TECHNICAL ASSISTANCE IN ENVIRONMENT AND NATURAL RESOURCES MANAGEMENT

NILE MUKUNGWA CATCHMENT INTEGRATED POLLUTION MANAGEMENT PLAN

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NILE MUKUNGWA (NMUK) CATCHMENT INTEGRATED POLLUTION MANAGEMENT PLAN

UNIVERSITY of RWANDA

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ABBREVIATIONS AND ACRONYMS

BMPs	Best Management Practices
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
DDS	District Development Strategy
DO	Dissolved Oxygen
DPSIR	Drivers, Pressure, States, Impacts and Responses
EAC	East African Community
EbA	Ecosystem-based Adaptation
EDCs	Endocrine Disrupting Chemicals
EDPRS-2	Economic Development Poverty Reduction Strategy - 2
EIP	Early Implementation Project
EUCL	Energy Utility Cooperation Ltd
FONERWA	Rwanda Green Fund
GEF	Global Environment Fund
GIS	Geographical Information System
GoR	Government of Rwanda
JMP	Joint Monitoring Programme
IPMP	Integrated Pollution Management Plan
IWRM	Integrated Water Resources Management
LODA	Local Administrative Development Authority
LULC	Land Use Land Cover
LVB	Lake Victoria Basin
LVEMP	Lake Victoria Environmental Management Project
LWH	Land Husbandry, Water Harvesting and Hillside Irrigation
M&E	Monitoring and Evaluation
MIDIMAR	Ministry of Disaster Management and Refugee Affairs
MIGEPROF	Ministry of Family and Gender Promotion
MINAFFET	Ministry of Foreign Affairs and Cooperation
MINAGRI	Ministry of Agriculture and Animal Resources
MINALOC	Ministry of Local Government
MINECOFIN	Ministry of Finance and economic Planning

MINEDUC	Ministry of Education
MINICOM	Ministry of Commerce
MININFRA	Ministry of Infrastructure
MINIRENA	Ministry of Natural Resources
MIS	Management Information System
MoE	Ministry of Environment
NGO	Non-Governmental Organization
NMUK	Nile Mukungwa
NWRMP	Water Resources Master Plan
PhACs	Pharmaceutically Active Compounds
PAREF	Reforestation Support Project (Projet d'Appui à la Reforestation)
POPs	Persistent Organic Pollutants
RDB	Rwanda Development Board
REMA	Rwanda Environment Management Authority
RHA	Rwanda Housing Authority
RLMUA	Rwanda Lands Management and Use Authority
RNRA	Rwanda Natural Resources Authority
RSSP	Rural Sector Support Project
RWB	Rwanda Water Board
RWFA	Rwanda Water and Forestry Authority
SDG	Sustainable Development Goals
SEA	Strategic Environmental Assessment
UNEP	United Nations Environment Programme
WASAC	Water and Sanitation Corporation
WHO	World Health Organisation
W4GR	Water for Growth Rwanda

0. EXECUTIVE SUMMARY

0.1. Introduction

The Government of Rwanda (GoR) through Rwanda Environment Management Authority (REMA) is implementing a pilot project of Least Developed Countries Fund (LCDF) II titled "Building resilience of communities living in degraded forests, savannahs and wetlands of Rwanda through an Ecosystem-based Adaptation (EbA) approach" funded by Global Environment Facility (GEF) through United National Environment Programme (UNEP) under climate change adaptation GEF focal rea. The main objective of the project is to increase capacity of Rwandan authorities and local communities to adapt to climate change by implementing Ecosystem based Adaptation (EbA) interventions in degraded forests, savannahs and wetlands ecosystems.

During the implementation, a need was identified to conduct a study on Wetland and Catchment Management Framework that will be used for upscaling of wetland ecosystem restoration activities under the project. Nile Mukungwa Integrated Pollution Management Plan was developed under Water Quality Management task undertaken as part of the above study. It provides a comprehensive analysis of pollution issues in the Nile Mukungwa catchment and proposes adequate interventions to sustainably tackle those issues.

