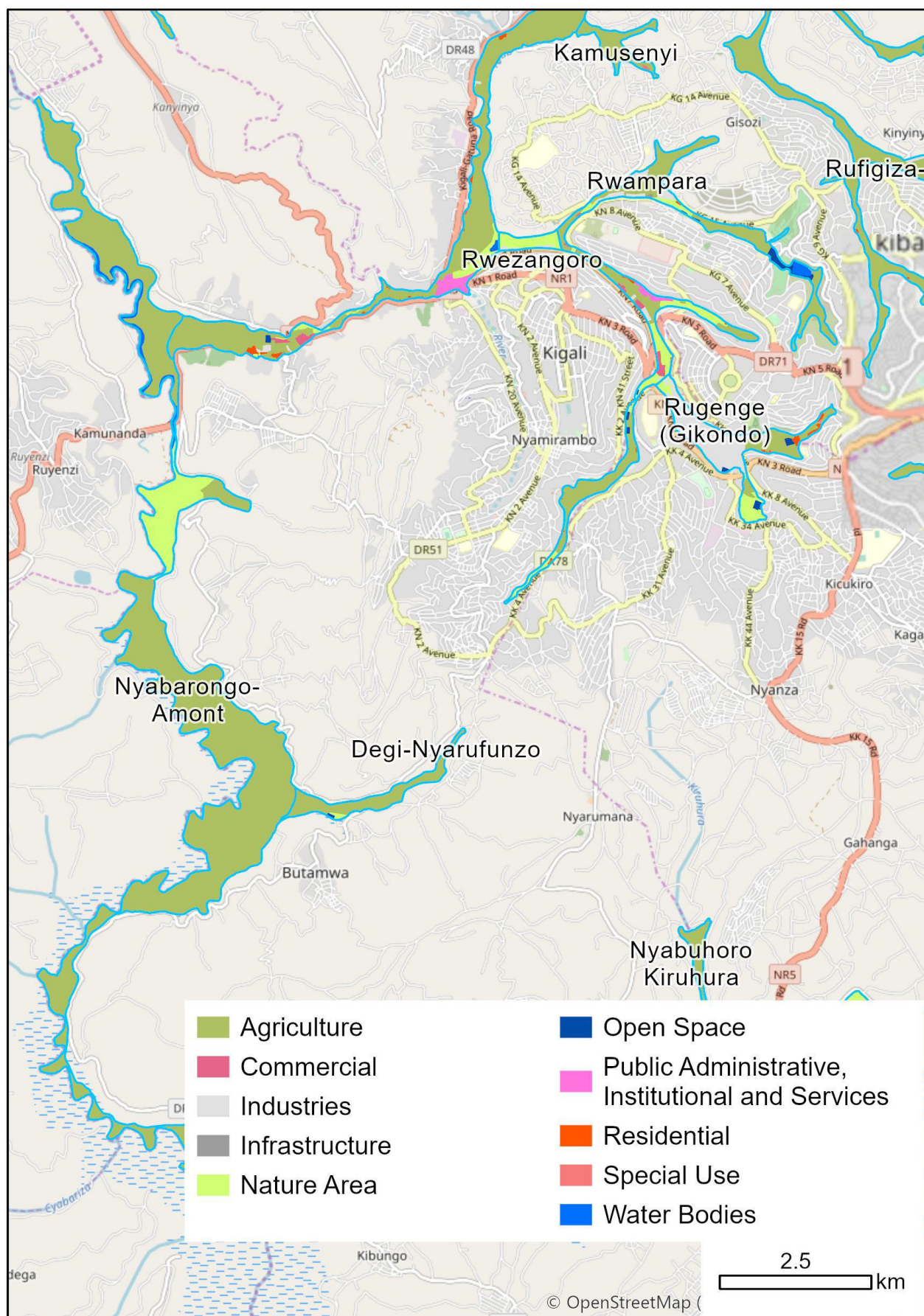


Figure 24: Land-use map of Nyabarongo Amont, Degi-Nyarufunzo, Rwezangoro, Rwampara and Rugenge (Gikondo) Wetlands

3.4.3 Wetlands in the City of Kigali Urban Master Plan

The Kigali 2050 Master Plan was drafted considering the upcoming “Kigali Urban Wetland Master Plan” and its implication on the overall planning strategy and wetlands’ integration within the City Plan. As per Kigali 2050 Master Plan (Zoning Report), all the wetlands in Kigali are zoned as “P4 – Protected Zone” while buffer areas are zoned, whenever possible, as “P1 – Passive Recreational”. Further classification of wetlands delineated as P4 Zone has been carried out as a part of the Wetland Master planning exercise.

The Kigali Master Plan recognises the sensitivity of urban wetlands from the point of view of the ecosystem services that it offers to the city. It also recognises the social and economic relevance of the wetlands for the CoK and the impact that each planning indication would have on the communities that currently depend on them for their livelihood. Therefore, it adopts a balanced approach to protect the wetlands based on their ecological sensitivity and to deploy them for sustainable use based on their potential and proximity to key urban nodes in an optic of Green Growth.

The proposed Vision Framework envisages wetlands as a key pillar of the ‘Green City’ goal. It is elaborated with proposed strategies and targets for its protection. Proposed strategies are: (1) Conservation and restoration of encroached wetlands and waterbodies; (2) Resettlement of settlements encroaching or endangering wetlands or those subject to flooding risk; (3) Reducing wetland informal and non-sustainable cultivation and mineral extraction; (4) Restoring natural drainage network; (5) Use wetlands for recreation activities; and (6) Promotion of green economy activities and jobs (sustainable farming, horticulture, fishing and clay extraction). Proposed targets are: (1) Zero net-loss of wetlands and waterbodies; (2) Maintain wetland area as 75 km² (10% of city area); and (3) 20 m mandatory buffer for wetlands (as per the Organic Law).

3.5 Socio-Economic Context

3.5.1 Survey and Consultations

The methodology used to conduct the socio-economic study was based on desk research and field research. The desk research reviewed existing policies, studies and programmes in relation to wetlands and people who live near wetlands. In the field research, a structured questionnaire was used to collect data from local farmers and interviews with wetland users and local authorities were carried out to develop questions used in Focus Group Discussions.

The key information collected during the field visits included: (1) Agricultural activities within wetlands: main crops, farming systems, land-use; (2) Fishing activities: main fishing systems and impacts on livelihoods; (3) Tourism activities; (4) Mining activities and impacts on livelihoods; (5) Settlements: type of habitat where wetland settlements occur; health and economic impact of residents in or near wetlands; and (6) Solid and liquid waste management: waste collection and treatment; threats and impacts on the life of residents.

3.5.2 Human Use of Wetlands

3.5.2.1 Agriculture and livestock

Agriculture in wetlands is principally based on food crop production and some cash crops like sugar cane and flowers. Fruit plants that grow in or around wetlands include papaya, watermelon, pineapple, mango, avocado, strawberry, lemon, orange and passion fruit. Watermelon, strawberry and pineapple are cultivated for sale in markets while the others are mostly cultivated for family consumption. Some wetlands are used to provide pasture for cattle and goats.

3.5.2.2 Water use and abstraction

The main source of drinking water is the public standpipe (50%), followed by a protected spring (15%) while a river and surface waters provide water to about 12%. Households members do not boil water before drinking. 40% of respondents are supposed to have access to clean water via public standpipe but this is not the case. Clean water is only available once a week or once in two weeks. Only a protected spring located in wetlands provides a continuous free supply of water. 20% of respondents stated that they use unclean water from rivers.

3.5.2.3 Tourism and recreation

The wetlands sampled are not subject to tourism or recreation activities. According to the views of respondents about their perception on whether the Government of Rwanda (GoR) decides to restrict their farming activities and give priority to tourism and recreation activities in wetlands, 73.5% of respondents said that they would be unhappy with the loss of plots as they are essential for their life even though most know that the land in the wetland is a public property.

3.5.2.4 Cultural use of wetlands

Almost of respondents (86.3%) said that they do not use the wetland for any cultural reasons. Only a few respondents said that they may be some who come to pray or use water for baptisms. Some respondents indicated that they use products such as vegetables harvested only from wetlands during family ceremonies like marriage, baptism or other family meetings.

3.5.3 Perceptions of Wetlands by Urban Residents

Users were asked if they had noticed changes in the wetlands and 68% of respondents indicated that the wetlands have changed, such as a decrease in size, changes in vegetation and an increase in water. Others noted changes in land-use, a decrease in water or an increase in people living around and using wetland.

3.5.4 Human Health and Wetlands

Respondents reported suffering from the following major diseases over the last 12 months: malaria, intestinal parasites and skin infections. Major health problems were caused by mosquitoes and unsanitary drinking water. Most respondents (96%) had paid health insurance.

3.5.5 Gender Aspects of Wetland Use

Agriculture is an important engine of growth and poverty reduction. In Rwanda, female and male farmers do not always face the same production conditions, nor do they always make the same production choices. They consequently do not always have identical levels of agricultural productivity.

The main drivers of gender-based differences in access to productive inputs were: (1) the age of the owner; (2) their education; (3) the total number of crops harvested; (3) spending on insecticides; (4) household size; (5) the dependency ratio (i.e. the relationship between those aged 0–15 and 65 and older to those aged 15–64); and (6) the sales of production (UNDP, undated).

In Rwanda, female-managed farms were 10.5% smaller than farms managed by men and female farm managers spent 25% less on fertilizers and insecticides than farms managed by males. Female-managed farms were thus more beneficial to the farm ecology with more positive gender-environment interactions, but this difference also affected farm production and income. Female-managed farms tended to use rented fields. A higher household size and a higher dependency ratio result in more unpaid care and domestic work, reducing the amount of female labour available to work on female-managed farms—and thus reducing the returns on production (UNDP, undated).

However, gender-based inequalities in access to and control of productive and financial resources inhibit agricultural productivity and reduce food security. For instance, women are required to undertake domestic tasks which are unpaid. As a consequence, domestic work limits a women's flexibility by reducing their labour availability for on-farm work. This has an impact on the cash and non-cash resources that women are able to generate. The gender gap in agricultural productivity exists and benefits result from closing the gap.

In Sub-Saharan Africa, the gender gap in agricultural productivity—measured by the value of agricultural produce per unit of cultivated land—ranges from 4 to 25%, depending on the country and the crop (UNDP, UNEP and the World Bank Group, 2015). The UNDP Rwanda Gender Equality Strategy (UNDP Rwanda, 2019) stated that the agricultural productivity gap in Rwanda is evaluated at 11.7 %. This means that, on average, a female-managed farm was 11.7% less productive than a male-managed farm in Rwanda due to differential access to and returns from productive and financial resources. This gap exists because women frequently lack adequate access to key agricultural inputs such as land, labour, knowledge, fertilizer and improved seeds.

Closing the gender gap in agricultural productivity between female- and male-managed farms in Rwanda could have resulted in a one-off increase of US\$418.6 million in gross domestic product (GDP). Closing the gap could also have lifted 2.1 million people out of poverty in 2013–2014 (UNDP, UNEP and the World Bank Group, 2015).

Resource use of wetlands has positive and negative impacts on women and families. First of all, structural barriers to economic freedom are multi-faceted, institutional, societal, political and legal policies and practices can all be responsible for the perpetuation of economic gender inequality. Several key factors must be considered when discussing structural barriers to the economic empowerment of women. First, women in Rwanda experience higher rates of unemployment (17.5%) than men (16.1%). Second, occupational segregation is prevalent in Rwanda, in which a higher proportion of women work in agriculture whereas more men work in industry and the service sectors. Women have a right to engage equitably in agriculture and other socio-economic activities and contribute effectively to attaining Sustainable Development Goals (SDG).

Women do gain some benefits from sustainable wetlands conservation. Resource users in Akanyaru Wetland claimed: “The benefits of Akanyaru Wetland include poverty alleviation through handicrafts and compost production from water hyacinth that generate income and increase yield respectively, improved health through using clean water and getting clean air, and access to materials that are needed to make bags, hats, and ornaments.”, claimed an active member of the cooperative (The Rufford Foundation, 2018). Women recognize the importance of Akanyaru Wetland in their daily lives. Akanyaru Wetland provides food and raw materials that women use in handicrafts. The wetland is also a source of water although it has a low quality.

Okwaro (2018) indicated that gender norms in agriculture should be confronted through policy interventions that target women’s engagement in the agriculture sector. Women should be more involved in policy formulation and implementation and more empowered through enhanced knowledge and skills and by building the capacity of women in financial management. Women should have greater access to labour saving technologies in agriculture and in performing household tasks.

3.5.6 Social Policies of Wetland Use

Wetlands are relevant to the 2030 Agenda Sustainable Development Goals (SDGs) through their capacity to provide water and food, sustainable human settlements, poverty eradication, recreational activities and appropriate infrastructure. The New Partnership for Africa’s Development (NEPAD) recommended sustainable urbanization within social, environmental, economic and political frameworks. The local players, particularly local authorities, must be supported by improving their capacities for planning and urban management.

The Vision 2020 Rwandan Policy stated that by 2020, the percentage of households involved directly in primary agriculture be reduced from 90% to less than 50%. These updated regulations are adapted to protect the environment and manage natural resources sustainably. The rate of diseases related to environmental degradation, should be reduced by 60% and the share of wood in the national energy balance be reduced from 94% to 50%.

The Economic Development and Poverty Reduction Strategy II (EDPRS II) considers environment and climate change as cross-cutting issues. These involve: (1) mainstreaming environmental sustainability into productive and social sectors; (2) reducing vulnerability to climate change; and (3) preventing and controlling pollution. EDPRS II states priorities related to transforming Rwanda’s economy by pursuing a green economy and by rural development through improving land-use and increasing agricultural productivity.

3.5.7 Socio-Economic Issues

The wetlands in the CoK are used for agriculture and livestock grazing. Preventing these activities will result in reduced food production for family consumption and income supplementation. Wetlands can provide a breeding ground for insects that carry diseases and therefore an increase in stagnant water may result in an increase in diseases such as malaria. People live within the wetland areas and loss of their homes will result in some social dislocation. Socio-economic benefits from rehabilitated wetlands include: (1) creation of nature areas for passive and active recreation; (2) opportunities for small businesses operating near the wetlands; (3) Opportunities to expand eco-tourism; (4) opportunities for sustainable harvesting of wetland products; and (5) an increase in tree cover will assist in climate change mitigation.

4 Environmental Economy of Wetlands

4.1 Introduction

Wetlands provide a variety of ecological services but not all wetlands provide the same services or function at the same level of performance. The capacity of a wetland to provide economic goods and beneficial ecological services is a measure of the systems ecological health. A good indicator of wetland health is its biological integrity and its ability to support a diverse and balanced community of plants and animals.

As each wetland is different, once selected to be a candidate for rehabilitation, a detailed economic valuation of the wetland or wetland area will be needed. This will entail a cost-benefit analysis and will require production of a Resettlement Action Plan (RAP) and a Livelihood Restoration Plan (LRP) for each wetland area. These plans should include a census and socio-economic survey of all Project Affected Persons (PAP), an inventory of assets (e.g. structures, fruit trees, farmed land), identification of land parcels to resettle PAP and identification of new job opportunities to replace activities carried out in the wetland areas so that the impact on the PAP is mitigated, identification of people with land titles that require compensation payments.

The water, land, soils, plants, hydrological and ecological characteristics of the wetlands in the CoK directly support two major categories of economic activities: (1) those based on wetland resources (ecosystem goods); and (2) those which depend on wetland services (ecosystem services).

Wetland resources: include the water, land, soils, plants and animals contained within wetlands, all of which provide goods which can be used to generate subsistence income and employment. In Kigali, the use of wetland resources for crop cultivation, papyrus harvesting, brick-making and fish farming are of particular economic importance to surrounding communities.

Wetland services: include the hydrological and ecological functions of wetlands, which support and maintain economic activities and human settlement because they act as a sink for wastes and residues and protect human and natural production systems. In Kigali, the most important wetland service is provision of water and the purification and treatment of wastewaters. This provides economic benefits which accrue throughout the CoK.

4.2 Ecosystem Goods

The resources contained in the CoK wetlands support subsistence and income-generating activities. These activities are carried out mainly by the residents of the low-cost settlements which directly border the wetlands. By far the most significant use of wetland resources in the CoK is small-scale cultivation. Other wetland utilisation activities, currently of less economic importance, include papyrus harvesting, brick-making and fish-farming.

4.2.1 Agriculture

It is estimated that the CoK wetlands cultivation supports the annual production of crops valued at over 20.36 billion RwF and net incomes in excess of 15.59 billion RwF. This includes both the value of crops grown for home consumption and the proportion that is sold. The net revenue of RwF 15,588,245,313 is generated from 7273 ha implying that on average agricultural production in the wetlands generates a value of RwF 2,143,274 per ha.

Once an area of wetland has been identified for rehabilitation, a study of what crops are being grown, the area under cultivation and the crop yield will need to be undertaken. The results of this study will then be entered into a spreadsheet based on Table 8 and the value of the cultivated area calculated. This study will assist in determining the value of any compensation that will need to be paid and will also provide an estimate of one component of the social cost of undertaking the rehabilitation.

Table 8: Estimated income from wetland cultivation

CROP	TOTAL AREA (ha)	ESTIMATED YIELD (kg ha ⁻¹)	PRICE (RwF kg ⁻¹)	TOTAL REVENUE (RwF)	TOTAL VARIABLE COSTS (RwF)	TOTAL GROSS MARGIN (RwF)
Bananas	1744	30,000	120	6,279,568,799	502,358,597	5,777,210,202
Flowers (stems)	203	250,000	25	1,270,139,320	889,085,300	381,054,020
Irish potatoes	174	18,000	300	938,886,985	610,268,150	328,618,836

CROP	TOTAL AREA (ha)	ESTIMATED YIELD (kg ha ⁻¹)	PRICE (RwF kg ⁻¹)	TOTAL REVENUE (RwF)	TOTAL VARIABLE COSTS (RwF)	TOTAL GROSS MARGIN (RwF)
Rice	327	4000	250	327,413,691	85,126,389	242,287,302
Soybeans	131	3200	200	83,817,905	23,468,691	60,349,214
Sweet Potatoes	1512	16,000	200	4,837,593,741	532,127,995	4,305,465,746
Sugarcane	1039	50,000	15	779,018,783	163,591,695	615,427,088
Tomatoes	615	19,000	200	2,338,185,362	818,353,625	1,519,831,737
Egg plants	462	18,000	250	2,077,947,928	623,375,807	1,454,572,120
Cabbages	308	25,000	100	770,551,188	385,270,296	385,280,891
Pigweed	155	950	100	14,694,101	1,469,390	13,224,711
Cassava	242	17,500	80	338,252,214	60,884,561	277,367,652
Maize	181	4800	150	130,062,266	31,214,515	98,847,752
Beans	181	3800	250	171,609,935	42,901,894	128,708,041
Total	7273			20,357,742,217	4,769,496,904	15,588,245,313

4.2.2 Papyrus Harvesting

Papyrus is harvested in Akanyaru Nord, Kajevuba, Kanyetabi, Kitaguzirwa, Mugasagara, Nyabarongo Amont, Nyabarongo Aval and Rugende–Isumo Wetlands. Most papyrus is harvested from shallower parts of the wetlands.