0.2. Methodology

Nile Mukungwa Integrated Pollution Management Plan was developed using various methods. Literature review was undertaken to familiarise the project team members with the catchment area under consideration, and the historical pollution issues that have been documented. The review of relevant district development plans, catchment management plan, and district sanitation master plans was made, provided that the last ones were available at the time. Consultation with institutions at national level such as Rwanda Land Use and Management Authority (RLMUA), Rwanda Water Board (RWB) and Rwanda Housing Authority (RHA) provided data and information (shapefiles) that were used to delineate the catchment boundaries and generated different maps related to catchment. Field visit and interviews with district officials, community users and others with knowledge of pollution sources and concerns within the catchment allowed the team to identify pollution hotspots in their area, what the pollution concerns were and their impacts, the possible sources of pollution, and what is or could be done to manage it. At last, stakeholder workshops were organised to give officials and other delegates from the catchment and national level the opportunity to confirm and prioritise the pollution issues in their area, to develop the key elements of an integrated pollution management vision for their area, and to develop initial goals, objectives and interventions to manage pollution in their catchment.

0.3. Situation analysis

The total surface area of Nile Mukungwa (NMUK) level one catchment within Rwanda is estimated at 1,902 km^2 covering the following five districts: Burera, Musanze, Gakenke, Nyabihu, and Ngororero with some minute areas of the catchment located in the district of Gicumbi. Nile Mukngwa catchment comprises a large zone with tuff and lava deposits sloping downward from a series of five towering volcanoes characterized by rather thinly distributed, partly ephemeral and discontinuous surface channels interacting with very complex and intricate groundwater flows in the north-west. The east of the catchment features steep hills that drain onto a spectacular cascading system of high altitude wetland (Rugezi) and lakes (Burera and Ruhondo) from which the Mukungwa River emerges in the centre of the catchment. This river drains the remaining upland valleys and slopes in the central and south western part of the catchment in a mostly southern direction towards its confluence with the Nyabarongo River.

The rainfall pattern shows average annual rainfall slightly above 1,300 mm/year which equates to some 2,563 hm^3/annum with separate two rain seasons (long rains which spans from March, April and May, and short rains which spans September, October, November and December and two dry seasons (Jan-February and June-September). Average water quality data from monitoring network in the catchment indicate low levels of suspended sediments in Mukungwa upstream (7 NTU at Burera Lake outlet and 43NTU at Nyakinama sampling station) but sediments enrichment increases while moving far downstream and attain the high level (6504NTU) after receiving Giciye river. Also, the water quality monitoring data show elevated nitrogen (4.794mg/L at Mukungwa before meeting Nyabarongo), chemical and biochemical oxygen demands as well as E.Coli (5.2x103 Cfu/100ml at Giciye) consequent to effluent discharges from urban centres and poor sanitation.

Basing on data from 2012 population census, the total population in Nile Mukungwa catchment was standing at 1,048,631 population in 2012. The medium projection scenario estimated that in 2020, population in Mukungwa would stand at 1,674,552 with about 517,842 being urban and 1,156,680 rural population (RWRMP, 2014)

Agriculture is dominant socio-economic activity in Nile Mukungwa catchment since the catchment is home to part of the Northwest Volcanic Irish Potato Zone, once with highly fertile volcanic soils. Rain-fed agricultural production serves as the basis for rural household livelihoods. Irish potatoes, maize and beans are the main crops in the catchment while the main cash crop is pyrethrum.

0. 4. Main pollution issues

The Analysis of emerging pollution issues in Nile Mukungwa catchment prioritised the following issues:

- Contamination of water bodies and wetlands by discharge of inadequately treated wastewater;
- Littering of municipal solid wastes;

- Encroachment to sensitive ecosystems such as wetlands, natural reserves and river banks;
- Low level of prioritisation of pollution issues in district plans, and
- Low skills & awareness levels on pollution management

0.5. Integrated Pollution Management Vision and Goals

The vision for the Nile Mukungwa catchment is:

"A well-managed and eco-friendly catchment that welcomes eco-tourists and supports sustainable development through green infrastructure"

Achievement of the vision will be through the following strategic goals:
1. Enhanced governance of pollution management at catchment level
2. Efficient and effective pollution management in Nile Mukungwa catchment
3. Effective information and knowledge management

0.6. Proposed interventions

The main interventions for integrated pollution management considered in Nile Mukungwa are:

- *Interventions for aligning and coordination planning processes at District and catchment levels*, including supporting district authorities to enforce pollution control guidelines and standards, coordinate planning meetings at catchment level, carry out regular catchment committee & environment committee meetings as well as coordination of water users organisations.
- *Interventions for addressing issue of contamination of water bodies and wetland due to following discharges of inadequately treated wastewater,* including to support the construction of centralised sewerage system for Musanze secondary city, support the operationalisation and maintenance of Musanze sludge treatment facilities, invest in ecological sanitation to enhance the recycling of nutrients, support resettlement of population in high risk zones, support small industries &SMEs to implement cleaner production measures, support rainwater harvesting on rooftops of settlement areas upgrade the existing water drainage systems to capture road drainage & settlements, and multiply inspections for environmental compliance in mining sector
- *Interventions for addressing issues of municipal solid waste litter:* the plan will support the valorisation and recycling of municipal solid wastes as well as remediation of closed dumping sites, promote waste-to-resource initiatives including composting, biogas to energy, plastic recycling for construction materials, maximize collection of electronic devices for dismantling and promote voluntary clean-up activities through community work initiatives and local NGOs

- *Interventions for addressing issue of encroachment to sensitive ecosystems such as wetlands, natural reserves and river banks:* this plan will enhance payment of ecosystem services in NMUK for catchment protection, support sustainable conservation of protected areas, river bank protection along all rivers and wetlands in NMUK, provide incentives to the population riparian to natural reserves and protected areas as well as increase awareness and education on environment protection
- *Interventions for capacity building and increasing awareness:* including to invest in research on manure and fertiliser use, support groundwater monitoring network in lava region, integrate key urban hotspot monitoring points to national sampling program, develop training package on urban and rural pollution and BMPs.conduct trainings , awareness raising and capacity building among farmers on smart agriculture and disseminate policies, laws and regulatory instruments on environment protection, sustainable mining and smart agriculture.

0.7. Implementation, Monitoring & Evaluation

The above plan goals, objectives and associated interventions can only be achieved with clear institutional arrangements. Institutions roles and responsibilities were defined in this plan. The plan will be implemented through the District Development Strategies (DDS) at District level as well as Imihigo targets and action plans. Local Administrative Entities Development Agency (LODA) and Rwanda Water Board will coordinate the integration of interventions proposed in this plan into Districts annual action plans and Imihigo. Nile Mukungwa catchment committee will also support the implementation of the plan.

The overall success of implementation of the Nile Mukungwa Integrated Pollution Management Plan lies in strengthening the human and financial resources capacity of Districts and Rwanda Water Resources Board by sourcing for funds needed for the execution of the proposed interventions.

CHAPTER 1. INTRODUCTION

1.1. Background and context

LDCF II Project entitled "Building resilience of communities living in degraded wetlands, forests and savannas of Rwanda through an ecosystem-based adaptation approach"

The Least Developed Countries Fund (LDCF) II Project titled "Building resilience of communities living in degraded forests, savannahs and wetlands of Rwanda through an Ecosystem-based Adaptation (EbA) approach" is funded by Global Environment Facility (GEF) through United Nations Environment Programme (UNEP) under climate change adaptation GEF focal area for total duration of four years..

The main objective of the project is to increase capacity of Rwandan authorities and local communities to adapt to climate change by implementing Ecosystem based Adaptation (EbA) interventions in degraded forests, savannahs and wetlands ecosystems. The above objective will be achieved through

i) increasing the technical capacity to plan and implement E-bA at national and local levels;

ii) strengthening the national and local policies, strategies and plans to facilitate the national implementation of E-bA;

iii) restoring degraded savanna, forests and wetlands to provide proof-of-concept for the role of ecological infrastructure in increasing climate resilience and providing alternative livelihoods for local communities

The project has three components:

1. The National and local institutional capacity development for the use of an EbA approach.

2. Policies, strategies and plans for adaptation to climate change.

3. Ecosystem based Adaptation (EbA) interventions that reduce vulnerability and restore natural capital.

The LDCF II Project was designed to demonstrate The LDCF- demonstrates the benefits of EbA by using intervention sites in the most vulnerable areas in Rwanda. To maximise the sustainability and upscaling of the interventions, the project will:

(i) train national- and local-level authorities as well as local communities at intervention sites on the use of EbA;

(ii) increase scientific knowledge on the benefits of EbA and identify best practices for EbA;

(iii) provide guiding documents to mainstream EbA into policies, plans and strategies in Rwanda; and

(iv) increase local community awareness on the role of ecological infrastructure in increasing climate resilience.