Papyrus generates income in three major ways: (1) Through the sale of papyrus straws for mulching; (2) Raw materials to artisans such as thatchers or mat-makers; and (3) Through the production of rough, low-cost mats or production of fine, higher-price mats and artefacts. Based on interviews with banana farmers, almost 50 % of the total cropped area of bananas is mulched. Approximately 1 ha of papyrus produces sufficient straw to mulch 1 ha of bananas. For the farmers who purchase the papyrus straw, they pay about Rwf 300,000 RwF ha⁻¹ for the mulching straw. The estimated value of papyrus used for mulching is Rwf 261,600,000.

In addition to the above, it is estimated that about 100 ha of papyrus are harvested and sold for other purposes including thatching and sale to artisans for making of mats and other artefacts. It is assumed that all papyrus is sold in the form of dry bundles and that each hectare of papyrus produces 25 tonnes of dry papyrus. The total production and estimated annual income from papyrus for thatching and sale to artisans is 214,200,000 RwF.

The total value of papyrus in Kigali wetlands is therefore estimated to be Rwf 475,800,000 (Rwf 261,600,000 for bananas mulch and Rwf 214,200,000 for other purposes). Since in total the area under papyrus is estimated to be 408 ha, the estimated value of papyrus for purpose of mulching, thatching and mats is Rwf 1,166,176 ha⁻¹.

4.2.3 Brick-making

Brick-making occurs in Byabagabo, Kamusenyi, Kanyetabi, Nyabuhoro and Rugende-Isumo Wetlands. There are indications that over 5 ha of these wetlands are used for brick production. Estimates indicate that on average, every hectare produces 12 million bricks over a period of 4 years with each brick being sold for 100 Rwf. In total, 1 ha can therefore generate revenue worth 1.2 billion Rwf within 4 years. If 60 % of this revenue is assumed to cover operational costs, it is estimated that the brick-makers would be making a profit of 120 million Rwf ha⁻¹. The 5 ha estimated to be under brick-making are therefore valued at over 600,000,000 RwF annually. Every hectare of bricks therefore generates 120,000,000 RwF per year.

4.2.4 Fisheries

There is insufficient information on fish capture and fish farming in Kigali wetlands. However, interviews with fish farmers with the Abakumburwa Cooperative of Vegetable Farmers in Kajevuba wetland indicated that in 2018, the Cooperative harvested 1080 kg of fish which they sold for 2,160,000 RwF (2000 RwF kg⁻¹).

4.3 Ecosystem Services

Wetlands provide a number of ecological services: water supply, water purification (e.g. sediment and nutrient removal), flood mitigation and water storage, biodiversity conservation, ecotourism opportunities, recreation and landscape beautification. It is very challenging to put a financial value on some of the ecosystem services that wetlands provide. What is the value to a person walking alongside a beautiful wetland? What is the value of a species that lives in a wetland? Once a wetland has been identified as a candidate for rehabilitation, a detailed economic cost and benefit analysis should be undertaken. However, it is possible to value some ecosystem services and these are described below.

4.3.1 Water Supply

One of the most important functions of wetlands in the CoK is provision of water for drinking by humans and livestock. A significant proportion of people living in the CoK access water from wetlands and our valuation is based on communities residing around the wetlands (mainly cultivating crops). In total there are about 7273 ha of cultivated land which is farmed by about 14,500 households. From the socio-economic survey carried out in July 2019, it was found that each household consumes about 21 jerrycans of water per week and each jerry can (20 L) of untreated water costs about 20 RwF. Using this price and the volume of water consumed, it is estimated that each household consumes water valued at 21,840 RwF per year and therefore the total value of water consumed by the 14500 Households is 316,680,000 RwF per year. Similar estimations were done for water consumed by cattle, sheep and goats. The cattle, sheep and goats in Kigali are estimated to consume about 864,795,230 litres of water valued at 864,795,230 RwF per year.

Thus, the CoK wetlands are estimated to provide water (to humans and livestock) valued at Rwf 11,181,475,230 which is equivalent to a total value of Rwf 162,447 ha⁻¹. This excludes the value of irrigation water which is part of the value under agricultural production.

4.3.2 Wastewater and Water Quality Treatment

Wetlands play an important role in maintaining the quality of the city's water supply by physically, chemically and biologically removing pollutants and sediments from the wastewater which pass through them. The wetlands also reduce pollution loads through mineralisation and sedimentation processes.

Two major types of costs would be incurred to replace artificially the waste treatment and water purification services of Kigali wetlands: (1) the construction of proper sewerage and sanitation facilities in low-cost settlements around the wetlands; and (2) the construction of a sewerage network and wastewater treatment plant to serve other areas in the CoK.

There is information on construction of a centralized sewerage network and wastewater treatment plant in Kigali. The project will involve construction of a sewerage network (89 km long) with a wastewater treatment plant in the Gitikinyoni area Nyarugenge District. The first phase of the project will cover the Central Business District (CBD), Muhima and Kiyovu. The wastewater treatment plant will have the capacity to treat liquid wastes at 12,000 m³ day⁻¹. In total the project is expected to cost Euros 96 million which is equivalent to 98 billion RwF or an average annual cost of about 3,267,000,000 RwF assuming an economic lifespan of 30 years.

4.3.3 Wetlands in Flood Control

Floods have become a common phenomenon in the CoK and this is most likely because most of the wetlands have been degraded and they no longer effectively perform their function of absorbing or reducing the extent of floods. As a result, the City now has to spend 1.5 billion RwF every year on drainage and they have to in addition build a dam. As of now, it is not yet known what the capacity of the dam would be. However, it is estimated that to control the floods arising from peak flows (100 year return period) within Kigali area, 31 reservoirs with a total reservoir capacity of 11,082,000 m³ would need to be constructed across 31 wetlands.

The construction of the reservoirs with capacity of 11,524,800 m³ would cost 130,324,320,000 RwF which amounts to about 4,344,144,000 RwF every year assuming the reservoirs have a lifespan of at least 30 years. This translates to a value of about 204,027 Rwf per ha of wetlands per year.

4.3.4 Ecotourism

The Rwanda Environment Management Authority (REMA) has recently started developing Nyandungu Wetland into an urban wetland recreation and eco-tourism park. The project will provide social and economic benefits to the communities and support innovative approaches in restoring wetland ecosystems. The project is expected to cost

around 2.41 billion RwF and employ a workforce of more than 30 people. Projections indicate that the park would generate over 1 billion RwF profit in the first 12 years of operation. This profit can be used to represent the potential value of recreational and eco-tourism parks in Kigali wetlands. The expected profit of 1 billion RwF in 12 years amounts to a value of 83,333,000 RwF per year and this is assumed to be the value of recreational and eco-tourism parks in Kigali.

4.3.5 Estimated Value of Papyrus Wetlands in Carbon Sequestration

Tropical papyrus wetlands have the ability to assimilate and sequester significant amounts of carbon. The total carbon sequestered from five papyrus wetlands in Kigali is estimated to have a value of 15,807,662,640.00 RwF every year or 2,846,176.20 RwF ha⁻¹.

4.4 Economic Valuation

The goods and services associated with wetlands in the CoK have been valued to yield economic benefits worth approximately 41.35 billion RwF a year (Table 9). Carbon sequestration from papyrus wetlands accounts for about 38.2 % (15,807,662,640 RwF) of this while crop cultivation in the wetlands accounts for 37.7% (15,588,245,313 RwF annually). These figures represent a minimum estimate of these wetlands total economic value because they exclude consideration of other benefits yielded by the wetlands most importantly non-use values such as those attached to the conservation of biodiversity, cultural and aesthetic values and particular indirect values such as groundwater recharge services. They also deal only with existing wetland resource activities, which represent a small proportion of potential utilisation opportunities.

Table 9: Summary of Kigali wetlands economic values

ECONOMIC ACTIVITY	VALUE (RwF)	ESTIMATED VALUE PER ha (RWF)
Wetland resources		
Crop cultivation (net income)	15,588,245,313	2,143,274
Papyrus harvesting	475,800,000	1,166,176
Brick-making	600,000,000	120,000,000
Fish-farming (only known figures)	2,160,000	3,500,000
Wetland services		
Water consumption (human and livestock)	1,181,475,230	162,447
Water treatment and purification	3,267,000,000	423,131
Flood attenuation	4,344,144,100	562,640
Eco-tourism	83,333,000	641,023
Carbon sequestration	15,807,662,640	2,846,176.20
Total Value (RwF)	41,349,820,283	

4.5 Conclusions

As each of the wetlands in the City of Kigali are different, the total value of all these wetlands in the CoK is rather irrelevant. What will be needed is completion of an economic valuation exercise on each wetland areas once identified for rehabilitation. The value of crops grown, clay removed or papyrus harvested will need to be assessed. Also, each wetland area will differ in its capacity to provide ecological services such as flood mitigation, water storage, carbon capture and storage and to support a variety of plants and animals. The economic valuation process will be simplified when applied to smaller, more discrete wetland areas.

5 Wetland Rehabilitation, Remediation and Restoration

Rehabilitation of the degraded wetlands in the CoK will take time and the process is likely to cause civil dislocation and therefore a carefully staged campaign that includes a programme to raise community awareness will be required. Currently, many people in the CoK value wetlands based on the crops that are produced within the wetland boundaries. This valuation is understandable and as the rehabilitation programme begins, people will need to be convinced that wetlands will provide more greater value through ecological services than that from agricultural production. The transition from one value system to the other will take time, education and require patience.

Wetlands in the CoK have undergone significant transformation mainly through agricultural activities that have drained wetlands and replaced wetland plants with crop plants. Other impactful human activities include infrastructural developments (e.g. buildings, roads) within wetland boundaries, pollution and the extraction of clay for brick-making. These changes can be reversed through either ecological rehabilitation or ecological restoration programmes. Rehabilitation programmes seek to re-establish some of the ecosystem processes and services that the natural wetland provided (Table 10). Ecological restoration seeks to create a wetland that is as close to the former natural wetland as possible. Restoration requires knowledge of the ecological status of the wetland prior to human activity.

Table 10: Scheme for describing ecological character (Horwitz et al., 2008)

ECOLOGICAL COMPONENTS	ECOLOGICAL PROCESSES	ECOSYSTEM SERVICES
Geomorphic setting in the landscape, catchment area, including altitude	Primary production	Drinking water for humans and livestock
Prevailing climate, zone and major features (precipitation, relative humidity, temperature, wind)	Nutrient cycling	Water for irrigation and industry
Habitat types (including comments on particular rarity)	Carbon cycling	Groundwater recharge
Habitat connectivity	Animal reproductive productivity	Water quality enhancement
Area, boundary and dimensions, site shape (cross-section and plan view), area of water/wet area (seasonal maximum and minimum), length, width, depth (seasonal maximum and minimum))	Pollination, regeneration processes, succession, role of fire	Food production for humans and livestock
Plant communities, vegetation zones and structure (including comments on rare or endangered plants)	Species interactions, including grazing, predation, competition, diseases and pathogens	Wetland plant products for thatching, fibre, weaving, medicines
Animal communities (including comments on rare or endangered animals)		Flood control and water storage
Geology, soils and soil biology		Soil and water retention, erosion control
Water sources (surface or groundwater), inflow/outflow, evaporation, flooding frequency, seasonality and duration of flood, links with groundwater		Local climate regulation and climate change mitigation

ECOLOGICAL COMPONENTS	ECOLOGICAL PROCESSES	ECOSYSTEM SERVICES
Sediment regime (erosion, accretion, transport of sediments)		Clay and sand for building; peat for energy
Water turbidity and colour, dissolved oxygen, temperature and pH, nutrient concentrations, conductivity		Recreation, ecotourism, aesthetic values, spiritual values, research and education

Restoration ecology is a relatively new science and it has as its objective to re-establish an ecosystem that existed prior to any human disturbance. This will not be possible with the wetlands in the CoK because there is little information on the structure and species composition of the wetlands prior to disturbance. Furthermore, ecosystem disturbance will continue because the residents of the city live so close to the wetlands. Ecological restoration will require establishing biodiverse communities and maintaining them and this would require significant financial commitment. Furthermore, some wetland attributes may have been irreversibly lost and therefore restoration is no longer possible. Rehabilitation seeks to restore just some of the ecological communities and ecological functions provided by a wetland and does not have to consider the historical ecosystem that previously existed. Rehabilitation can also utilize exotic species if these are effective in providing ecological services, but the use of native species is always preferable.

5.1 Introduction to Wetland Rehabilitation

Rehabilitation is the process that re-establishes a wetland ecosystem in an area where a diverse wetland previously existed. It is a complex process as wetlands are living systems and therefore are dynamic and change through time (Russell, 2009). Some of the natural attributes of wetlands in the CoK have been changed irreversibly and therefore it may be impractical to reverse all the modifications that have contributed to their current degraded state.

Wetlands form in response to several driving forces: (1) geomorphological setting; (2) hydrology; (3) biogeochemical processes (e.g. nutrient cycling); and (4) biological processes (e.g. colonization by plants and animals, competition between species, population growth and decline and decomposition). Rehabilitation seeks to re-establish these processes and thereby restore the ecological services that they can provide.

Wetlands change through time and wetland rehabilitation should aim to develop an ecological self-maintaining system that requires only a little human intervention. Changes in wetlands are impacted by processes that occur within the catchment area of the wetland and therefore their management is inextricably linked with catchment area activities.

Wetland rehabilitation will have socio-economic consequences and therefore programmes must have buy-in by local people and stakeholders and particularly those who have used the wetlands areas to produce food, raise livestock or for fishing.

Rehabilitation may need to be preceded by remediation which includes the removal of all infrastructure including those below ground and the removal of any pollutants or polluted soils and sediments.

Before a wetland can undergo ecological rehabilitation, the cause of the degradation needs to be determined. This cause may extend into the wetland's catchment area. For success, any causes of degradation need to be addressed. Clear goals need to be established and this may require some investigation into the past ecological state of the wetland.

Wetland rehabilitation is not easy and each wetland area may require 3-5 years before some measure of success is achieved. Clear objectives for any programme need to be established. The process can (1) provide new habitats; (2) reduce erosion and trap sediments entering the wetland; (3) provide flood mitigation (wet season) and water storage (dry season); (4) provide recreational opportunities; and (5) store carbon. A well-designed wetland rehabilitation programme may serve to fill a number or even all of these objectives.

Rehabilitation involves a number of basic steps:

1. Cessation of any human activities within the wetland area and its catchment area that contributed to the wetland loss or degradation;
2. Removal of any structures built in the wetland area including any foundations or below-ground installations;
3. Reduction in the inflow of any effluents or polluted waters;

4. Removal of contaminated soil or sediments;
5. Soil movement should be done during the dry season to minimize erosion and downstream sedimentation;
6. Filling in drainage channels and ditches and levelling of the wetland surface so that water flow inundates a large area of the wetland undergoing rehabilitation (restoration of hydrological integrity);
7. Construction of berms to re-distribute water and to prevent erosion;
8. Creation of basins to form areas of open water that will serve for water storage during dry periods and as flood retention basins during heavy rain storms;
9. Developing strategies to minimise impacts on downstream systems from earth-moving and other restoration activities;
10. Establishing a variety of wetland plants in appropriate depth zones (restoration of wetland habitats);
11. Planting trees (preferably native species) outside and inside the wetland buffer zone; and
12. Monitoring the development of the wetland and take remedial action as appropriate.

Before rehabilitation efforts begin on a particular part of a wetland, the hydrology of the wetland must be carefully considered. The seasonal variation in the minimum daily flow of water into the wetland needs to be established. Furthermore, water quality (nutrient, pollutant and sediment loads) must be assessed to ensure that it will meet the needs of wetland vegetation and animals.

The wetland topography will determine water depths, water velocity and the capacity of the wetland to store water and mitigate floods. The impact of heavy rainstorms (stormwater inflows) and prolonged dry periods must be assessed. Similarly, the quantity and quality of wastewater inflows will impact the growth of wetland plants.

Establishing favourable hydrological conditions is essential to successful wetland rehabilitation. Many of the wetlands in the CoK have been drained through excavation of ditches that capture rainfall and run-off that results in more rapid water loss than prior to the drainage works. These ditches remove water before it can infiltrate the soil and cause saturation that will adversely impact the crops being grown in the wetland.

Once hydrological integrity has been restored, wetland vegetation may be planted or may invade the area naturally. Wetlands seedlings may not need to be planted in all areas but carefully selected regions of the wetland should be selected to minimise erosion and provide a nuclear population for subsequent spread to other parts of the wetland.

Most of the wetlands in the CoK, are the recipients of stormwater following heavy rainfall. Therefore, stormwater management and wetland management are intimately interconnected and should be managed in an integrated manner. This integration will lead to more effective mechanisms of flood mitigation that protect lives, livelihoods and property. Combining stormwater and wetland management through low impact, cost effective, nature based solutions that protect catchment areas and improve the capacity of wetlands to deliver ecological services, will lead to flood attenuation and improve the quality of water flowing from urban areas.

There is need to prepare for an increased stormwater generation as Rwanda continues to urbanize and increase paved areas. Wetlands in the CoK are degraded and have a diminished capacity to store water and release it slowly following storm events. Wetland rehabilitation will increase the capacity to store stormwater and improve water quality through natural processes. Where stormwater drains enter wetlands, particularly from steep slopes, erosion controls to slow water flow will be essential.

Soil erosion is how most rehabilitated wetlands are again degraded. Soil loss leads to the formation of gullies and channels that results in faster water loss from the wetland and more soil erosion.

5.2 Wetland Rehabilitation Planning, Design and Construction

The wetland rehabilitation process should be carried out in three phase:

1. Planning and design phase
2. Construction phase
3. Operations and monitoring phase

5.2.1 Planning and design

The planning stage should: (1) Assemble background information (site evaluation: type of wetland, location in catchment area, current value of the wetland); (2) Identify issues of concern (what are the threats to the wetland and any rehabilitation programme, what can be done to mitigate the threats) and initiate a community-awareness campaign; (3) Demarcate the area that is to be manipulated; (4) Obtain any permits or permissions required and establish legal ownership of any land within the wetland boundary; (4) Set preliminary goals and conduct public outreach; (5) Set goals for the rehabilitation programme; (6) Determine the funding that will be required; (7)

Determine major inflows and identify sources of pollution; (8) Assess the topography of the wetland and changes that will be required to restore wetland hydrology (effective sheet flow of water); (9) Determine the best time of the year to carry out rehabilitation work (soil moving activities will best be done during dry periods); (10) Prepare a planting design for wetland plants and trees; (11) Check that plans fit with the CoK Master Plan; (12) Roads that cross wetlands should be re-routed, be incorporated into the wetland design or have bridges to carry traffic over the wetland; (13) Set aside areas for recreation, nature reserves and small appropriate business opportunities; and (14) Prepare a monitoring programme that will assess the progress of the rehabilitation programme and determine whether goals have been achieved, monitoring will also provide information to determine whether strategies need to be modified.