Technical Assistance in Environment and Natural Resources Management (this project)	With aim to collate current knowledge on status and health of the environment within catchments that include forest, savannah, and wetland ecosystems in Rwanda, to develop systematic mapping and monitoring tools to identify basin management needs and track progress towards addressing them as well as to develop an understanding of the drivers of their degradation and to prepare a range of plans based on the results of the analyses and in response to climate threats, LDCF II/REMA
Terms of Reference for Integrated Pollution Management Plan	In accordance with the Term of References, the Technical Assistance in Environmental Management consists of a number of tasks: Strategic Plan for Ecosystem Based Adaptation and Wetland Management which includes a status quo description, national wetland management plan, guidelines for wetland management, and technical support with implementation of the plan. Water Quality Management which includes identification of pollution hotspots in Rwanda, develop water quality management guidelines, develop water quality management plan for Rwanda, a water quality modelling tool, and integrated pollution management plans for four catchment areas. Develop integrated catchment management for some catchments in Rwanda (Nile-Akagera , Nile-Nyabarongo lower and Nile-Mukungwa including Nyiramuhondi watershed), and Capacity building and training This report is part of Water Quality Management task and presents the Integrated Pollution Management Plan for Nile-Mukungwa Catchment According to the ToRs the development of the Integrated Pullution Management Plan will requires identification of key pollution indicators of interest (e.g. fecal coliforms, BOD, COD, DO, Nitrates, etc.), mapping of major sources of pollution (e.g. residential areas, schools, abattoirs, major industrial areas, etc.), existing pollution management facilities and their capacities, and loading estimates for key pollutants, understanding of the transport and fate of these pollutants, key sensitive areas (e.g. water intakes, areas of ecological concern, etc.), appropriate standards/guidelines, and a longer-term plan of investments to help meet these standards/guidelines. To the extent possible, the plan should also survey economic costs and benefits to pollution and pollution management respectively. In addition, the pollution management analysis and prioritization should consider the impacts and lessons from the current activities under the LDCF II and LVEMPII project and suggest improvements in the targeting or design of future activities, as appropriate

1.2. Scope and purpose

In Rwanda, high population density, expanding industrialization and urbanization, inappropriate waste and wastewater management, high rainfall intensity on steep slope high elevation are putting pressure on natural environment leading pollution, particularly in urban areas. The potential pollutants that could arise from the above pollution drivers requires careful management to avoid negative impacts on human health, and environmental factors such as groundwater, soils, surface water and ecology.

This Integrated Pollution Management Plan provides identified key pollution indicators, mapped major sources of pollution in the catchment, provided appropriate standards and guidelines applicable to pollution management and proposed long term actions to tackle pollution in Nile Mukungwa catchment.

1.3. Layout of the report

The Integrated Pollution Management Plan for Nile Mukungwa catchment consists of the following chapters:

Chapter 1: gives an introduction to the study through presenting the general background of the Integrated Pollution Management plan, scope of the plan as well as the layout of the report.

Chapter 2: is a description of the methodology followed in the preparation of the Integrated Pollution Management Plan

Chapter 3: provides a brief overview of the catchment description, its key geographic features, and the challenges that affect pollution.

Chapter4: provides an overview of the emerging pollution issues in the Nile Mukungwa catchment, their characteristics and related mapping

Chapter 5: describes an integrated pollution management plan to deal with the problems of pollution in the catchment, targets to achieve, indicators to be monitored as well as the resources required.

Chapter 6: describes monitoring that should be undertaken to assess the situation and the success of interventions.

CHAPTER 2. METHODOLOGY

The process of developing strategies and plans to address the problems associated with pollution is known as integrated pollution management planning. The Integrated Pollution Management Plan (IPMP) is the main output of the planning process. The IPMP records a vision for the catchment area and formalises the key current and future trends of the various pollution categories such as water, land, air and noise pollution. The IPMP also provides additional details with regard to the specific implementation of options for improved catchment pollution management while still promoting green growth and development objectives.

The IPMP states how issues and concerns will be addressed through management strategies within a specified time period, and outlines an associated procedural and technical framework for implementation.

The first step of the planning process, is to determine the current pollution state of the catchment area. The steps followed for the integrated pollution management planning process are outlined in Figure 1.

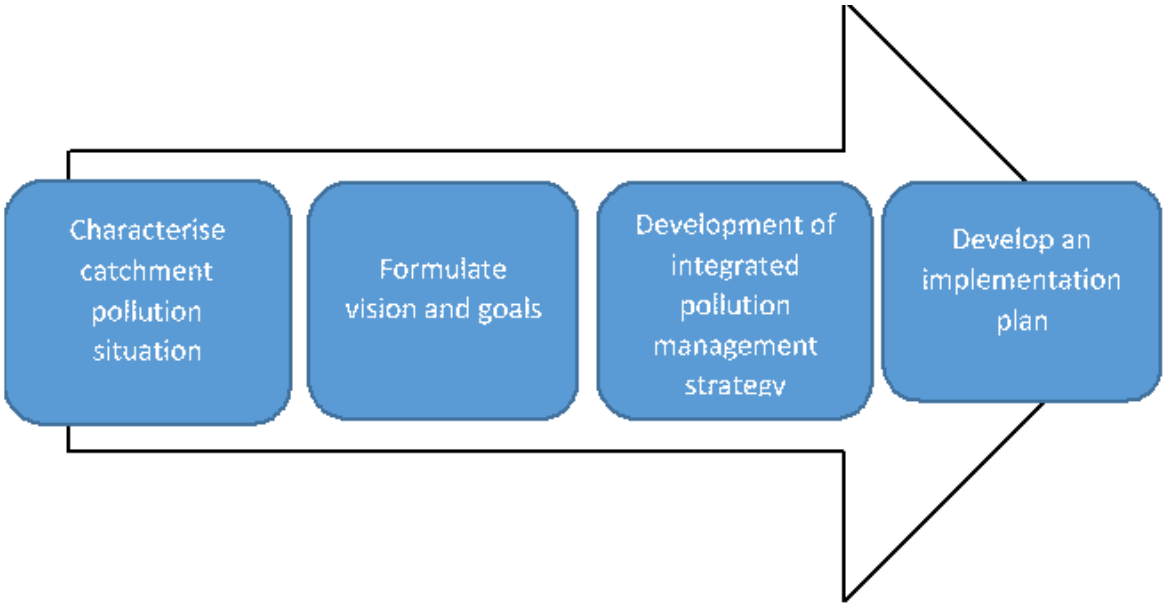

Figure 1: Steps in developing the Nile Mukungwa Integrated Pollution Management Plan

Step 1: Characterise the catchment pollution situation

This step provides for gaining an understanding of current characterization of pollution issues and sources in the catchment area. It also identifies and prioritize the key pollution challenges and opportunities.

1. A review of relevant literature was undertaken to familiarise the project team members with the catchment area under consideration, and the historical pollution issues that have been documented. In this task the team also consulted the relevant district development plans, catchment management plans, and district sanitation master plans provided these were available at the time.

2. The project team generated maps of the relevant catchment areas. The data and information (shapefiles) provided by the Rwanda Land Use and Management Authority (RLMUA), Rwanda Water Board (RWB) and Rwanda Housing Authority (RHA) were used to delineate the catchment boundaries and urban areas in the catchment. .
3. The team then met with district officials which included the District Environmental officers and others with knowledge of pollution sources and concerns. The objectives of the meetings were to identify pollution hotspots in their area, what the pollution concerns were and their impacts, the possible sources of pollution, and what is or could be done to manage it.