5.2.2 Construction phase

This phase will comprise significant earthmoving to create basins, to plug drainage systems, to fill in eroded areas and develop structures to reduce water flow rates at major inflows. It may be necessary to construct berms to avoid sediment loss to downstream systems. Once the ground is prepared, the planting design can be implemented. Development of the wetland may take 2-3 years.

The construction phase must first seek to restore wetland hydrology. This term refers to the movement of water through the wetland. The quantity, timing and frequency of water entering the wetland are important determinants. The topography of the wetland then determines the distribution of water and how long it takes to pass through the wetland (period of retention). Water enters from direct rainfall, runoff from the immediate surrounds, stream inflows, and groundwater discharges. Wetland communities are determined by the timing, frequency, duration and water depth. Wetland hydrology can be modified by damming, creation of erosion channels and water extraction.

Ditches have been dug in many of the wetlands in the CoK in order to move water more quickly through the wetland. The dredged material has been piled onto the areas that have been used in cultivation. This earthmoving has stopped the sheet flow of water that is characteristic of natural wetlands and this needs to be restored as part of the wetland rehabilitation. Backfilling the ditches will help restore the natural topography and, with that, the natural hydrology. There may be a need to obtain additional soil for this backfilling as wetland soils lose mass when the organic matter they contain is oxidised.

Water movement within the wetlands can be directed by the construction of berms or dykes. These can protect adjacent property from flooding and facilitate sheet flow within the wetland. Material required to backfill ditches may be obtained by creating detention basins within the wetland that will form areas of open water. These detention basins will serve to store water and also provide flood mitigation.

Detention basins will also create habitat zones: (1) terrestrial; (2) riparian; (3) emergent plant; and (4) aquatic (open water). The terrestrial zone should have vegetation and tree cover so that soil erosion is minimised. The riparian zone will have water tolerant vegetation that can survive occasional flooding. These plants are important in providing bank stability. Emergent plants include species such as *Typha domingensis* and *Polygonum senegalense* and will form a ring around the open water area. The emergent zone will serve as filters by removing sediment from inflowing water. The aquatic zone will be colonised by floating-leaved plants (e.g. *Nymphaea nouchali*), free-floating plants (e.g. *Pistia stratiotes*) and submerged plants (e.g. *Ceratophyllum demersum*). All these zones serve to provide habitat for terrestrial and aquatic animals.

Where possible, construct islands within a detention basin as these can provide important habitats that provide safe nesting and roosting sites for birds and increase habitat for emergent and aquatic plants. Spoil removed to create detention basins can be used to fill drainage ditches and smooth the wetland topography.

Restoring a hydrology that mimics the former wetland may require the construction of water control structures such as weirs and dams. These may need to be equipped with spillways that allow water to pass through during floods without damaging the control structure. These water control structures will need to be monitored and repaired as needed.

Wherever possible, the construction phase should utilize low-impact landscaping and erosion control techniques. This phase needs to ensure that erosion is minimized, water detention within the wetlands serves to improve water quality and mitigate floods and produce habitats that have aesthetic appeal. Tree-planting programmes can begin during this phase.

5.2.3 Operations, monitoring and management

Maintenance, monitoring and evaluation are important to ensure that rehabilitation achieves the goals set and whether changes are required to how the site is managed.

Management strategies need to focus on: (1) Maintaining hydrology; (2) Establishing and maintaining riparian habitats; (3) Reducing water pollution and sedimentation; (4) Preventing invasion of exotic species; (5) Regulating the harvest of wetland plants and fish; and (6) Adapting the programme as the wetland develops.

The growth of plants should be monitored and any weeds removed. The hydrology of the wetland will need to be monitored to ensure that water reaches all the areas where it is needed. As the wetland develops, education of stakeholders and local people should continue to show the benefits that accrue from wetland rehabilitation.

There are thirty-seven wetlands in the CoK and they vary in size from Mugasagara (2.4 ha) to Nyabarongo Aval (6,199 ha). Most of the wetland areas are being used to grow crops and this activity will need to end with wetland rehabilitation. Wetland rehabilitation takes time and effort and not all these wetlands can be improved at the same time. Therefore, a priority list needs to be developed and a timeline established so that the rehabilitation programme can be scheduled and stakeholders prepared for the changes that will need to be made. Rehabilitation of any wetland area should be preceded by a community awareness campaign so that people who will be impacted will have time to prepare for the change.

6 Wetland Management

Wetland management requires:

- Clear objectives and goals for site management;
- Appreciation of the values of the wetland site;
- Coordination among relevant government agencies that have a role in wetland use and management;
- Communication and education to raise public awareness regarding the importance of wetlands;
- Involvement of stakeholders in planning wetland rehabilitation programmes;
- Consideration of appropriate economic activities that can continue within wetland boundaries such as agriculture, fish ponds, tourism, small businesses;
- Benchmarks to measure success and failure of management activities;
- Monitoring programmes to assess attainment of benchmarks;
- Mechanisms to adapt management strategies based on monitoring programmes;
- Strategies for conflict resolution;
- Compliance with local, national and international legislation; and
- Financial resources to achieve the stated objectives.

The management process must define objectives, implement management strategies, monitor results, and if necessary review, refine and adjust the management strategies and implementation programmes.

Wetlands in a human-dominated environment will require as much management as any city park. The wetland will need to be monitored for its hydrological integrity (ensuring that water flows to all parts of the wetland) and to ensure the healthy growth of wetland plants and exclusion of weeds.

6.1 Objectives of Management Interventions

Management strategies need to focus on:

- Maintaining hydrology;
- Maintaining wetland habitats that support biodiverse communities;
- Establishing and maintaining riparian habitats;
- Reducing water pollution and sedimentation;
- Preventing invasion of exotic species; and
- Regulating the harvest of wetland plants and fish.

Before rehabilitation efforts begin on a particular part of a wetland, the hydrology of the wetland must be carefully considered. The seasonal variation in the minimum daily flow of water into the wetland needs to be established. Furthermore, water quality (nutrient, pollutant and sediment loads) must be assessed to ensure that it will meet the needs of wetland vegetation and animals.

The wetland topography will determine water depths, water velocity and the capacity of the wetland to store water and mitigate floods. The impact of heavy rainstorms (stormwater inflows) and prolonged dry periods must be assessed. Similarly, the quantity and quality of wastewater inflows will impact the growth of wetland plants.

7 Proposed Wetland Zoning Plan

This section covers the objective of the zoning plan, definitions of proposed zones, proposed regulations determining uses/activities to be allowed in wetlands among several other parameters, and a summary presented in the form of a zone-land-use matrix.

The Zoning Plan is a combination of a map and regulations. The Zoning Map identifies specific zones within the wetlands based on existing predominant land-use, natural features, their interaction with the surrounding built environment, potential for rehabilitation and need for conservation. Zoning is also cognizant of recommended actions discussed in earlier sections under the Wetland Management Plan and compatibility with the Kigali Masterplan.

There is a growing body of evidence that integrated urban planning can enable densification and agglomeration and at the same time reduce per-capita resource use (UN-Habitat, 2012 in Ramsar Convention Secretariat, 2013). The proposed Zoning Plan adopts an 'integrated approach' that promotes conservation and rehabilitation of wetlands on one side and encourages wise use of wetlands in alignment with national development vision of a green growth.

7.1 Zonation and Permitted Uses of Wetlands

7.1.1 Objective

Systematic implementation of the proposed conservation and rehabilitation plan would require clear physical delineation of such areas on the map along with a specific set of regulations associated with them. i.e. 'Wetland Zoning Plan'.

The main objective behind preparation of the Wetland Zoning Plan are:

1. To provide a clear direction to the enforcement agency to regulate activities within the wetland;
2. To streamline regulations for all wetlands, identifying areas of importance for their potential conservation or sustainable use;
3. To ensure synergism between the zoning assigned to the wetlands and designated zoning of surrounding built environment as per ongoing Kigali Master Plan; and
4. Identify strategic projects to be implemented within the wetlands and in synergy with the City of Kigali Implementation Plan.

7.2 Wetland zoning

Zoning regulations use two categories: Conditional and Prohibited uses.

Conditional Use: Conditional uses are usually activities that may have an impact and for which further assessment by MoE or other concerned Authorities is required. A SEIA may be required before such activity is implemented

Prohibited Use: These are uses that are deemed prohibited and include activities that have been found to be incompatible with the zone.

7.2.1 Definitions of Zones

Wetlands have been classified into five zones (Figure 26):

1. W1 - Buffer Zone

Buffer zones are established by Law and are set to establish a minimum distance between developed areas and protected sites. In the case of wetlands, the buffer zone is set at 20 m. While all areas included within the official wetland boundary are automatically considered Public Domain, buffer zones can also be under private property. Although privately owned plots may be zoned by the Kigali Master Plan with different uses (commercial, residential), wetland buffer zones supersede any other regulations. Plots that are partially affected by the buffer zone will be able to transfer Development Rights on that specific portion to the remaining developable part of the plot as prescribed by the CoK MP.

2. W2 - Rehabilitation Zone

Areas showing signs of a diverse wetland ecosystem that previously existed but are now under different uses, have been studied and their boundaries have been delineated as a Rehabilitation Zone. Planning intent behind creation of such zones is to re-establish a wetland ecosystem.

3. W3 - Sustainable Exploitation Zone

There are certain wetlands which are to be rehabilitated and their ecosystem improved, while retaining their existing economic/utilitarian/recreational value. It is recommended to follow sustainable practices while deploying resources offered by the wetlands. Such zones are delineated as Sustainable Exploitation Zone.

4. W4 - Conservation Zone

The wetlands which are still supporting significant areas of natural vegetation, where water is permanently present and that represent a valuable ecosystem, have been delineated as a Conservation Zone. Wetlands with these existing natural values are to be fully conserved.

5. W5 - Recreational

Wetlands which offer potential to be developed as recreational spaces due to their proximity to strategic areas in the Kigali Master Plan have been identified as a Recreational Zone. There are certain wetlands which are currently under other uses that can be transformed with a focus on public open spaces, passive and active recreational uses and these are also delineated as W5.

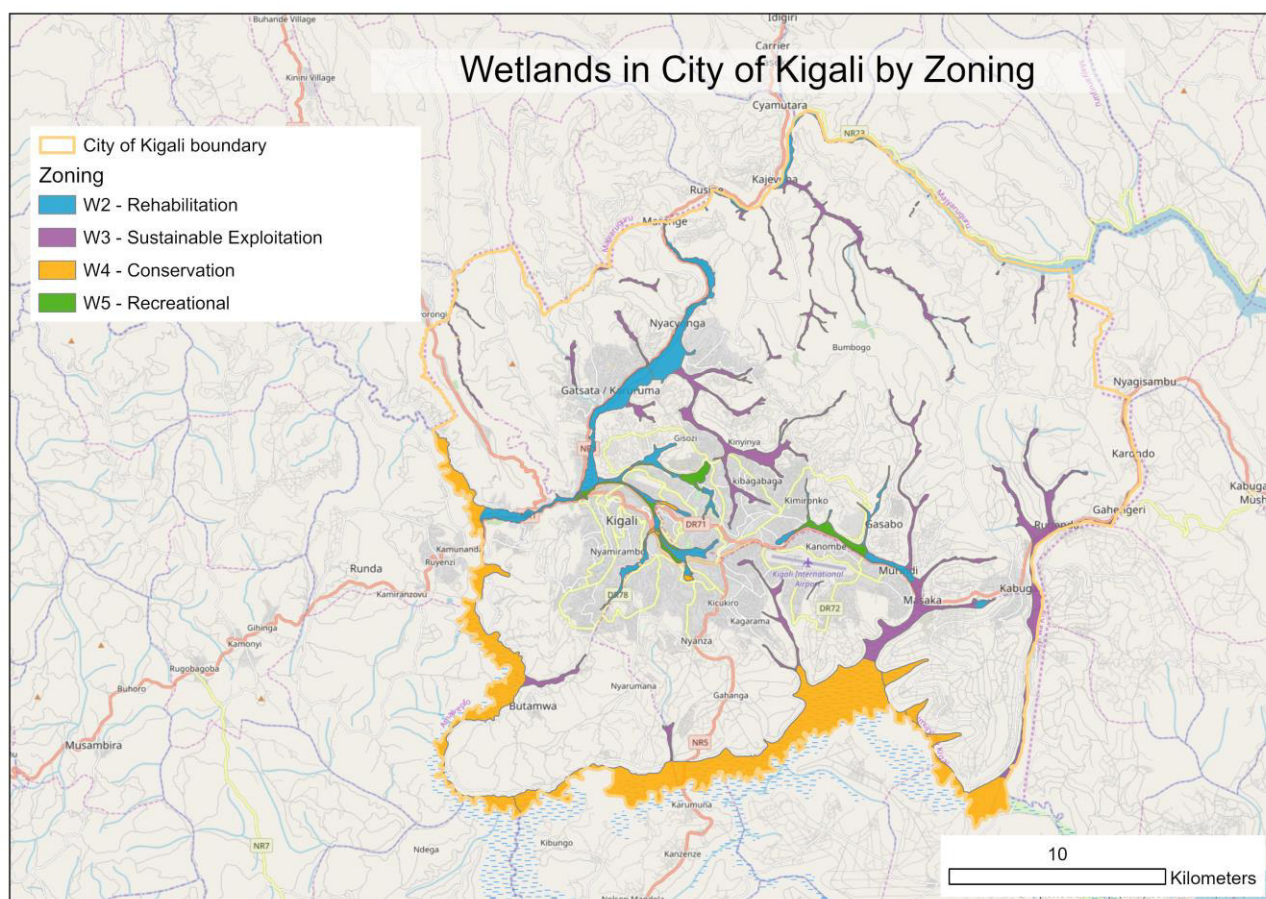


Figure 26: Proposed wetland zoning plan

7.2 Zoning Regulations

Zoning Regulations would essentially serve as a guide for the authority to regulate various human interventions within wetlands. Therefore, most common interventions are grouped under six zoning parameters to frame the regulations. Such parameters are: (1) wise use; (2) structures; (3) fencing; (4) road access/crossing; (5) stormwater drainage; (6) and waste management. These parameters are also representative of all the existing activities carried out in the wetlands. Zone-wise regulations are given in Table 11.

Table 11: Zoning regulations for wetlands in the City of Kigali

ZONE	REGULATION
W1- Buffer Zone	
Wise use	Predominant use: - Conditional and Prohibited Uses shall conform to Zoning-Land-use Matrix Ancillary use: - Public Toilets - Pavilions
Structures	- No commercial activity permissible - Only temporary structures are permissible - Minimum spacing between structures 6 m - Only organic building materials (for example wood, bamboo) are to be used for construction
Fencing	- Fenceless - In case of buffer facing private/public property where fencing to those properties is inevitable, $\geq 2/3^{\text{rd}}$ of fence height shall remain visually accessible
Infrastructure	- Roads and utility lines crossing and running parallel to wetlands are permissible - Permeable materials permitted for paved access roads/walkways - Use of man-made materials to be limited to support structure (foundations); superstructures (e.g., bridges) to be made from organic building materials if in-situ construction is involved
Stormwater drainage	- Grading of buffer zone to be carried out to drain it towards wetland - Location of stormwater inlets to be retained and its cross section to be widened wherever possible - Provision of necessary structures/sumps to segregate inorganic materials from storm water to minimise pollution risk - Stormwater outlets to have an erosion control design so wetland is not impacted
Waste management	- In-situ waste management mandatory
W2- Rehabilitation Zone	
Wise use	Predominant use: - Conditional and Prohibited uses shall conform to Zoning Land-use Matrix - Agriculture use and clay extraction to be phased out Ancillary use: - Pump sheds - Wells - Storage of agricultural produce

ZONE	REGULATION
Structures	- Any structure constructed with organic building materials - Removal of existing structures including any foundations or below-ground installations irrespective of current usage
Fencing	- Fenceless
Infrastructure	- Roads and utility lines crossing and running parallel to wetlands are permissible provided it causes no obstruction to the natural drainage flow - Elevated road crossings are recommended - Existing roads built at grade to be removed
Stormwater drainage	- Prohibit direct discharge of stormwater from industrial and agricultural areas into the wetland by creating artificial wetland within designated area within the wetland - Mandatory waste and effluent treatment for industrial areas - Prohibit use of pesticides in surrounding agricultural areas - Fill up drainage channels and ditches to the level of wetland surface - Construction of berms to re-distribute water and to prevent erosion
Waste management	- Prohibit direct wastewater discharge into the wetlands and minimise discharge locations - Plan piped sewage network and locate sewage treatments plants/artificial wetlands, for waste water treatment, outside wetland boundaries - Sewage Treatment Plants to include phosphorus removal (tertiary treatment) - Prohibit disposal and storage of any form of solid waste into the wetlands - Convert fish ponds into storm water detention ponds - Convert clay extraction basins into stormwater detention basins
W3- Sustainable Exploitation Zone	
Wise use	Predominant use: - Conditional and Prohibited uses shall conform to Zoning-Land-use Matrix - Agriculture use may continue provided it complies with EIA provisions Ancillary use: - Pavilions - Security post - Watch towers
Structures	- Any structure constructed with organic building materials provided it complies with EIA provisions - Removal of existing structures including any foundations or below-ground installations irrespective of current usage
Fencing	- Fenceless - In case fencing of certain properties is inevitable, 100% of fence height shall remain visually accessible and it shall not obstruct flow of stormwater drainage to wetland
Infrastructure	- Roads and utility lines crossing and running parallel to wetlands are permissible - Permeable materials permitted for paved access roads/walkways - Use of man-made materials to be limited to support structures (foundations); superstructures (e.g. bridges) to be made from organic building materials if in-situ construction is involved

ZONE	REGULATION
Stormwater drainage	- Fill up drainage channels and ditches to the level of wetland surface - Construction of berms to re-distribute water and to prevent erosion
Waste management	- In situ treatment of organic waste is mandatory
W4- Conservation Zone	
Wise use	Predominant use: - Conditional and Prohibited uses shall conform to Zoning-Land-use Matrix Ancillary use: - Pavilions - Security post - Watch towers
Structures	- Any structure to be constructed with organic building materials - Removal of existing structures including any foundations or below-ground installations irrespective of current usage
Fencing	- Fence without affecting natural stormwater drainage flow
Infrastructure	- Road and utility lines running parallel to wetlands is permissible - Existing roads built at grade to be removed
Stormwater drainage	- Prohibit direct discharge of stormwater from industrial and agricultural areas into the wetland by creating artificial wetland within designated area within the wetland - Mandatory waste and effluent treatment for industrial areas - Prohibit use of pesticides in surrounding agricultural areas - Fill up drainage channels and ditches to the level of wetland surface - Construction of berms to re-distribute water and to prevent erosion - Stormwater outlets to have an erosion control design so wetland is not impacted
Waste management	- Prohibit direct wastewater discharge into the wetlands - Relocate existing discharge locations with piped network - Relocate existing sewage treatment plants or any utility outside wetland - Prohibit disposal and storage of any form of solid waste into the wetlands
W5- Recreational Zone	
Wise use	Predominant use: - Conditional and Prohibited uses shall conform to Zoning-Land-use Matrix Ancillary use: - Pavilions - Security post - Watch towers
Structures	- Any non-habitable structure constructed with organic building materials is permissible
Fencing	- Fence without affecting natural storm water drainage flow is permissible

ZONE	REGULATION
Infrastructure	- Roads and utility lines crossing and running parallel to wetlands are permissible provided it causes no obstruction to the natural drainage flow - Elevated road crossings are recommended - Existing roads built at grade to be removed
Stormwater drainage	- Bio-swales are permissible
Waste management	- In situ treatment of organic waste permissible

7.3 Zoning-Land-use Matrix

The Zoning-Land-use Matrix provides predominant land-uses which are generally allowed with conditions or prohibited with conditions within each wetland zone (Table 12).

Allowed with conditions (C) implies that an Environmental Impact Assessment (EIA) is essential before an authority grants permission. In the case of transport related applications, permission shall be granted only after the satisfactory outcome of Transport Impact Assessment (TIA) as well as an EIA.

The following rationale can be seen behind disposition of various land-uses into respective Zones:

- Integration of passive recreation activities (e.g. gardens, playgrounds) promoted across all zones;
- Considering shortage of land for developing Public Facilities and Utilities, it is generally allowed (with conditional approval) across all zones;
- Based on Ministerial Order N°004/2008 OF 15/08/2008, land-uses such as infrastructure, agriculture and animal husbandry, parks and buffers, mining, public facilities (>100 people capacity) would require an EIA.

Table 12: Land-use permitted within wetland zones (C = Conditional; P = Prohibited)

PREDOMINANT LAND-USE	W1 BUFFER ZONE	W2 REHABILITATION ZONE	W3 SUSTAINABLE EXPLOITATION ZONE	W4 CONSERVATION ZONE	W5 RECREATIONAL
Farming or horticulture	C	C	C	P	C
Fish farming	C	P	C	P	P
Grazing	C	P	C	P	P
Livestock farming	C	P	C	P	P
Plantation or nursery	C	C	C	C	C
Clay, peat and sand extraction	C	P	C	P	P
Mining	C	P	C	P	P
Groundwater extraction	C	P	C	P	C
Garage	P	P	P	P	P
Petrol or gas station	P	P	P	P	P
Roads	C	C	C	C	C
Transport terminal	P	P	P	P	C

PREDOMINANT LAND-USE	W1 BUFFER ZONE	W2 REHABILITATION ZONE	W3 SUSTAINABLE EXPLOITATION ZONE	W4 CONSERVATION ZONE	W5 RECREATIONAL
Railway	C	C	C	C	C
Railway station	C	P	C	P	C
Airport	C	C	C	C	C
Forest	C	C	C	C	C
Afforestation	C	C	C	C	C
Park, garden or playground	C	C	C	P	C
Amphitheatre	C	C	C	C	C
Boardwalk (elevated)	C	C	C	C	C
Botanical garden	C	C	C	C	C
Biodiversity park	C	C	C	C	C
Waterfront promenade	C	C	C	C	C
Picnic or camping site	C	C	C	C	C
Ecotourism	C	C	C	C	C
Cycling trail	C	C	C	C	C
Hiking trail	C	C	C	C	C
Residential	P	P	P	P	P
Commercial	P	P	P	P	P
Mixed-use	P	P	P	P	P
Industrial	P	P	P	P	P
Warehouse	P	P	P	P	P
Market	P	P	P	P	P
Retail shop	P	P	P	P	C
Restaurant	C	P	C	P	C
Office	P	P	P	P	P
Post Office or bank	P	P	P	P	P
Supermarket or shopping mall	P	P	P	P	P
Movie theatre	P	P	P	P	P

PREDOMINANT LAND-USE	W1 BUFFER ZONE	W2 REHABILITATION ZONE	W3 SUSTAINABLE EXPLOITATION ZONE	W4 CONSERVATION ZONE	W5 RECREATIONAL
Hotel	P	P	C	P	C
School	P	P	C	P	C
R & D centre/biotechnology research Institution	P	C	C	C	C
College or university	P	P	P	P	P
Government office	P	P	P	P	P
Hospital	P	P	P	P	P
Civic centre	P	P	C	P	C
Civic plaza	C	P	P	P	C
Art gallery or museum	C	P	C	P	C
Community hall	C	P	C	P	C
Library	C	P	C	P	C
Auditorium	P	P	C	P	C
Any public building (>100 people capacity)	P	P	C	P	C
Slaughter house	P	P	P	P	P
Cemetery	P	P	P	P	P
Indoor games	P	P	C	P	C
Outdoor sports	C	C	C	P	C
Gymnasium	P	P	C	P	C
Swimming pool	C	P	P	P	C
Exhibition hall or ground	C	P	C	P	C
Entertainment or amusement park	P	P	C	P	C
Golf course	P	P	P	P	C
Sewage treatment plant and Sewage network	C	P	C	P	C
Water treatment plant and distribution network	C	C	C	C	C
Water filtration unit	C	C	C	C	C

PREDOMINANT LAND-USE	W1 BUFFER ZONE	W2 REHABILITATION ZONE	W3 SUSTAINABLE EXPLOITATION ZONE	W4 CONSERVATION ZONE	W5 RECREATIONAL
Waste transfer station or recycling centre	C	P	P	P	P
Water detention pond/ Rain water harvesting structure	C	C	C	C	C
Dam, weir or berm	C	C	C	C	C
Dyke	C	C	C	C	C
Electric substation	C	C	C	C	C
Overhead power line	C	C	C	C	C
Communication network	C	C	C	C	C
Oil pipe line	C	C	C	P	C
Oil storage or refinery	P	P	P	P	P
Landfill	P	P	P	P	P

7.4 General recommendations

Following are the general recommendations to be considered while elaboration of the Wetland Masterplan:

1. Official application procedure may be set up requiring permission from REMA/CoK before conducting any activity within a wetland;
2. Guidelines covering items below may be prepared along with illustrations explaining the best practices:
 - Economic activities such as agriculture, aquaculture, clay extraction, brick-making;
 - Erecting temporary or permanent structures in the wetlands;
 - Infrastructure provision (protection of natural corridors, technical solutions to be used, preferred location, need for impact mitigation);
 - Environmental restoration after cessation of agriculture or clay, peat or sand extraction;
 - Sustainable farming practices and incentives to stimulate organic farming; and
 - Approved materials to be used for construction.

7.4.1 Wetland use

Most wetland areas within the CoK are being used for agriculture. Portions of wetlands are being used for industry, residences, commercial operations and public facilities (e.g. schools). All these activities, occurring within a Protected Zone (P4) are technically prohibited. Many of these activities should cease and any infrastructure removed. However, this process will cause some civil dislocation and therefore it will need to be handled with sensitivity and allow adequate time for adjustment. In some cases, removal of infrastructure may not only cause significant inconvenience, but it also may be environmentally damaging. In some wetlands, the infrastructure that has been established is environmentally damaging and this is the case with most structures in the Gikondo area of Rugenge Wetland. However, other structures are more environmentally benign and serve a social good. This applies to schools that are operating within wetland boundaries. Some industries that are present within wetlands are non-polluting and serve to provide jobs. While the ultimate goal should be to remove all infrastructure that is prohibited within wetlands, a well-considered timeline for this needs to be established.

A strict ban on building any other infrastructure within the established boundaries of wetlands should be instituted. This should include all buildings and roads unless the structures fall within the conditional infrastructure as listed above (Protected Zone P4 – Conditional).

Wastewater management will become a bigger issue when a sewage treatment plant (STP) is built to serve the residents in the CoK. The outfall from a STP will almost certainly be to a wetland. The sewage effluent should receive tertiary treatment (phosphorus removal). Even so, the effluent will be nutrient-rich with a high Biological Oxygen Demand (BOD). The effluent will almost certainly stimulate the growth of some aquatic plants and phytoplankton (algae). A plant likely to respond to the influx of sewage effluent is water hyacinth (*Eichhornia crassipes*). An increase in phytoplankton will make the water turbid and this will suppress the growth of submerged and floating-leaved plants. Therefore, care needs to be taken in selecting sites for any STP outfall. It would be preferable to have the sewage enter a large river, away from dense human populations and downstream from any intake providing a source for drinking water. The sewage effluent could enter a constructed wetland that would serve to improve the water quality of the effluent by sediment particle removal and denitrification. Some uptake of phosphorus may also occur.

Ecoplanet (2017) recommended that bamboo could be planted in the buffer zones of lakes and wetlands. Bamboo is a Non-Timber Forest Product and has multiple use in construction, furniture-making, handicrafts and as a fibre source to make paper products. The largest bamboo forests in Rwanda are located in National Parks and these are protected and no utilization should occur within these areas. However, production and harvesting of bamboo should be encouraged within the buffer zones of wetlands. The national bamboo policy was launched in 2011 and seeks to provide financial incentives for Rwandans to grow bamboo (Republic of Rwanda, 2011).

Where it is absolutely necessary to use a wetland such that it effectively is destroyed, the no-net-loss policy will need to be invoked. This wetland mitigation policy should balance the loss or disturbance of a wetland by a programme of wetland rehabilitation or creation. Mitigation for the loss of an existing wetlands should occur within the same watershed and be integrated with remaining wetlands in the CoK.

7.5 Planned Developments in City of Kigali Wetlands

As per the Kigali 2050 Master Plan, the following projects (tourism attractions and recreational spaces) are proposed within the wetlands (Figure 27): (1) Agro Tourism Valley Rutunga and Bumbogo (part of Kajevuba Wetland); (2) Lake Muhazi Tourism Area; (3) Nyandungu Recreational Project (part of Mwanana-Mulindi-Kanombe and Kitaguzirwa Wetland); (4) Kicukiro Wetland and Biodiversity Park (part of Nyabarongo Aval Wetland); (5) Equestrian Park; (6) Nyabarongo ECO Park and Wetlands (part of Nyabarongo Amont Wetland); (7) Kanyinya Wetland Town Park (part of Nyabarongo Amont Wetland); (8) Golf Course at Nyarutarama (part of Rwampara Wetland); (9) Kigali Wetland front; (10) Botanic Garden at Gahanga (part of Nyabarongo Aval Wetland); (11) Golf Course at Nyabarongo Aval; (12) Gikondo Regeneration / Lake Park; (13) Kimicanga Entertainment District; (14) Horticulture Park at Ntora; and (15) Nyabugogo Transport Hub. These projects have been integrated into the proposed Wetland Master Plan.

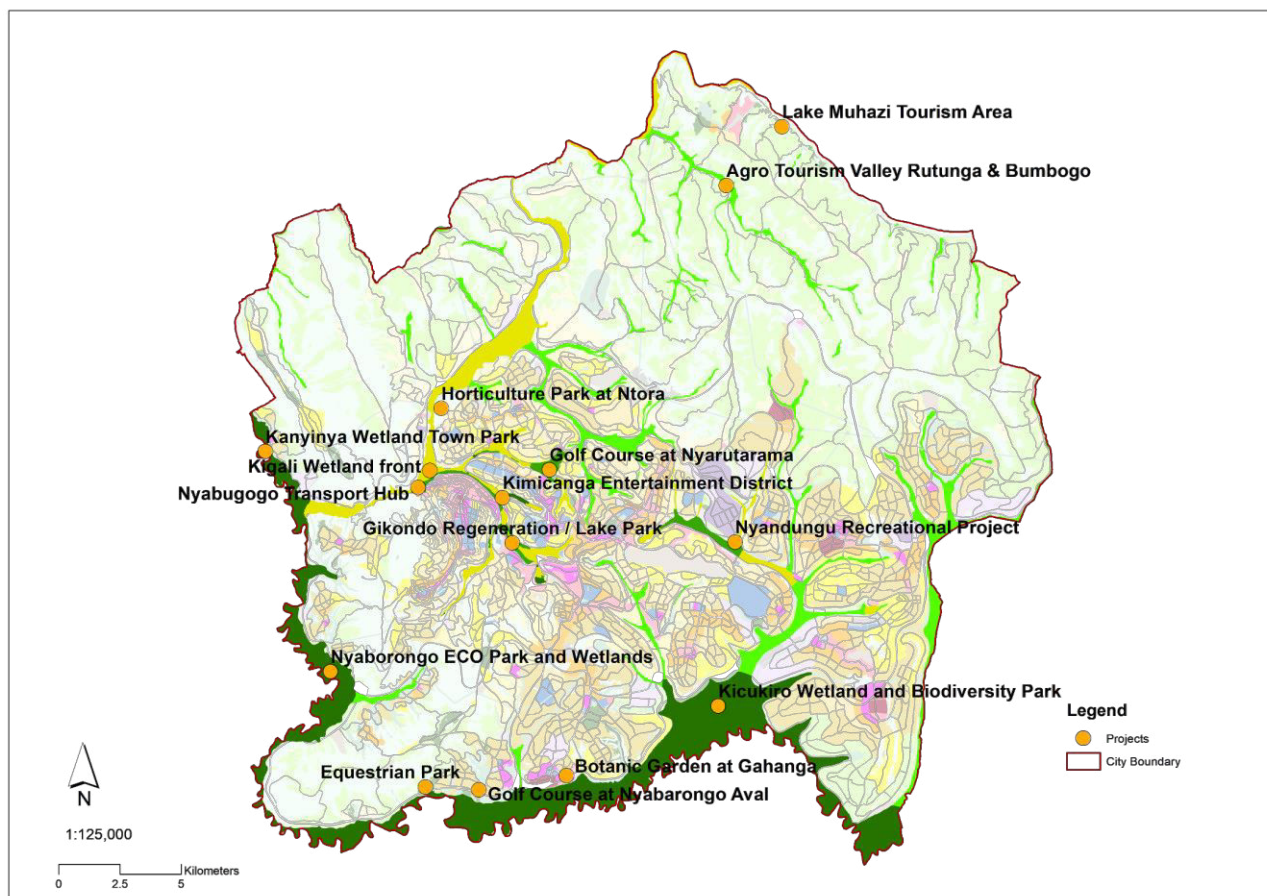


Figure 27: Map showing Proposed Projects as per Kigali 2050 Master Plan

7.6 Digital Wetlands Master Plan

A digital version of the Wetlands Master Plan is available through a web application at <https://wetlandskigali.maps.arcgis.com> (<https://arcg.is/nKWOG>). It allows users to query the zoning for each wetland in the CoK. It is planned to provide documents as downloadable files and related links to the Wetland Master Plan on this website. Also, a link to the Kigali Master Plan will be added as soon as it is publicly available.

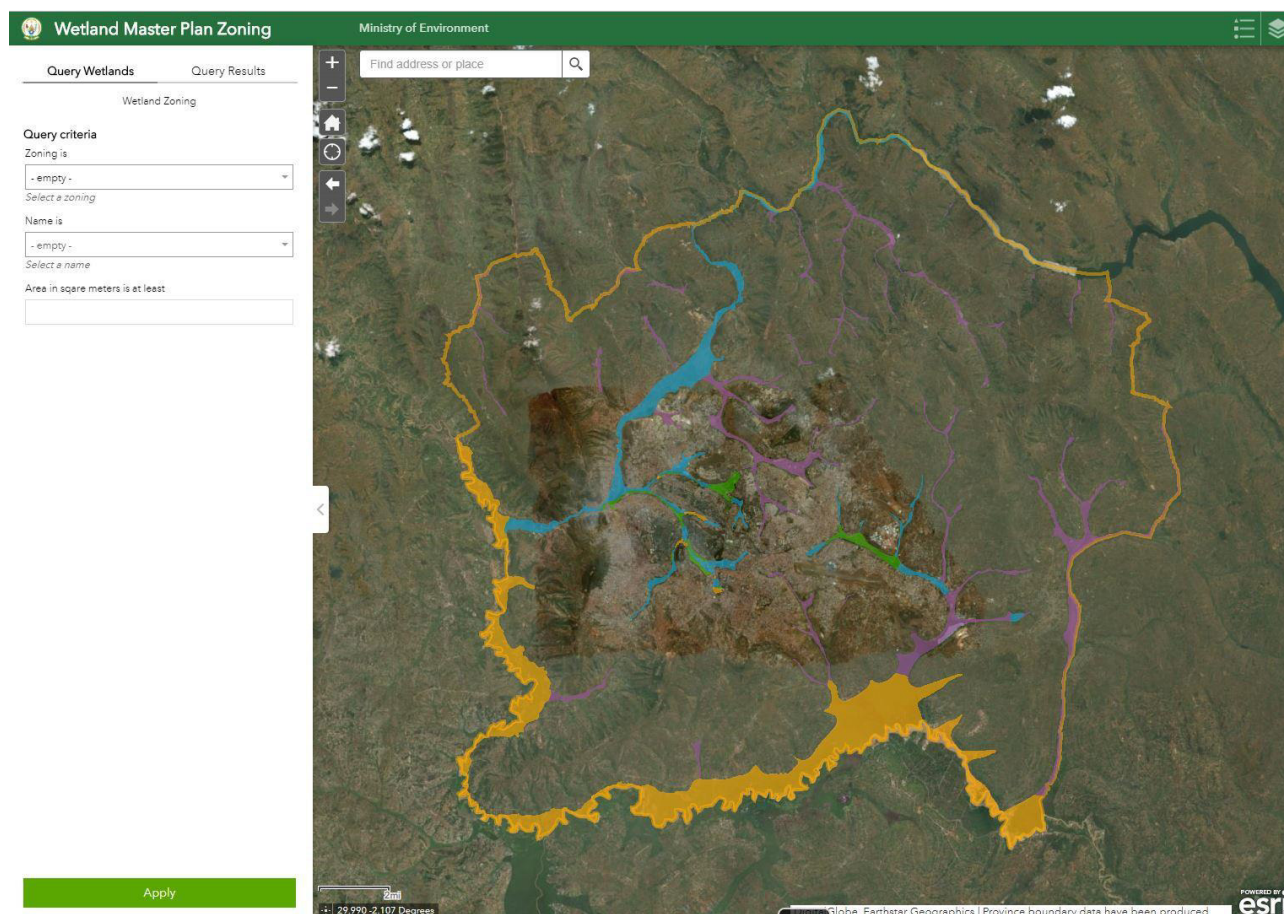


Figure 28: Wetland Master Plan web application

7.7 Management Actions

7.7.1 Hydrology

Developing a hydrological regime that will support wetland organisms is key to wetland rehabilitation. This requires knowing the water balance (inflows and losses), inundation depth and water distribution and the water quality. The water balance is determined by:

$$\text{Balance} = \text{Precipitation} + \text{Inflow} + \text{Groundwater input} - \text{Evapotranspiration} - \text{Outflow} - \text{Groundwater loss}$$

Wetland areas will vary in the timing and depth of inundation. Areas will be permanently inundated, seasonally inundated, intermittently inundated, seasonally waterlogged or always dry. The degree of inundation will depend on the water balance and the topography. Ideally, wetlands should have a variation in depths across the basin as this will provide habitat for a variety of organisms.