In order to guide the discussion, the officials were requested to consider beforehand the following aspects and whether it is relevant in their area:

(i) Examples of sensitive urban areas which should be protected against pollution

- Important water abstraction points (surface or groundwater) for domestic or urban agricultural use
- Cultural areas at or near urban streams and rivers
- Important urban parks or conservation areas
- Stormwater drainage network

(ii) Examples of types of pollutants

- Sediments and erosion
- Nutrients (nitrogen, phosphates) and excessive algae in streams and dams (fertilisers)
- Hydrocarbon pollution from fuels, oils, and grease
- Agrochemicals such as pesticides and herbicides
- Microbiological pollution (pathogens) that cause diseases such as diarrhoea, cholera, etc.
- Organic pollutants that consume oxygen in the water when it breaks down leading to fish kills
- Trace metals from solid waste dumps, landfills, and industries
- Solid waste and litter in streams

(iii) Possible point sources of pollution

- Wastewater Treatment Systems and their effluents
- Industrial effluents
- Hotels, hospitals, etc.
- Formal and informal abattoirs
- Landfills and solid waste dumps
- Fish farm outflows

(iv) Nonpoint or diffuse sources of pollution

- Stormwater drainage system
- Grey water disposal into stormwater system
- Informal sewage disposal into urban canals, stormwater drains and urban streams
- agriculture and wetland agriculture, aquaculture
- Garages, vehicle workshops, vehicle service centres
- Fresh produce markets with no or poor solid waste management
- Unpaved and poorly maintained urban roads, construction sites
- Seepage from septic tanks

(v) Existing pollution management options

- Regulations and bylaws that control certain activities and discharges into the stormwater drainage system
- Riparian buffer zones
- Stormwater detention dams, natural and artificial wetlands

Where possible, coordinates for issues were captured and integrated into the maps developed by the project team or directly in Google Earth as place marks with a title and description. These were then summarised in this report along with other issues stemming from the literature review

4. Some of the pollution hotspots that were identified during the discussions were visited to visually inspect the situation at the selected hotspots, to take photographs at the sites, and to undertake some water sample collection for measurement of temperature, pH, electrical conductivity, and turbidity.

Step 2: Formulating a vision and goals

This involves describing the desired state of the catchment area over the long term with respect to pollution, together with goals (preliminary objectives) and targets to achieve this over time. This should be developed in a participatory approach with stakeholders from the catchment area.

A stakeholder workshop was held on the 3rd of October 2017 where officials were given the opportunity to confirm and prioritise the pollution issues in their area, to develop the key elements of an integrated pollution management vision for their catchment area, and to develop initial goals, objectives and interventions to manage pollution in their catchment area.

Step 3: Developing an integrated pollution management strategy

This includes specifying a coherent suite of strategic objectives and outcomes related to pollution management, designed to achieve the vision.

Incorporating the vision, goals and objectives determined through the stakeholder engagement process, as well as the information provided from the pollution characterisation, pollution management strategy is proposed.

Step 4: Detailing an implementation plan

The main activity at this point is defining the actions needed to give effect to the catchment pollution management strategy and that should ultimately achieve the vision and objectives, as well as who is responsible for the actions, the indicative phasing and cost estimates for the actions.

To give effect to the proposed strategy, and for the achievement of the goals, objectives and ultimately the vision of the Nile Mukungwa area, an implementation plan is included in this IPMP.

CHAPTER 3. OVERVIEW OF THE NILE-MUKUNGWA CATCHMENT

The purpose of this chapter is to provide a brief overview of the Nile Mukungwa catchment, with a focus on those features that would affect both rural and urban pollution. Key pollution issues identified during the project are described in the chapters that follow on this descriptive chapter.

3.1. Administrative boundaries

Nile Mukungwa (NMUK) catchment area is essentially covered by the following five districts (Burera, Musanze, Gakenke, Nyabihu, and Ngororero. Some minute areas of the catchment are located in the district of Gicumbi.