Water quality features include sediment loads, pH, concentrations of key plant nutrients (nitrogen and phosphorus), presence of heavy metals or other pollutants. A healthy wetland will serve to improve water quality by trapping sediment particles and removing nutrients (denitrification and immobilization). There is some evidence that wetland plants may take up heavy metals.

7.7.2 Developing a biodiverse community

Biodiverse plant and animal communities are more ecologically stable than depauperate communities. The plant community should consist of a mix of annual, seasonal and perennial species that occupy different zones within the wetland. Aquatic plants may be free-floating (surface or submerged), floating-leaved or emergent. These plants often form distinct zones based on water depth and this is why variation in wetland topography is important. A diverse plant community will make it more difficult for exotic weeds to invade. Three notorious weeds could invade the wetland and these will need to be removed: *Lantana camara*, *Eichhornia crassipes* and *Mimosa pigra*.

Animal communities will be dependent on the variety of plants that form the base of the wetland food chain. Animal abundance will depend on the productivity of the wetland. Some of the animals will be permanent residents but many

birds will be migrants visiting the wetland seasonally. It is important that communities surrounding a wetland are interconnected with other wetlands and this can be achieved by developing riparian corridors within the wetlands and their buffer zones.

7.7.3 Ecosystem processes

A thorough analysis of any wetland undergoing rehabilitation should be subject to a study of the wetland's ecological characteristics as described in Table 13. This evaluation will assist with setting rehabilitation priorities and in developing a management programme.

Table 13: Wetland components, processes and the ecosystem that they may deliver

WETLAND CHARACTERISTICS	DESCRIPTIONS
Ecosystem components (abiotic and biotic)	Geomorphic setting (landscape, catchment area characteristics); Climate (precipitation, temperature, evaporation, humidity); Physical setting (area, boundaries, topography (bathymetry), shape, habitats, habitat connectivity); Water regime (inflow, outflow, balance, groundwater interactions, inundation regime, water quality); Soil (texture, chemistry, biological communities); Biota (Plant and animal communities)
Ecosystem processes (interactions between biotic and abiotic components)	Physical processes (water depth, sedimentation, erosion, channel formation); Energy flow and nutrient cycling (primary production, decomposition, denitrification, biological oxidation and reduction); Population dynamics (animal and plant reproduction, invasion, migration, mortality); Species interaction (competition, predation, succession, herbivory)
Ecosystem services	Provisioning (fisheries, waterfowl, use of aquatic vegetation for economic purposes); Environmental regulation (flood control, dry season water storage); Socio-economic values (recreation, tourism, small business activity, cultural activities, scientific research and education)

7.7.4 Rehabilitation actions

Wetland rehabilitation will require careful planning and involve stakeholders and people who live near and use the wetland. Management issues and relevant actions to be undertaken in wetland rehabilitation are listed in Table 14.

Table 14: Management issues and actions in the process of wetland rehabilitation

MANAGEMENT ISSUE	ACTIONS
Boundary demarcation	Wetlands in the City of Kigali have been delineated; the area within a wetland that is going to be rehabilitated needs to be mapped and any infrastructure to be removed noted
Community awareness	Discuss with stakeholders the changes that are to be made and explain why; assist with relocation and seek ways to minimize the impact on the lives of people who have been using the wetland; continue consultation with stakeholders and local residents throughout the rehabilitation process; where possible, employ people who previously used the wetland in the rehabilitation process
Catchment management	Assess any changes that can be made in the wetland's catchment area; consider tree-planting programmes
Infrastructure removal	Identify infrastructure to be removed and assess the impact on people affected by the change; develop a timeline for removal or provide users with a conditional use permit; consider the environmental impact of building removal versus the impact on the wetland of letting it remain and continue to serve its purpose; ensure that building waste is disposed of appropriately

MANAGEMENT ISSUE	ACTIONS
Hydrology	Assess inflow volumes and construct a water budget for the wetland area; fill drainage ditches with plugs to slow water flow and encourage water to spread out over the wetland area; establish a berm at the end of the wetland being rehabilitated; include pipes so that water can be released if needed and structure the berm to allow for overtopping during floods; where appropriate, create deeper areas to serve as detention basins
Plant biodiversity	Select a few wetland plant species and plant in appropriate depth areas; once plants are established, natural spread will occur and therefore there is no need to cover the entire wetland with plants; plant native species of trees at the wetland boundary
Animal diversity	Animals will be naturally attracted to a well-developed wetland
Monitoring and adaptive management	Monitor the water flow through the wetland and make sure that gullies and channels do not form; check the wetland for invasive weeds; assess whether the wetland can support harvesting of plants or fish; assess wetland development annually and adjust management strategies accordingly

Wetland plants provide a substrate for microbial growth. These microbes are responsible for chemical transformations such as the breakdown of organic matter and denitrification. The plants also play an important role within the sediments with their root systems maintaining hydraulic conductivity, releasing organic matter and providing a conduit for oxygen to enter the sediments. Plants take up nutrients like nitrogen and phosphorus but these will be returned to the water column or sediments when the plants die. In order to remove these nutrients, wetland plants can be harvested to provide materials for weaving or thatching or to make compost. Wetland plants are often found to grow in zones that are related to water depth and availability (in both time and space). A selection of suitable plant species is provided in Table 15 (adapted from NEMUS, 2017).

Table 15: Native plant species that could be planted in wetland zones depending on water availability (NEMUS, 2017)

WETLAND ZONE	WATER AVAILABILITY	SPECIES
Open water, permanent inundation	Water available at all times, floating-leaved, submerged and rooted plants	<i>Cyperus papyrus</i> , <i>Nymphaea nouchali</i> , <i>Potamogeton thunbergia</i> , <i>Typha domingensis</i> , <i>Ceratophyllum demersum</i>
Fluctuating water levels	Water level fluctuating with sediments covered with water or exposed to air	<i>Cyperus articulatus</i> , <i>Cyperus laevigatus</i> , <i>Cyperus latifolius</i> , <i>Juncus</i> spp., <i>Phragmites mauritianus</i>
Aquatic-terrestrial zone	Soils occasionally saturated with water but also dry at times	<i>Aframomum angustifolium</i> , <i>Fleroya rubrostipulata</i> , <i>Pennisetum purpureum</i> , <i>Phragmites mauritianus</i> , <i>Phoenix reclinata</i> (on stream banks)

NEMUS (2017) provided a table that linked the objectives of wetland rehabilitation, the functions provided and the need for planning considerations (Table 16).

Table 16: Planning considerations related to the objectives and purpose for wetland rehabilitation (adapted from NEMUS 2017 and United States Department of Agriculture, 1997)

OBJECTIVE	FUNCTIONS PROVIDED	PLANNING CONSIDERATIONS
Water quality improvement	Associated benefits include lower sediment loads, improved aquatic habitats, enhanced	Design of wetlands for water quality should be influenced by the concentration of the

OBJECTIVE	FUNCTIONS PROVIDED	PLANNING CONSIDERATIONS
	aesthetic and recreation quality and improved water quality for water supply; concentration of toxic and nuisance substances may preclude or impair other wetland functions	contaminants in the inflows, treatment objectives, and realistic performance expectations; the effectiveness of the wetland will be increased by spreading inflows over the wetland, eliminating stagnant areas and increasing detention times; harvesting or removal of vegetation might be needed to reduce pool of accumulated nutrients or for maintenance purposes
Flood storage	Flood detention basins provide aesthetic wetland habitats, may incorporate recreational facilities and may have a significant effect on flood water storage; detention basins may also enhance groundwater recharge	Design requirements are similar to flood conveyance, but often less restrictive; roughness caused by trees and shrubs, as well as other effects, such as reduced stream capacity, are not as critical within flood storage reservoirs; rapid water level fluctuations are a major constraint to wetlands
Flood conveyance	Flood conveyance can be compatible with many other uses or it can be a significant constraint; where design and construction are limited by space or other factors, and vegetation is limited to herbaceous growth, its value for wildlife, fish, recreation, or aesthetics can be very limiting. Where design and construction is less constrained and allows greater vegetative diversity, including woody riparian vegetation, these values can be much enhanced	Individual wetlands or multiple wetland projects seldom provide sufficient land area to increase flood conveyance along waterways or rivers; designs for floodplain wetlands adjacent to rivers and waterways must consider local flood conveyance requirements; for example, the decision as to whether the flood conveyance should include flow retardance/roughness provided by herbaceous or woody vegetation will dictate design requirements; maintenance of vegetation at design water levels is also important
Erosion control	Stabilization of riparian strips with wetland vegetation can benefit many other uses, primarily through reduction of sediment and improved water quality; wetland vegetation installed for erosion control can improve aesthetic and recreational values, and protect the adjoining uplands from erosion	Wetlands provide erosion control through soil stabilization (vegetation establishment, roots) and energy dissipation of drawdowns; wetland vegetation for erosion control, usually located in high energy environments, often requires protection during establishment; in very high energy environments, permanent or semipermanent structures (i.e., rock riprap, revetments, gabion blankets) may be required to provide a stable environment for wetland vegetation
Sediment control	Wetlands trap sediments and this can benefit many other uses through improved water quality downstream; unless removed periodically sediment can accelerate wetland ecological succession and impair its capacity for serving other functions over the long term; corrective measures to remove sediment periodically can	Wetlands for sediment control must consider sediment load and delivery anticipated over the life of the project or include periodic removal and appropriate disposal

OBJECTIVE	FUNCTIONS PROVIDED	PLANNING CONSIDERATIONS
	adversely impact other functional values such as aesthetic quality and recreation	
Natural habitat	Rehabilitated wetlands can provide compatible habitat for wildlife; aesthetic quality, open space, flood storage values and functions are generally compatible; careful monitoring of water withdrawn for water supply and vegetation removed for food or wood products, as well as sensitive use of wetlands for recreational education, can be mutually beneficial for both humans and wildlife; indiscriminate use of wetland resources can adversely affect wildlife	Design wetlands to provide water at the correct depth, time and duration to promote desired vegetation; make it accessible and provide other habitat elements required for the targeted species of wildlife; habitat requirements for water, food, cover (for protection from adverse weather and predators) and reproduction (mating, nesting, brooding) should be considered; migration corridors may be a concern, as are the lack of corridors or widely dispersed habitats
Open space and aesthetic quality	Aesthetic quality and open space are generally very compatible with other functional uses; sediment control, flood conveyance and associated activities may so impair the area's condition, however, as to seriously degrade aesthetic quality or preclude open space; other wetland functions, such as wildlife habitat, education and research, historic and cultural and water quality, often provide the attributes prerequisite for high aesthetic quality	Aesthetic quality and open space are generally natural products of wetland rehabilitation; planning and design for these and other wetland functions must consider the effect and compatibility of alternatives with overall landscape
Food production	Where wetlands are managed primarily for human food, competition with wildlife is often not desired and is constrained by management; other wetland functions which are dependent upon more stable wetland conditions are generally subject to adverse impact by food production activities	The specific requirements (water depth, hydrologic cycle) for each desired species needs to be considered
Recreation	Recreational activities are generally very compatible with other functional uses; season of use and number of visitors may be limited by other functions; flood control may restrict human use during peak flood periods; other functions, such as sediment control, may also place restrictions on recreational use	Specific requirements for desired experiences and levels of activity must be considered during the design phase, as must the type of materials and construction methods that are compatible with other wetland resources; recreation design includes special features, such as walkways, paths, restrooms and visitor centres

8 Action Plan and Implementation Schedule

Many of the wetlands in the CoK, while having a different name, are intimately interconnected. Rugenge Wetland flows sequentially into Rwampara Wetland, Rwezangoro Wetland, Nyabugogo Wetland and Nyabarongo Amtong Wetland. Therefore, any activity in Rugenge Wetland could impact the four wetlands which lie downstream. This interconnectivity also has implications for wetland rehabilitation. Wetland rehabilitation will require some earthmoving to remove drainage channels and create basins and as this is done in upstream wetlands, impacts will occur in any wetland downstream. The usual impact is the input of suspended solids and, potentially, pollutants if the upstream wetland is contaminated. Therefore, a rehabilitation programme must consider techniques that reduce the impact on downstream wetlands. This is important as the rehabilitation priority plan must not focus on just the wetland selected but consider the impacts operations may have on adjacent wetlands and terrestrial systems. In Table 17, some wetlands have been given a medium priority rating because they are interconnected with wetlands that have a high priority rating.

Blackwell and Pilgrim (2011) noted that significant ecosystem services can be delivered by small wetlands and therefore restoration of an entire wetland area may not be necessary in order to achieve some ecological gains. The CoK has a range of wetlands and a number could be selected for conservation through protection while others could be identified as sites suitable for habitat rehabilitation (Table 17). Many of the named wetlands in the CoK have a number of arms and therefore rehabilitation programmes could initially focus on just one arm.

Thirty-seven wetlands have been named and delineated by the Ministry of Environment (MoE). While it is not feasible to start rehabilitation or conservation efforts on all these wetlands, there are activities that can start now. A concerted tree-planting campaign should begin with trees being planted within the wetland buffer zones and areas adjacent to these buffers. Where possible, trees should be native and candidates include: *Albizia gummifera*, *Anthocleista grandiflora*, *Bersama abyssinica*, *Blighi unijugata*, *Borassus aethiopicum*, *Bridelia micantha*, *Celtis Africana*, *Chaetachme aristate*, *Clausena anisate*, *Combretum umbricola*, *Cordia africana*, *Croton macrostachyus*, *Croton megalocarpus*, *Ekebergia capensis*, *Erythrina abyssinica*, *Euphorbia candelabrum*, *Euphorbia tirucalli*, *Ficus lutea*, *Ficus natalensis*, *Ficus sycomorus*, *Podocarpus latifolius*, *Ficus thonningii*, *Ficus vallis-choudae*, *Kigelia africana*, *Maesa lanceolata*, *Maesopsis eminii*, *Phoenix reclinata*, *Prunus africana*, *Pterygota mildbraedii*, *Sapium ellipticum*, *Senegalia* (formerly *Acacia*) *polyacantha*, *Spathoda campanulata*, *Symphonia globulifera*, *Teclea nobilis*, *Trimeria grandiflora*, *Vachellia* (formerly *Acacia*) *kirkii*, *Vachellia* (formerly *Acacia*) *hockii*, *Vachellia* (formerly *Acacia*) *tortilis*, *Vachellia* (formerly *Acacia*) *sieberiana*. Fruit trees, such as avocado, mango, papaya, may also be included.

Clay removal and brick-making activities have significant impacts on wetland ecology and on wetlands that lie downstream of these activities. Brick-making is an important commercial activity but it requires greater regulation and monitoring. Government agencies need to ensure that adequate habitat restoration occurs when the clay resource is exhausted.

Wetlands in the CoK are described in Table 17 and given a priority ranking for either conservation or rehabilitation.

Table 17: Preliminary listing of the priority of the wetlands in the City of Kigali for either conservation or rehabilitation programmes

WETLAND	DESCRIPTION OF WETLAND	RECOMMENDED ACTION	PRIORITY
Akanyaru Nord	Area: 5,146 ha; Large wetland dominated by <i>C. papyrus</i> vegetation with sugar cane plantations and some clay extraction, drained by the Akanyaru River; most of this wetland lies outside the City of Kigali	Conservation	High
Byabagabo	Area 36 ha; Cultivated, sugar cane, clay extraction, human impacts in this wetland will impact Nyabugogo Wetland	Rehabilitation	Medium
Degi-Nyarufunzo	Area: 64 ha; Intense cultivation	Plant native trees next to buffer zone	Low

WETLAND	DESCRIPTION OF WETLAND	RECOMMENDED ACTION	PRIORITY
Gikono	Area: 151 ha; Intense cultivation	Plant native trees next to buffer zone	Low
Kajevuba	Area: 287 ha; Intense cultivation, small lake has <i>C. papyrus</i> vegetation and may provide a model site for rehabilitation methods; clay extraction	Wetland rehabilitation	Medium
Kamusenyi	Area: 40 ha; cultivation, pasture	Rehabilitation	Low
Kanyetabi	Area: 45 ha; <i>C. papyrus</i> vegetation, some cultivation	Conservation	Medium
Karuruma	Area: 41 ha; Intense cultivation, riparian vegetation	Rehabilitate riparian zone by planting native trees	Low
Kaziramuboro	Area: 8 ha; Cultivation, fish ponds, wetland drains into Nyabugogo Wetland	Ensure river and wetland buffer zones are maintained, plant native trees	Medium
Kibobo	Area: 21 ha; Drains to Lake Muhazi, Intense cultivation	Restore the riparian zone of stream draining to L. Muhazi; plant native trees in riparian zone, maintain 50 m buffer zones into L. Muhazi and the wetland	Low
Kiradiha	Area: 42 ha; Intense cultivation, wetland drains into Kitaguzirwa Wetland, and upstream is Mwanana-Mulindi-Kanombe and Mulindi-Kanombe Wetlands. These wetlands need to be managed as a unit. Downstream lies Akanyaru Nord Wetland which is of conservation significance	Include in rehabilitation plans for Mwanana-Mulindi-Kanombe	Medium
Kitaguzirwa	Area: 290 ha; Cultivation and pasture, road and buildings	Include in rehabilitation plans for Mwanana-Mulindi-Kanombe	Medium
Misare	Area: 33 ha; Cultivation, wetland drains to the Nyabugogo River	Plant native trees in and near buffer zone	Low
Mugasagara	Area 2.4 ha; Two small wetlands, cultivated with drainage system, some riparian vegetation in narrow valley between the two patches	Plant native trees in and near buffer zone and maintain buffer zones into L. Muhazi and the wetland	Low
Mulindi-Kanombe	Area: 122 ha; Cultivation, flows into Mwanana-Mulindi-Kanombe	Plant native trees in and near buffer zone	Low

WETLAND	DESCRIPTION OF WETLAND	RECOMMENDED ACTION	PRIORITY
Mwanana-Mulindi-Kanombe	Area: 244 ha; Some cultivation, pasture, buildings and roads, large industrial site nearby, polluted from untreated wastewater that flows from densely populated settlements and possible industrial pollutants, opportunity to develop a recreation and ecotourism park; upstream of Kitaguzirwa Wetland	Significant rehabilitation and remediation required	High
Nyabarongo Amont	Area: 4,849 ha; Wetland straddles the Nyabarongo River, mix of sugar cane plantations and <i>C. papyrus</i> vegetation. The site has been identified for RAMSAR designation. Clay brick factories are present near the wetland	Conservation	High
Nyabarongo Aval	Area: 6,199 ha; Wetland straddles the Nyabarongo River, mix of sugar cane plantations and <i>C. papyrus</i> vegetation. The site has been identified for RAMSAR designation. Clay brick factories are present near the wetland	Conservation	Medium
Nyabugogo	Area: 1,006 ha; Wetland is drained by the Nyabugogo River; some cultivation; wetlands upstream include Rwezangoro, Kamusenyi, Rwampara, Nyabugogo-Kabuye, Misare; the river is significantly polluted but has a prime real estate position	Rehabilitation and remediation	High
Nyabugogo-Kabuye	Area: 230 ha; Intense cultivation; upstream of Nyabugogo Wetland and any rehabilitation plans should include this wetland	Rehabilitation of riparian zone in the centre of the wetland	Medium
Nyabuhoro	Area: 4 ha; Three small wetland patches with cultivation and pasture; northern patch abuts on L. Muhazi with a <i>C. papyrus</i> buffer zone before the lake	Plant native trees in and near buffer zone and maintain 50 m buffer zones into L. Muhazi	Low
Nyabuhoro-Kiruhura	Area: 27 ha; Cultivation, drained by a central stream into the Nyabarongo Aval wetland and then into the Nyabarongo River	Plant native trees in and near wetland buffer zone	Low
Nyacyonga-Mulindi	Area: 99 ha; Cultivation	Plant native trees in the riparian zone of the central stream that drains the wetland	Low
Nyacyonge-Rubilizi-Nyacyonga	Area: 17 ha; Cultivation crossed by two roads, buildings in wetland, wetland ends with <i>C. papyrus</i> vegetation before	Plant native trees in and near wetland buffer zone	Low

WETLAND	DESCRIPTION OF WETLAND	RECOMMENDED ACTION	PRIORITY
	it flows into the Nyabarongo Amont Wetland		
Nyagasozi-Kigozi	Cultivation, some pasture; central stream flows into L. Muhazi; long wetland in narrow wetland	Plant native trees in and near wetland buffer zone	Low
Rubilizi	Cultivation, northern end of the wetland is lined with dense urban settlements, two small roads and one main road cross the wetland; central area of the wetland has a wide cultivated buffer that lines the wetland boundary; some pasture, drains by a small stream to Nyabarongo Aval wetland	Plant native trees in and near wetland buffer zone	Low
Rufigiza-Akagogo	Cultivation, sand and clay extraction;	Plant native trees in and near wetland buffer zone; include in planning rehabilitation of Nyabugogo Wetland	Medium
Rufigiza-Nyagisenyi	Cultivation, joins Rufigiza-Akagogo before flowing into Nyabugogo-Kabuye	Plant native trees in and near wetland buffer zone; include in planning rehabilitation of Nyabugogo Wetland	Medium
Rugende Isumo	Cultivation, southern end has <i>C. papyrus</i> vegetation; large wetland that drains into Nyabarongo Wetland; plans need to include Rwabashamana and Rwamugeni Wetlands	Plant native trees in and near wetland buffer zone	Low
Rugenge	Wetland is almost covered with an industrial site; some green space where this wetland abuts on Rwampara Wetland; includes the area known as Gikondo; this wetland drains into Rwampara, Rwezangoro and Nyabugogo Wetlands	Rehabilitate and remediate, coordinate programme with actions in Rwampara, Rwezangoro and Nyabugogo Wetlands	High
Ruhosha-Ayabaraya	Dominated by <i>C. papyrus</i> vegetation, flows into the Nyabarongo River	Conservation	High
Rwabashamana	Cultivation, clay extraction	Plant native trees in and near wetland buffer zone	Low
Rwampara	Southern end is surrounded by a large green space; reservoir and golf course; cultivation fills most of the wetland beyond the golf course but significant areas of industrial activity; wetland is heavily polluted through disposal of untreated wastewater, industrial pollutants; given large area of	Rehabilitation and remediation; coordinate activities with programmes in Rugenge, Rwezangoro and Nyabugogo Wetlands	High

WETLAND	DESCRIPTION OF WETLAND	RECOMMENDED ACTION	PRIORITY
	undeveloped land that surrounds this wetland, this area should be protected as an urban green space; establish timeline to remove schools (or exclude from wetland boundary) and other buildings		
Rwamugeni	Cultivation; areas with <i>C. papyrus</i> vegetation and open water; joins Gikono and Rugende-Isumo	Plant native trees in and near wetland buffer zone	Low
Rwezangoro	Cultivation, with some <i>C. papyrus</i> vegetation and open water; this small wetland lies between Rwampara and Nyabugogo Wetlands; buildings and industry within the wetland boundary	Rehabilitation and remediation; programme needs to be coordinated with any activities in Rwampara and Nyabugogo Wetlands	High
Rwintare	Dominated by <i>C. papyrus</i> vegetation, cultivation occurs outside the entire wetland boundary; clay extraction and brick factory	Conservation	Medium
Yanze	Three patches; northern patch has a clear central drainage channel and is under intense cultivation; some tree cover; middle patch has meandering stream, mostly under cultivation; stream flows through the southern patch, under cultivation	Plant trees along stream and outside the wetland buffer zone	Low

8.1 Conservation

The following wetlands have been identified as priority wetlands for conservation: Akanyaru Nord, Kanyetabi, Nyabarongo Amont, Nyabarongo Aval, Ruhosha-Ayabaraya and Rwintare. The wetlands selected for priority conservation are those that still support some natural vegetation. Nyabarongo Aval is listed as a medium priority because much of this wetland has cultivation. Rwintare is listed as medium because there is a clay brick factory but most of this wetland has dense *Cyperus papyrus* vegetation and may be worthy of conservation consideration. Kanyetabi Wetland has some cultivation (Table 18).

Table 18: Conservation measures to be taken in high priority wetlands in the City of Kigali

WETLAND	WETLAND DESCRIPTION AND KEY ISSUES	RECOMMENDED ACTIONS	RESPONSIBLE INSTITUTION AND TIMING
Akanyaru Nord	This wetland (5,146 ha) is dominated by a <i>Cyperus papyrus</i> vegetation and a low-medium water pollution rating. Key issues: Agriculture within the wetland.	Conservation plan: Restrict expansion of agricultural activities within the wetland; phase out clay extraction activities and require site restoration when the clay resource is exhausted; encourage development of ecotourism opportunities; assess areas of this wetland for RAMSAR site designation	REMA, MINAGRI Medium term

WETLAND	WETLAND DESCRIPTION AND KEY ISSUES	RECOMMENDED ACTIONS	RESPONSIBLE INSTITUTION AND TIMING
Kanyetabi	This wetland (45 ha) is dominated by <i>Cyperus papyrus</i> . The wetland has brick-making and chicken processing factories. This wetland has a medium water pollution rating. Key issues: Agriculture within the wetland and pollution from chicken factory.	Conservation plan: Phase out the small areas of clay extraction; no agricultural activities in this wetland and most of the area is covered in a <i>Cyperus papyrus</i> vegetation; little would need to be done to have this area designated as a RAMSAR site.	REMA; MINAGRI, RDB, CoK Medium term
Nyabarongo Amont	This large wetland (1,118 ha) straddles the Nyabarongo River and is a mix of sugar cane plantations and <i>Cyperus papyrus</i> vegetation. The site has been identified for RAMSAR designation. A number of clay brick factories are present near the wetland. This wetland has a medium-high water pollution rating. Key issues: Agriculture within the wetland and clay mining near and within the wetland.	Conservation plan: Restrict expansion of agricultural activities within the wetland; phase out clay extraction activities and require site restoration when the clay resource is exhausted; encourage development of ecotourism opportunities; sediment loads in the Nyabarongo River are high and catchment management programmes are urgently needed.	REMA; MINAGRI, RDB, CoK Medium term
Nyabarongo Aval	This large wetland (2,569 ha) straddles the Nyabarongo River and is a mix of sugar cane plantations and <i>Cyperus papyrus</i> vegetation. The site has been identified for RAMSAR designation. The wetland has medium-high water pollution owing to agricultural activities and through the impacts of clay extraction and several clay brick factories. This wetland has a medium-high water pollution rating. Key issues: Agriculture and clay mining within the wetland.	Conservation plan: Restrict expansion of agricultural activities within the wetland; phase out clay extraction activities and require site restoration when the clay resource is exhausted; create detention basins; encourage development of ecotourism opportunities.	REMA; MINAGRI, RDB, CoK Medium term
Ruhosha-Ayabaraya	This wetland (49 ha) is dominated by <i>Cyperus papyrus</i> . There is low to medium water pollution and there is pig farm within the area. Key issues: Agriculture within the wetland.	Conservation plan: Restrict expansion of agricultural activities within the wetland; phase out clay extraction activities and require site restoration when the clay resource is exhausted; encourage development of ecotourism opportunities.	REMA; MINAGRI, RDB, CoK Short term

WETLAND	WETLAND DESCRIPTION AND KEY ISSUES	RECOMMENDED ACTIONS	RESPONSIBLE INSTITUTION AND TIMING
Rwintare	This wetland (79 ha) is dominated by a <i>Cyperus papyrus</i> vegetation. Significant cultivation occurs outside the entire wetland boundary. The Human population density surrounding the wetland is low. There is clay brick factory in the wetland. This wetland has a medium water pollution rating. Key issues: Agriculture and clay mining within the wetland.	Conservation plan: Restrict expansion of agricultural activities within the wetland; phase out clay extraction activities and require site restoration when the clay resource is exhausted; encourage development of ecotourism opportunities.	REMA; MINAGRI, RDB, CoK Short term

8.2 Rehabilitation

Table 19 provides brief rehabilitation plans for those wetlands not being considered for conservation status. These plans need to be staged and any rehabilitation work needs to be preceded by a community awareness campaign. Wetland rehabilitation will cause some social upheaval and people need to prepare for any changes in their lives. Some activities (e.g. tree planting) can begin before any major rehabilitation is undertaken. Wetland rehabilitation is not a simple process and will require significant commitment of resources. Steps to be taken in this wetland rehabilitation are described below.

Table 19: Rehabilitation plans for wetlands in the City of Kigali

WETLAND	WETLAND DESCRIPTION AND REHABILITATION PLAN	RECOMMENDED ACTIONS	RESPONSIBLE INSTITUTIONS AND TIMING
Byabagabo	This wetland (36 ha) has a brick factory at its northern end. Cultivation, including sugar cane fields, occurs along most of its length. There are fishponds within the wetland. A truck depot is present within the wetland boundary. Low human population density around the wetland. This wetland has a medium-high water pollution rating.	Rehabilitation Plan: Restore clay extraction site at northern end; remove infrastructure at the southern end; cease agricultural activity, remove drainage ditches, create detention basins and restore wetland hydrology, plant native trees along stream banks and in and next to the buffer zone; this wetland drains into the Nyabugogo River and therefore impacts sediment loads within this river; Priority: Medium.	REMA, MINAGRI, RLMUA, MINICOM Timing: 10-15 years
Degi-Nyarufunzo	This wetland (64 ha) has a wide area of green space surrounding the boundary of the wetland. However, most of the wetland is under intense cultivation. Sugar cane cultivation occurs where the wetland abuts on Nyabarongo Amont. Roads cross the wetland in two places. This wetland has a medium-high water pollution rating.	Rehabilitation Plan: Cease agricultural activity; remove drainage ditches, create detention basins and restore wetland hydrology; plant native trees in and next to the buffer zone; Priority: Low.	REMA, MINAGRI, RTDA Timing: 15-20 years

WETLAND	WETLAND DESCRIPTION AND REHABILITATION PLAN	RECOMMENDED ACTIONS	RESPONSIBLE INSTITUTIONS AND TIMING
Gikono	Gikono Wetland (29 ha) is divided into two areas. The southern area is under intense cultivation with a few fishponds. The northern area is 'Y'-shaped and the western arm is short and traversed by a road and a few residences occur within the boundary. This arm is almost all under cultivation with two fishponds. The other arm (eastern) has many fishponds at its western end. Some of this arm is cultivated and some is pasture. The area around the wetland is sparsely populated. A large area of the wetland is under rice cultivation with drainage channels. Other crops include sweet potato and banana. This wetland has a medium water pollution rating.	Rehabilitation Plan: Remove infrastructure; convert fish ponds into detention basins for water storage and flood mitigation; cease agricultural activity; remove drainage ditches and restore wetland hydrology; plant native trees in and next to the buffer zone; allow roads within the wetland to remain; Priority: Low.	REMA, MINAGRI, RTDA, CoK Timing: 15-20 years
Kajevuba	Kajevuba Wetland (287 ha) has significant cultivation (sweet potato, beans, maize and taro) with herring-bone drainage into a central channel. There is a residential area along the western boundary at the northern end of the wetland but otherwise there is a low human population density surrounding most of this wetland. Two roads cross the wetland and there is a small reservoir that fills the wetland boundary. A <i>Cyperus papyrus</i> vegetation is at the southern end of the reservoir. A small lake surrounded by a <i>Cyperus papyrus</i> wetland is near the south-eastern end of the wetland. A degraded area (possible from clay extraction) occurs towards the end of the wetland where a road crosses the wetland. This wetland has a low-medium water pollution rating.	Rehabilitation Plan: Remove houses within the wetland boundary; restore areas degraded by clay extractions; cease agricultural activity; remove drainage ditches and restore wetland hydrology; create detention basins for water storage and flood mitigation; plant native trees in and next to the buffer zone; Priority: Low.	REMA, MINAGRI, RTDA, CoK Timing: 15-20 years
Kamusenyi	Most of Kamusenyi Wetland (40 ha) is cultivated but there are degraded areas (clay mining) and poor pasture within the wetland boundary and also surrounding the wetland. A number of roads are present within the wetland boundary. This wetland has a medium water pollution rating.	Rehabilitation Plan: Restore areas degraded by clay extraction and create detention basins for water storage and flood mitigation, cease agricultural activity; remove drainage ditches and restore wetland hydrology; plant native trees in and next to the buffer zone; Priority: Medium.	REMA, MINAGRI, RLMUA, RTDA, CoK Timing: 10-15 years

WETLAND	WETLAND DESCRIPTION AND REHABILITATION PLAN	RECOMMENDED ACTIONS	RESPONSIBLE INSTITUTIONS AND TIMING
Karuruma	Intense cultivation covers most of this wetland (33 ha) that is drained by a tree-lined stream. Some buildings within the wetland boundary. This wetland has a medium water pollution rating.	Rehabilitation Plan: Restore sites degraded by clay extraction; cease agricultural activity; remove drainage ditches and restore wetland hydrology, restore riparian zone by planting native trees along stream, plant native trees in and next to buffer zone; Priority: Low.	REMA, MINAGRI, CoK Timing: 15-20 years
Kaziramuboro	Some cultivation (sugar cane, maize and banana) is present within this wetland (8.4 ha). Two fishponds and a few groves of trees are present. This wetland has a medium water pollution rating.	Rehabilitation Plan: Cease agricultural activity; remove drainage ditches and restore wetland hydrology; plant native trees in elevated areas within the wetland boundary; Priority: Low.	REMA, MINAGRI, CoK Timing: 15-20 years
Kibobo	Kibobo Wetland (21 ha) drains into Lake Muhazi and is under intense cultivation with a grid of drainage channels that flow into a central stream. A road crosses the centre of the wetland. Major crops are sweet potato and rice. This wetland has a low-medium water pollution rating.	Rehabilitation Plan: Cease agricultural activity; remove drainage ditches and restore the riparian zone of stream draining to L. Muhazi; plant native trees in riparian zone, maintain 50 m buffer zones into L. Muhazi and the wetland; rehabilitation will assist in improving water quality in L. Muhazi; Priority: Low.	REMA, MINAGRI, RTDA, CoK Timing: 15-20 years
Kiradiha	Kiradiha Wetland (42.4 ha) is under intense cultivation and is surrounded by medium-density residential areas. This wetland has a medium water pollution rating.	Rehabilitation Plan: Cease agricultural activity; remove drainage ditches and restore wetland hydrology; include in rehabilitation plans for Mwanana-Mulindi-Kanombe; Priority: Medium.	REMA, MINAGRI, CoK Timing: 10-15 years
Kitaguzirwa	The western end of Kitaguzirwa Wetland (290 ha) is cultivated and a main road crosses the wetland. There is an area of open water and the eastern end of the wetland is covered in <i>Cyperus papyrus</i> vegetation. There are a number of structures and buildings in an arm of the wetland to the north of the area of open water. This wetland has a medium-high water pollution rating.	Rehabilitation Plan: Protect <i>Cyperus papyrus</i> vegetation and area of open water at southern end of the wetland; cease agricultural activity; remove drainage ditches and restore wetland hydrology; establish a timeline for the removal of the large processing plant that is within wetland boundary (Inyange) or develop a wetland mitigation plan in conjunction with Inyange or provide conditional approval for operations to continue; include in rehabilitation plans for Mwanana-Mulindi-Kanombe; Priority: Medium.	REMA, MINAGRI, RTDA, MINICOM, CoK Timing: 10-15 years

WETLAND	WETLAND DESCRIPTION AND REHABILITATION PLAN	RECOMMENDED ACTIONS	RESPONSIBLE INSTITUTIONS AND TIMING
Misare	Misare Wetland (33 ha) is under intense cultivation for its entire area and is drained by a central channel that flows into Nyabugogo Wetland. The human population around the wetland is low. This wetland has a low-medium water pollution rating.	Rehabilitation Plan: Cease agricultural activities; remove drainage ditches and restore wetland hydrology; plant native trees on areas of higher ground, along the riparian zone and in and near the buffer zone; Priority: Low.	REMA, MINAGRI, CoK Timing: 15-20 years
Mugasagara	Mugasagara Wetland (2.4 ha) comprises two patches. One abuts the shores of Lake Muhazi (Mugasagara North) and the other lies to the south. The shoreline of Lake Muhazi is lined with <i>Cyperus papyrus</i> and to the south are crop fields (taro, banana and sweet potato). The southern end of the northern patch appears to be uncultivated. Mugasagara South is cultivated with fish-bone drains taking water into Mugasagara Stream. The area around both wetland patches is sparsely-populated. This wetland has a low-medium water pollution rating.	Rehabilitation Plan: Southern patch: cease agricultural activity, remove drainage ditches and restore wetland hydrology; Northern patch: cease agricultural activity, remove drainage ditches and restore wetland hydrology; plant native trees in and near the wetland buffer zone and maintain the 50 m buffer zone into L. Muhazi; Priority: Low.	REMA, MINAGRI, CoK Timing: 15-20 years
Mulindi-Kanombe	The northern end of Mulindi-Kanombe Wetland (122 ha) is 'Y-shaped' with the western and eastern branches both under intense cultivation. The southern section of the wetland has a central drainage channel and most is under cultivation. Two roads cross the wetland. This wetland has a medium-high water pollution rating.	Rehabilitation Plan: Remove small buildings at southern end of wetland; cease agricultural activities; remove drainage ditches and restore wetland hydrology; create detention basins from fish ponds to store water and mitigate flooding; plant native trees in and near the buffer zone and along central riparian zone; Priority: Low.	REMA, MINAGRI, RTDA, CoK Timing: 15-20 years
Mwanana-Mulindi-Kanombe	This wetland has an area of 244 ha. This wetland is heavily polluted from untreated wastewater that flows from densely populated settlements and possible industrial pollutants from Matelas Dodoma (mattress manufacturer), Speranza Ltd, Minimex, Centre Umushumba Mwiza, fertiliser factory, several car garages and fuel stations as well as other factories located in the SEZ. Further impacts come from agricultural activities. The middle section of this wetland (Nyandungu) is being developed as a recreation and ecotourism park. These efforts should continue with the rehabilitation and development of	Rehabilitation plan: provide a pragmatic timeline for the removal of the Palisse Hotel; provide a pragmatic schedule for the removal of all factories and commercial operations; provide a timeline for the removal of all residential buildings within the wetland boundary; allow all roads within the wetland boundary to remain; restore areas impacted by clay extraction and create detention basins for water storage and flood mitigation; cease all agricultural activities and remove drainage ditches; restore wetland hydrology; plant native trees in	REMA, MINAGRI, MINICOM, RTDA, RDB, CoK Timing: 0-10 years

WETLAND	WETLAND DESCRIPTION AND REHABILITATION PLAN	RECOMMENDED ACTIONS	RESPONSIBLE INSTITUTIONS AND TIMING
	Nyandungu Wetland Ecotourism Park (see Gasabo 3D and Astrik INT, 2017); Main road crosses the wetland.	the drier areas within the wetland boundary; create sites for passive and active recreation; Priority: High.	
Nyabugogo	The Nyabugogo River which flows into the Nyabarongo River drains this wetland (724 ha). Much of the wetland is under cultivation and there are a number of buildings and institutions within the wetland boundary. In places the river is lined with trees. The urban areas adjacent to this wetland are subject to flooding, particularly with the heavy rain that falls in October-November. In 2013, a flood affecting Nyabugogo Wetland caused the death of four people and much property loss (Munyaneza et al., 2013). Three flood zones were identified: (1) Confluence of the Yanze and Nyabugogo Rivers; (2) near Kiruhura Market where buildings obstruct water ways and cause back-ups following heavy rain; and (3) the flat area in the northeast. Flooding at Gatsata was caused by poor drainage infrastructure (Munyaneza et al., 2013). The Nyabugogo Wetland is heavily polluted from untreated wastewater the flows from the densely populated settlements that border the wetland and from industrial pollutants from the Nyabugogo taxi park (which is inside the wetland), Kabuye Sugar Factory, Jabana 1 Thermal Power Plant, Rwanda Chicken Farm, Akagera Motors, Phoenix Metals and several car garages and fuel stations including Gemeca, Kobil and Engen. Sekomo et al. (2011) found that chromium, copper and zinc concentrations in the water from Nyabugogo Wetlands were below WHO drinking water standards, whereas cadmium and lead levels were consistently above these limits. Except for cadmium, all metal concentrations were below the threshold levels for irrigation. High metal accumulations were found in sediment and the roots of <i>Cyperus papyrus</i> from the wetland. Concentrations of cadmium, chromium and lead were high in two fish species (<i>Clarias</i> sp and <i>Oreochromis</i> sp). These	Rehabilitation plan: Develop a time schedule for the removal of the Kabuye Sugar Factory or provide conditional approval for it to remain; remove infrastructure near the Nyabugogo and Nyabugogo-Kabuye Wetlands boundary; cease agricultural activities and remove drainage ditches; restore wetland hydrology; provide a timeline for removal of all residences within the wetland boundary; provide a timeline for removal of all infrastructure; develop a plan for the removal of all infrastructure (includes a taxi park, mosque and motel) on both sides of the NR3 highway that fall within the wetland boundary; downstream of the NR3 highway bridge, provide a timeline for the removal of all residences and commercial buildings; this river and wetland area could provide a scenic backdrop to the CBD waterfront development; rehabilitation provides an opportunity to create detention basins and floodplain areas that will lead to flood mitigation; wetland restoration could result in lower sediment loads and improved downstream water quality; roads in or crossing the wetland should remain; new roads should be built outside the wetland boundary or cross the wetland as an elevated bridge; remove infrastructure on the southern bank of this wetland near the boundary with Rwezangoro Wetland and landscape; land can be used for commercial activities as allowed by P4 Conditional Uses; detailed management plan for the wetland is presented in NEMUS (2017); Priority: High.	REMA, MINAGRI, MININFRA, MINICOM, RDB, RTDA, CoK Timing: 0-10 years

WETLAND	WETLAND DESCRIPTION AND REHABILITATION PLAN	RECOMMENDED ACTIONS	RESPONSIBLE INSTITUTIONS AND TIMING
	authors concluded that there is a human health concern for the people using water and eating fish from this wetland. Nhapi et al. (2011) also concluded that Nyabugogo River was heavily polluted with heavy metals and that urgent action is required to control both rural (mainly nutrients and suspended solids) and urban (heavy metals and sewage) sources of pollution. This large wetland area has a prominent position within the City of Kigali and therefore this wetland (and ones closely associated with it) make it a very high priority for rehabilitation; the wetland will also form part of the CBD Waterfront Park that is being developed as part of the City of Kigali Master Plan.		
Nyabugogo-Kabuye	Some rice cultivation occurs within this wetland (230 ha) The central channel is lined with trees and there are some roads and structures within the wetland boundary. This wetland has a medium-high water pollution rating.	Rehabilitation Plan: Restore sites degraded by clay extraction; remove buildings and roads; utilize the weir to restore wetland hydrology; cease agricultural activity and remove drainage ditches; rehabilitate the riparian zone in the centre of the wetland by planting native trees; coordinate rehabilitation plans with those for Nyabugogo Wetland; Priority: Medium.	REMA, MINAGRI, CoK Timing: 10-15 years
Nyabuhoro	This wetland (4.1 ha) lies in a narrow valley and is divided into three patches. The northern patch abuts Lake Muhazi and includes some <i>Cyperus papyrus</i> vegetation and much cultivation (egg plant and sweet potato). The middle patch is mostly cultivated with a few trees. The southern patch is also mostly cultivated with a few trees. This wetland has a low-medium water pollution rating.	Rehabilitation Plan: In all three patches: cease agricultural activity and remove drainage ditches to restore wetland hydrology; plant native trees in and near buffer zone and maintain the 50 m buffer zone into L. Muhazi and the 20 m wetland buffer zone; Priority: Low.	REMA, MINAGRI, CoK Timing: 15-20 years
Nyabuhoro-Kiruhura	This wetland (27 ha) is mostly under cultivation and is drained by a central stream that flows into the Nyabarongo Aval wetland and then into the Nyabarongo River. Major crops are sugar cane, tomato and banana. There are a few buildings within the wetland	Rehabilitation Plan: Restore site degraded by clay extraction, cease agricultural activities and remove drainage ditches to restore wetland hydrology; plant native trees in and near wetland buffer zone; Priority: Low.	REMA, MINAGRI, CoK Timing: 15-20 years

WETLAND	WETLAND DESCRIPTION AND REHABILITATION PLAN	RECOMMENDED ACTIONS	RESPONSIBLE INSTITUTIONS AND TIMING
	boundary and two roads cross the wetland. Some brick-making occurs within the wetland. This wetland has a low-medium water pollution rating.		
Nyacyonga-Mulindi	Most of this wetland (39 ha) is under cultivation. A stream flows down the centre of the wetland and there are groves of trees and a plantation of fruit trees. Some buildings occur within the wetland. This wetland has a medium water pollution rating.	Rehabilitation Plan: Large areas of sugar cane growing in the wetland, cease agricultural activity and remove drainage ditches and restore wetland hydrology; cease stone quarrying activity; plant native trees in the riparian zone of the central stream that drains the wetland; Priority: Low.	REMA, MINAGRI, CoK Timing: 15-20 years
Nyacyonge-Rubilizi-Nyacyonga	This wetland (16.9 ha) is almost entirely under cultivation and is crossed by two roads. Crops include egg plant, banana, pumpkin and maize. This wetland has a low-medium water pollution rating.	Rehabilitation Plan: Cease agricultural activities and remove drainage ditches and restore wetland hydrology; allow roads to remain; a few buildings within the wetland boundary should be removed; plant native trees in and near the wetland buffer zone; Priority: Low.	REMA, MINAGRI, RTDA, CoK Timing: 15-20 years
Nyagasozi-Kigozi	This wetland (19.4 ha) has a central stream that flows into Lake Muhazi. Most of the wetland is under cultivation and there is a road that crosses the wetland. Few people live around the wetland. This wetland has a low-medium water pollution rating.	Rehabilitation Plan: Restore Lake Muhazi 50 m buffer zone; cease agricultural activity and remove drainage ditches; restore wetland hydrology; wetland vegetation restoration could help improve water quality in Lake Muhazi; plant native trees in and near wetland buffer zone; Priority: Low.	REMA, MINAGRI, CoK Timing: 15-20 years
Rubilizi	Most of this wetland (92 ha) is under cultivation. The northern end of the wetland is lined with dense urban settlements and two small roads and one main road cross the wetland. The central area of the wetland has a wide cultivated buffer that lines the wetland boundary. Some of the wetland is pasture and the southern end is drained by a small stream that flows into the Nyabarongo Aval wetland. This wetland has a medium water pollution rating.	Rehabilitation Plan: Cease agricultural activities and remove drainage ditches and restore wetland hydrology; allow roads to remain; a few buildings within the wetland boundary should be removed; plant native trees in and near wetland buffer zone; Priority: Low.	REMA, MINAGRI, RTDA, CoK Timing: 15-20 years
Rufigiza-Akagogo	There are two main arms to this wetland (142 ha) and a discontinuous patch to northwest. The northern arm is bifurcated at the end. The northern	Rehabilitation Plan: Restore areas impacted by clay extraction; cease agricultural activities and remove drainage ditches; restore wetland	REMA, MINAGRI, RTDA, RLMUA, CoK

WETLAND	WETLAND DESCRIPTION AND REHABILITATION PLAN	RECOMMENDED ACTIONS	RESPONSIBLE INSTITUTIONS AND TIMING
	bifurcation has a central drain and most of the area is under cultivation. The southern bifurcation is also under cultivation (rice, taro, cassava, sweet potato and egg plant). A road crosses the wetland just to the west of where the bifurcations join. The rest of the northern arm and the entire southern arm is under cultivation. The discontinuous patch to the northwest is entirely under cultivation. Sand and clay are excavated from the wetland and there is a brick factory. This wetland has a medium water pollution rating.	hydrology; allow roads to remain; plant native trees in and near wetland buffer zone; include in planning rehabilitation of Nyabugogo Wetland; Priority: Medium.	Timing: 10-15 years
Rufigiza-Nyagisenyi	There are many arms to the Rufigiza-Nyagisenyi Wetland (322 ha). Almost all of this wetland is cultivated and drained but there are some areas of pasture. Crops include sweet potato, maize, taro, tomato, egg plant and cassava. Some of the arms extend into densely-settled urban areas. One arm has a wide buffer zone of cultivation. An area of the wetland has been impacted by clay extraction. This wetland has a medium-high water pollution rating.	Rehabilitation Plan: Restore areas impacted by clay extraction; cease agricultural activities and remove drainage ditches; restore wetland hydrology; allow roads to remain; plant native trees in and near the wetland buffer zone; include in planning rehabilitation of Nyabugogo Wetland; Priority: Medium.	REMA, MINAGRI, CoK Timing: 10-15 years
Rugende Isumo	The Rugende-Isumo Wetland (281 ha) has a number of arms. The northern arm that is orientated east-west is entirely cultivated with a buffer zone of cultivation outside the wetland boundary. A main road marks the end of this arm and on either side of the road as it crosses the wetland are buildings within the wetland boundary. On the other side of the road the wetland turns south and this arm is intensively cultivated with drainage channels. Two roads cross the wetland. Another eastern arm joins the wetland and this is divided into two. Both these arms are cultivated and both have a buffer zone of cultivation outside the wetland boundary. The southern end of this wetland is covered in a <i>Cyperus papyrus</i> vegetation. This wetland has been identified as a suitable for RAMSAR site designation. There is a clay brick factory adjacent to the	Rehabilitation Plan: Remove building in Rugende Park; allow roads to remain; restore areas impacted by clay extraction; create a detention basin from the fish ponds; plant native trees in and near wetland buffer zone; protect areas that support a natural vegetation; Priority: Low.	REMA, MINAGRI, RTDA, CoK Timing: 15-20 years

WETLAND	WETLAND DESCRIPTION AND REHABILITATION PLAN	RECOMMENDED ACTIONS	RESPONSIBLE INSTITUTIONS AND TIMING
	wetland. This wetland has a medium water pollution rating.		
Rugenge	This wetland has an area of 140.2 ha. Except for a small area at the southern end of Rugenge where there is a playing field and some cultivation (cassava, banana), the wetland is almost completely covered with an industrial site. There is some green space where this wetland abuts on Rwampara Wetland. This wetland includes the area known as Gikondo. The functions of the Rugenge Wetland have been compromised by the development of an industrial site that covered most of the wetland area. The impact was further exacerbated by drainage of the wetland. The industrial park infrastructure covered between 25-33% of the Gikondo Valley Wetland (KIEM 2006a) and a further area is occupied by lighter infrastructure and a university. This wetland has high water pollution. Water samples collected from the Gikondo Valley Wetland indicated that pollutants were at levels such that the water is no longer suitable for human and animal consumption. BOD levels indicated high levels of organic matter and microbiological analysis further confirmed that the water was unfit for human consumption (KIEM 2006b). Soil tests indicated high levels iron, zinc and chromium. REMA (2009) showed that factories in the CoK deposited approximately 0.12 mg L⁻¹ of metals in the tributaries of the Nyabarongo River.	Rehabilitation plan: The Gikondo industrial park valley is being relocated to the Kigali Special Economic Zone (SEZ) and other suitable special purpose areas in the City (Gimco, 2011; NEMUS, 2017). Continue with removal of infrastructure and include removal of any below-ground foundations, septic tanks or storage tanks; incorporate erosion control techniques where needed so that downstream areas are not impacted by demolition work; once infrastructure is removed, carry out soil and water quality analyses at sites where contamination may have occurred; area may require import of top-soil; plant native trees in areas cleared of infrastructure; provide timeline for removal of residential buildings and other structures in the area east of Gikondo; cease agricultural activities in this area and remove drainage ditches; restore wetland hydrology; plant native trees in the riparian zone of the stream that drains this area; in the area to the south, provide a time schedule for removal of sports facility or provide conditional approval for facilities to remain; cease agricultural activities in this area and remove drainage ditches; restore wetland hydrology; in the long term, the stream that flows down the northern edge of Gikondo will need to be landscaped to meander through the centre of the site; rehabilitation and remediation of this site will require a long-term commitment and significant resources; goal for the Gikondo site should be to create a green space with a meandering stream rather than a wetland; coordinate programme with actions in Rwampara, Rwezangoro and	REMA, MINAGRI, RTDA, MINICOM, CoK Timing: 0-10 years

WETLAND	WETLAND DESCRIPTION AND REHABILITATION PLAN	RECOMMENDED ACTIONS	RESPONSIBLE INSTITUTIONS AND TIMING
		Nyabugogo Wetlands; a detailed management plan for the Gikondo part of this wetland is presented in NEMUS (2017); Priority: High.	
Rwabashamana	This wetland (195 ha) comprises two areas: one linear area and one that is 'Y-shaped'. The linear area (to the West) is under cultivation with some pasture. The 'Y-shaped' area has a mix of cultivation, pasture, some trees and degraded areas. There is a large area of rice cultivation. Other crops include banana, egg plant and sugar cane. There are several areas showing clay extraction and there are several clay brick factories. This wetland has a medium-high water pollution rating.	Rehabilitation Plan: Restore areas impacted by clay extraction; create detention basins; cease agricultural activities and remove drainage ditches; restore wetland hydrology; plant native trees in and near wetland buffer zone; Priority: Low.	REMA, MINAGRI, RLMUA, CoK Timing: 15-20 years
Rwampara	This wetland has an area of 289 ha with a number of arms: the southern arm (Arm A) joins with Rugenge Wetland and continues to the KN3 Road and the roundabout; Arm B from KN3 Road to the boundary with Rwezangoro Wetland; Arm C is short, above KG3 Avenue; Arm D is the rest of the wetland to the north that includes the golf course. Cultivation fills most of the wetland beyond the golf course but there are significant areas of industrial activity. The wetland is heavily polluted through disposal of untreated wastewater, industrial pollutants from sources such as Utexrwa textiles, industries along KG15 Road (timber yard, petroleum depot) and several car garages. The environment is further impacted by burning tyres, the presence of main roads in the wetland and agricultural activities. Crops include banana, taro, sweet potato and maize.	Rehabilitation plan: Arm A: provide a timeline for the removal of infrastructure and residences; cease all agricultural activities and remove drainage ditches, restore wetland hydrology; remove roads except for KK2 Avenue and KN3 Road; the central channel is eroded and will require remedial work; Arm B: significant infrastructure to be removed near the boundary with Rugenge Wetland; restaurants near KN5 Road to be given a timeline to move or conditional approval to continue operation; Glory High School and La Colombiere to be given a timeline to move or conditional approval to continue operations (removal of these structures will cause significant environmental problems and cause social upheaval and conditional approval is recommended); a timeline should be provided for the removal of all other infrastructure and residences; KN12 Street and KN8 Avenue should remain, other roads should be removed; the central channel is eroded and will require remedial work; the upper section of Arm C is a good candidate to develop a model of	REMA, MINAGRI, RTDA, RDB, MINEDUC, MINICOM, CoK Timing: 0-10 years

WETLAND	WETLAND DESCRIPTION AND REHABILITATION PLAN	RECOMMENDED ACTIONS	RESPONSIBLE INSTITUTIONS AND TIMING
		wetland rehabilitation; the area is small and there is very little infrastructure; cease agricultural activities and remove drainage ditches; restore wetland hydrology; Arm D: The section above KG535 Street includes a reservoir and is surrounded by a wide buffer of green space; this section is another good candidate for rehabilitation; in the green space an area could be set aside to develop a botanical garden. This area would also lend itself to the development of hiking and biking trails; cease agricultural activities and remove drainage ditches; restore wetland hydrology; plant native trees; conditional approval should be given for the section of the golf course that falls within the wetland boundary to remain; the section from the golf course to the Utexrwa Factory is mostly under cultivation with some fish ponds; cease agricultural activities and remove drainage ditches; restore wetland hydrology; the Utexrwa Factory lies within the wetland boundary and it should either move or be given conditional approval to continue operations; the infrastructure between the Utexrwa Factory and above and below the KG33 Avenue should be removed; cease all agricultural activities in the remaining section to the boundary with Rwezangoro Wetland; restore wetland hydrology; coordinate activities with programmes in Rugenge, Rwezangoro and Nyabugogo Wetlands; Priority: High.	
Rwamugeni	This wetland has an area of 5 ha. The eastern end of Rwamugeni Wetland is intensively cultivated (maize, banana, taro and sugar cane). There is an area of open water before the wetland turns north. This northern arm is also cultivated but has groves of fruit trees particularly at the northern extremity	Rehabilitation Plan: Restore areas impacted by clay extraction, cease agricultural activities and remove drainage ditches; restore wetland hydrology; keep reservoir free of water hyacinth; plant native trees in and near the wetland buffer zone; Priority: Low.	REMA, MINAGRI, CoK Timing: 15-20 years

WETLAND	WETLAND DESCRIPTION AND REHABILITATION PLAN	RECOMMENDED ACTIONS	RESPONSIBLE INSTITUTIONS AND TIMING
	of the wetland area. This wetland has a medium water pollution rating.		
Rwezangoro	Rwezangoro Wetland (24 ha) has a mix of cultivation, areas with <i>Cyperus papyrus-Typha domingensis</i> vegetation and open water. Some of the wetland is infested with water hyacinth (<i>Eichhornia crassipes</i>). Intense urban development surrounds this wetland and industrial activity is occurring within the wetland boundary. The wetland has a medium water pollution rating. This wetland is given a high priority for rehabilitation because of its location between Rwampara and Nyabugogo Wetlands.	Rehabilitation Plan: Remove all infrastructure on the southern bank of this wetland and landscape; land can be used for commercial activities as allowed by P4 Conditional Uses; cease agricultural activities and remove drainage ditches; restore wetland hydrology; plant native trees along stretches of the north bank of the wetland; rehabilitation and remediation programme needs to be coordinated with any activities in Rwampara and Nyabugogo Wetlands; control water hyacinth; Priority: High.	REMA, MINAGRI, MINICOM, RDB, CoK Timing: 0-10 years
Yanze	This wetland has an area of 57 ha and is split into three patches. The northern patch has a clear central drainage channel and is under intense cultivation. An arm at the southern end of this patch is also cultivated but has some tree cover. The middle patch has meandering stream flowing through it and most of the area is under cultivation. The same stream flows through the southern patch and this area is also under cultivation. The human population density surrounding Yanze Wetland is low. This wetland has a medium water pollution rating.	Rehabilitation Plan: Northern patch: cease agriculture and remove drainage ditches, restore wetland hydrology; plant native trees along central drainage channel to form a riparian zone; Middle patch: cease agriculture and remove drainage ditches, restore wetland hydrology; plant native trees along central meandering stream to form a riparian zone; Southern patch: cease agriculture and remove drainage ditches, restore wetland hydrology; plant native trees along central channel to form a riparian zone; Priority: Low.	REMA, MINAGRI, CoK Timing: 15-20 years

8.2.1 Rehabilitation activities and timeline

Wetland rehabilitation largely relies on restoration of a hydrology that can support the growth of wetland plants. Once conditions are suitable, wetland plants may take some time to become established. Since trees are slow-growing, tree-planting should occur as a first step. An effective rehabilitation programme will require:

1. Identify funds for wetland rehabilitation programmes.
2. Carry out an awareness-raising campaign in the area around a wetland before beginning any rehabilitation activities.
3. Carry out a Livelihood Restoration Plan and a Resettlement Action Plan for each wetland before beginning any rehabilitation activities.
4. Prioritise rehabilitation efforts and start with a wetland that can show results reasonably quickly. This can then be used as a model in awareness-raising campaigns for other wetlands.
5. Remove infrastructure from wetlands undergoing rehabilitation. Provide a timeline for the removal of residences and institutions (e.g. schools) to allow time for alternative accommodations to be developed.
6. Consider altering wetland boundaries so that useful institutions can continue to serve their purpose or provide conditional approval for these institutions to continue operations.

7. Provide a timeline for the cessation of agriculture in wetlands to undergo rehabilitation.
8. Produce a landscape plan for wetlands to undergo rehabilitation that includes erosion control structures, water flow control structures, detention basins and wetland planting design.
9. Locate a source of native tree seedlings or establish a nursery to provide an adequate supply and diverse range of tree species.
10. Plant trees in buffer zones and areas adjacent to wetlands. Where possible use native trees or fruit-bearing trees (e.g. avocado, mango, papaya).
11. Clay removal and brick-making activities require greater regulation and monitoring. Government agencies need to ensure that adequate habitat restoration occurs when the clay resource is exhausted. Clay removal causes major problems with water turbidity as the fine clay particles take a long time to settle but water clarity can be restored by adding gypsum (CaSO_4).
12. Commercial clay removal may support a programme of wetland rehabilitation with the areas where clay has been removed becoming detention basins and deeper areas in the rehabilitated wetland.
13. Ensuring a good spread of water over a wetland area is essential to any wetland rehabilitation. Detailed hydrological studies will be required for each wetland area to ensure that there is an adequate supply of water throughout the year. In removing drainage ditches, detention basins can be created to serve water storage and flood mitigation functions. Variations in water depth will also promote plant biodiversity. The wetland will require monitoring to ensure that soil erosion does not lead to the formation of channels and gullies, allowing water to short-circuit the wetland.
14. Remove water hyacinth (*Eichhornia crassipes*), *Lantana camara* and *Mimosa pigra* from wetlands.

The timeline for any rehabilitation programmes will depend on access to funds and completion of the planning process that will entail cooperation from stakeholders who use the wetlands. Two timeline plans are presented below.

8.2.1.1 Five Years

1. Seek funds to carry out rehabilitation works on selected wetlands. This will require development of Conservation Investment Plans for each rehabilitation project and each request should include an allocation for funds to support a Community-Awareness Programme, Livelihood Restoration Plan and a Resettlement Action Plan.
2. Continue with the removal of infrastructure from the Gikondo part of Rugenge Wetland. Ensure that structures do not contain toxic materials such as asbestos and, if detected, dispose of these materials appropriately. Negotiate a timeline for the departure of companies and businesses that still have operations within this wetland. As structures are removed, landscape areas to reduce erosion and check soil and water quality within the cleared sites. If needed, import top soil and plant trees.
3. Continue with the rehabilitation of the Nyandungu area in the Mwanana-Mulindi-Kanombe Wetland.
4. Select a wetland or wetland area for a rehabilitation programme and begin with an awareness campaign. Check on the source of water for the wetland and make sure that there is an adequate supply. Draw plans for the wetland: ditches to be filled, where detention basins may be located, how water will be distributed over the area to be inundated. Design the end of wetland berm structure that will allow overtopping and release of water if needed downstream. Identify a source of wetlands plants.
5. Establish a source of trees and start a tree-planting campaign in those wetlands that are being used extensively for agriculture.

8.2.1.2 Ten Years

1. Develop a publicity programme that describes the benefits of the wetland rehabilitation programme using the wetland restored in the first five-year plan as a model.
2. Identify other wetlands to be rehabilitated and repeat the process as described above.

8.2.2 Socio-economic consequences of wetland rehabilitation

There will be negative and positive socio-economic consequences to the wetland rehabilitation programme. Negative impacts will include:

1. Loss of agricultural land and the food that it produces for family consumption and income supplementation;
2. Loss of access to pasture to raise livestock;
3. Increase in waterborne diseases such as malaria as area of stagnant water increases;
4. Social dislocation as people lose their residences and have to find elsewhere to live;
5. Loss of schools and other social institutions;
6. Loss of jobs as commercial operations are closed; and

7. Loss of access to wetland clay for brick-making operations.

Positive socio-economic impacts of rehabilitated wetlands will include:

1. Creation of jobs in wetland remediation and rehabilitation operations;
2. Creation of jobs in areas where industries are re-located;
3. Creation of nature areas for passive and active recreation;
4. Opportunities for small businesses operating near rehabilitated wetlands;
5. Opportunities to expand eco-tourism in wetland areas designated for conservation;
6. Opportunities for sustainable harvesting of wetland products such as plants for weaving;
7. Wetlands can provide fish, geese and ducks and a range of edible plants; and
8. Increase in tree cover will assist in climate change mitigation.

8.2.3 Environmental consequences of wetland rehabilitation

Wetland rehabilitation will provide the following environmental values:

1. Water storage and streamflow regulation: wetlands store water and prolong river flows;
2. Drought relief: wetlands provide water during dry periods;
3. Flood peak reduction: wetlands can reduce flood peaks and reduce the destructive force of floods;
4. Sediment accretion and protection from soil erosion: wetland plants stabilize soils and trap sediment particles;
5. Improvement in water quality: wetland plants improve downstream water quality by trapping sediments, immobilizing nutrients and transforming chemicals (e.g. denitrification, organic matter decomposition); and
6. Increase in habitat and species diversity.

The process of wetland rehabilitation may have some negative environmental impacts:

1. Waste generated by the removal of infrastructure will require appropriate disposal;
2. Soil erosion may occur as drainage ditches are filled and detention basins created;
3. Increase in habitat for aquatic weeds such as water hyacinth may impede the wetland rehabilitation.

These positive and negative impacts need to be explained through a community-awareness campaign that is carried out prior to the start of any wetland rehabilitation efforts. The rehabilitation programme should include strategies to minimize the impacts of relocations by providing alternative sites for residences and commercial operations. People currently using the wetlands should be offered jobs in the process of wetland rehabilitation such as landscaping and tree-planting. Changes that impact people need to be scheduled such that they have time to make alternative arrangements. Similarly, institutions that will lose buildings need to be given time to find alternative accommodation. Consideration should be given to modifying some of the wetland boundaries so that some environmentally-benign businesses and institutions can remain. As part of this process, the environmental consequences of building-removal need to be offset against any likely benefits.

8.2.4 Wetland and Storm Water Management

Storm water management and wetland management are intimately interconnected and should be managed in an integrated manner. This integration will lead to a more effective mechanism in flood mitigation leading to protecting lives and livelihoods, protecting infrastructure and improving water quality. Combining stormwater and wetland management through low impact, cost effective, nature based solutions that protect catchment areas and improve the capacity of wetlands to deliver ecological services, will lead to flood attenuation and water quality improvements.

There is need to prepare for an increased storm water generation as Rwanda continues to urbanize and increase paved areas. Wetlands in the City of Kigali are degraded and have a diminished capacity to store water and release it slowly following storm events. Wetland rehabilitation will increase the capacity to store storm water and improve water quality through natural processes.

9 Recommendations

9.1 General

1. Adopt the following definition of a wetland: “land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which in normal circumstances supports or would support vegetation typically adapted to life in saturated soils” (National Water Act (South Africa)).
2. There are many names for land areas that temporally or permanently wet, e.g. bog, carr, fen, marsh, mire and swamp. In Rwanda, legislation should use only ‘wetland’ when seeking to describe such areas.
3. Establish Catchment Committees and Catchment Water Management Offices at the catchment level to facilitate more effective resource management of the catchments in which the CoK lies.
4. Develop an integrated Water Resource Management (IWRM) Plan.
5. Develop and regularly update a wetlands and waterbodies management manual.
6. Develop a wetlands awareness campaign and capacity building training programmes.
7. Develop participatory programs and action plans for timely implementation.
8. Establish and maintain detailed records (electronic folders) on all wetlands in the CoK. Include drone survey photos, Google Earth photos, on site photos, records of crops grown, presence of infrastructure, inventories of plants and animals present and their distribution and data on hydrology, soils and water quality.
9. Develop an inventory of illegal activities in urban wetlands with maps and photos detailing these activities
10. Five wetlands (Akanyaru Nord, Kanyetabi, Nyabarongo Amont, Nyabarongo Aval, Ruhosha-Ayabaraya and Rwantare) within the CoK are listed as priority wetlands for conservation. Further consideration is required before these sites are nominated for RAMSAR designation.
11. Wetland rehabilitation programmes could be combined with a commercial clay extraction operation. The clay extraction would serve to create a series of deeper water regions (1-3 m) and these, together with shallower regions, would provide a variety of habitats for wetland organisms. The deeper areas would also ensure water remains in the wetland during extended dry periods. This programme of combining resource use with habitat restoration should be presented as a public-private partnership leading to wetland rehabilitation. A comparable programme was undertaken in Penrith near Sydney, Australia in which a sand and gravel extraction from a floodplain lead to the formation of the Penrith Lakes that are used for rowing regattas and other recreational activities (see: www.penrithlakes.com.au/home/).
12. Strengthen existing wetland research programmes and encourage conservation and restoration of ecosystems critically threatened by climate change.
13. The wetlands that should be a priority for rehabilitation include Rwampara, Rwezangoro, Nyabugogo, Rugenge and Mwanana-Mulindi-Kanombe. Rehabilitation programmes should focus on the upstream reaches of the wetlands and gradually work downstream.

9.2 Hydrology

1. In order to model the wetlands, elevation-area-capacity curves for the permanently flooded wetlands should be developed. This could be achieved through bathymetric and topographic surveys.
2. Flood inundation maps using hydraulic models when bathymetry data are available should be developed. This would provide decision-makers with information to establish buffer zones during wetland development.
3. Wetland water levels should be monitored including measuring outflows using hydraulic structures for better estimation of residence times.
4. The hydrology model used could be coupled with environmental flow assessment models and used to size stormwater management facilities such as ponds, set-backs, catch pits connected with natural wetlands.
5. Wetland mapping should also be intensified using aerial imagery, drone survey and other remote-sensing techniques. The mapping could be coupled with flood inundation maps to define buffer zones.
6. Storm water management and wetland management are intimately interconnected and should be managed in an integrated manner. This integration will lead to a more effective mechanism in flood mitigation leading to protecting lives and livelihoods, protecting infrastructure and improving water quality. Combining stormwater and wetland management through low impact, cost effective, nature based solutions that protect catchment areas and improve the capacity of wetlands to deliver ecological services, will lead to flood attenuation and water quality improvements.
7. There is need to prepare for an increased storm water generation as Rwanda continues to urbanize and increase paved areas. Wetlands in the City of Kigali are degraded and have a diminished capacity to store

water and release it slowly following storm events. Wetland rehabilitation will increase the capacity to store storm water and improve water quality through natural processes.

9.3 Water Quality

1. Identify polluted wetlands and develop a decontamination plan including the use of environmentally-sound technologies for pollution prevention, control and remediation.
2. The relatively high levels of Dissolved Inorganic Nitrogen (DIN) (low compliance) found in the catchments within the CoK are likely caused by the inorganic nitrogen fertilisers which are being applied liberally in cultivated areas. Raising public awareness of the importance of protecting water resources from pollution including that from the inappropriate use of fertilisers, should be undertaken. Alternatively, agricultural activities at encroached areas may be relocated to specially designated areas.
3. The relatively high levels of *E. coli* (low compliance) found in the catchments within the CoK indicate pollution of water courses by domestic wastewater. Therefore, better wastewater management and the construction of a centralised sewerage system in Kigali is recommended to alleviate this issue.
4. Establish a Sewage Treatment Plant that includes tertiary treatment of effluents (phosphorus removal).
5. The relatively high levels of Total Suspended Solids (TSS) and turbidity (low compliance) found in the catchments within the CoK are likely caused by erosion within catchments caused by unsuitable agricultural practices, as well as a result of pollution by domestic wastewater. Raising public awareness of the importance of protecting water resources from pollution including that resulting from poor cultivation and adoption of soil conservation practices, should be undertaken.
6. A practical and cost-effective water quality monitoring programme should be developed and undertaken systematically so as to identify the extent and status of water resources, detect problems and deploy timely remedial measures.
7. The restoration, by REMA, of a portion of the Mwanana-Mulindi-Kanombe (Nyandungu) Wetland as part of the 134 ha Nyandungu Urban Wetland Eco-Tourism Park project is a positive development. Importantly, compliance of the upstream Special Economic Zone (SEZ) industries is key to the success of this project. Polluting industries should be managed appropriately to ensure they have appropriate in-house wastewater treatment systems.
8. One possible management approach falls under the "polluter pays" principle. This principle needs to be applied in conjunction with other legal and administrative actions.
9. Several industries are in the process of being relocated from the Gikondo industrial park valley to the SEZ, another positive development aimed at restoring the Rugenge (Gikondo) Wetland. This presents an opportune moment to ensure that the industries set-up appropriate in-house wastewater treatment systems at their new locations in the SEZ, before they are allowed to relocate.
10. Ensure that new developments include techniques to reduce stormwater run-off by enhancing infiltration and to improve water quality using natural techniques such as pervious paving, swales, detention basins and constructed wetlands.

9.4 Wetland Ecology

1. Public education campaigns are needed so that people who live near wetlands in the City of Kigali are aware of the goods and ecological services that wetlands provide and are also aware that activities are prohibited within the wetland boundaries including the 20 m buffer zone. People also need to be aware of the environmental impact of using fertilizers, herbicides and pesticides.
2. Fisheries and aquaculture legislation and regulations should be strictly implemented for all national water bodies.
3. The impact of habitat destruction in wetlands should be reduced as the vegetation in these areas provide spawning areas and breeding sites for many biological species. Greater regulation of fishing methods and gears is required and programmes to reduce populations of *Clarias* and *Protopterus* species which are impacting populations of small cichlids and other native fish should be implemented.
4. A programme of recreational fishing could be established at Inyange Lagoon by stocking fish and creating safe and clean shorelines in Masaka and Kanombe Sectors.
5. Wetland rehabilitation needs to involve local communities, cooperatives and the private sector.
6. Wetland conservation policies should be applied to all wetlands in the City of Kigali.
7. Nyandungu Wetland has a population of the dragonfly *Crocothemis erythraea* which is listed in the IUCN Red Data Book and an endangered bird (grey-crowned crane) that should be protected.

9.5 Mapping, Land-Use and Urban Planning

1. There should be integration of different government agencies to fully implement the restoration of wetlands and ensure their sustainable use and conservation by creating a national committee to guide wetland reclamation and restoration.
2. A community watchdog team should be set up in order to prevent people from encroaching on wetlands and organize community awareness programmes.
3. Ownership and legal status of wetlands should be clearly defined, and the Government should reserve a budget to compensate developmental activities in wetlands and relocate people using wetlands to another place.
4. Promote a long-term phased reduction in wetland cultivation and an increase use of upland areas for agriculture (including household kitchen gardens and green roofs).

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