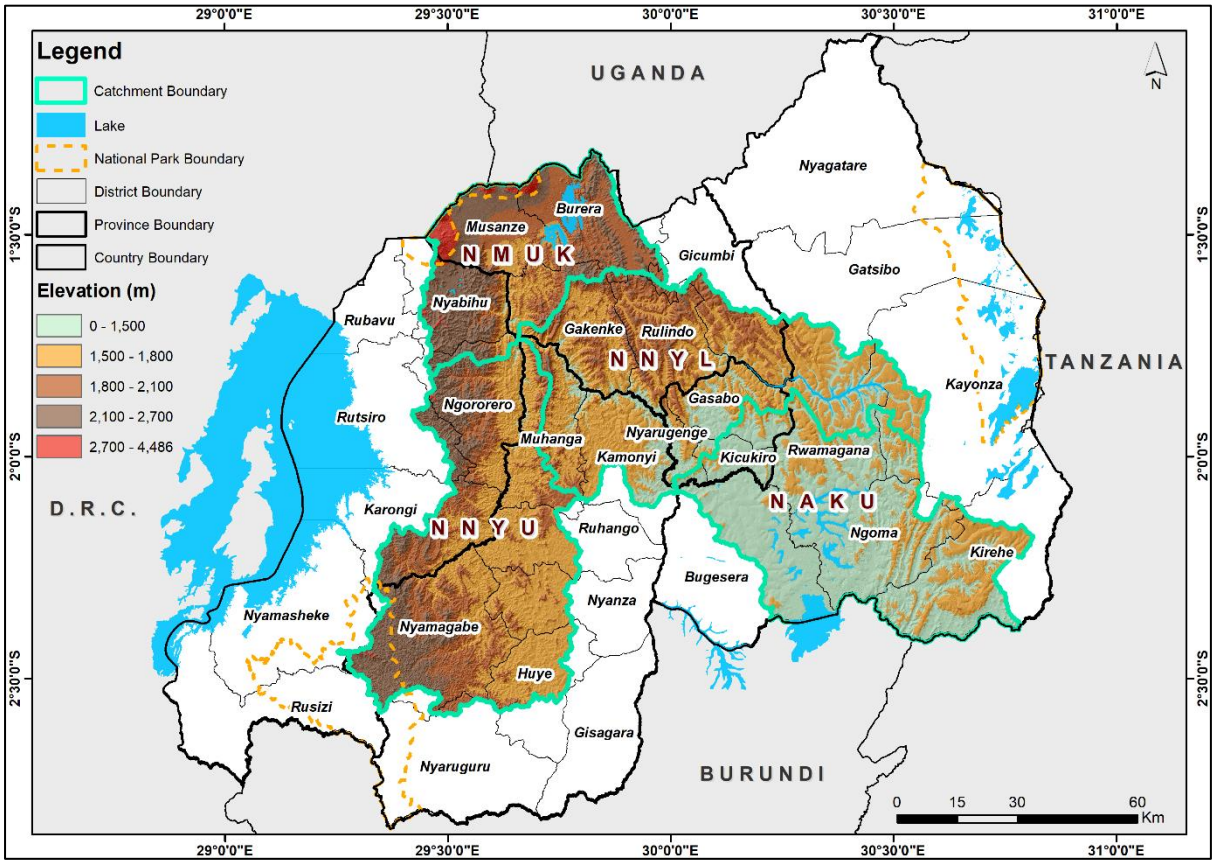

Figure 2: Nile Mukungwa catchment and district boundaries

3.2. Population distribution

According to the 2012 population census, the total population in the catchment was assessed at 1.085 million dispersed throughout the catchment with highest densities in and around the urban center of Musanze and along the Musanze - Rubavu national road. However, the projection made by Rwanda Water Resources Master Plan in 2012, by converting the 2012 census data per sector to population per catchment, found that the population in Nile Mukungwa catchment was standing at 1,048,631 population which was about 21.30 % below the low growth scenario projection. The medium projection scenario estimated that in 2020, population in Nile Mukungwa

would stand at 1,674,552 with about 517,842 being urban and 1,156,680 rural population (RWRMP, 2014)

3.3. Climate

The Mukunwa catchment has a tropical climate of high altitude with an average temperature of 20ºC and the rain that varies between 1400 mm and 1800 mm. April and May bring about the heaviest rains, whereas October and November have a much more moderate rainy period.

3.4. Land use

The current land use in Mukungwa catchment is predominantly rain-fed agriculture (70%) with some spots of forest plantation (2.5%) and natural forest in reserved area of Volcano National Park (6% for mainly the Volcano Park). Agricultural wetland and natural wetland are estimated at 4% while the built area (1%) is very modest extend and limited to Musanze and other localities along Musanze-Rubavu national road. Figure 3 below provides spatial distribution of existing land use in Nile Mukungwa catchment.

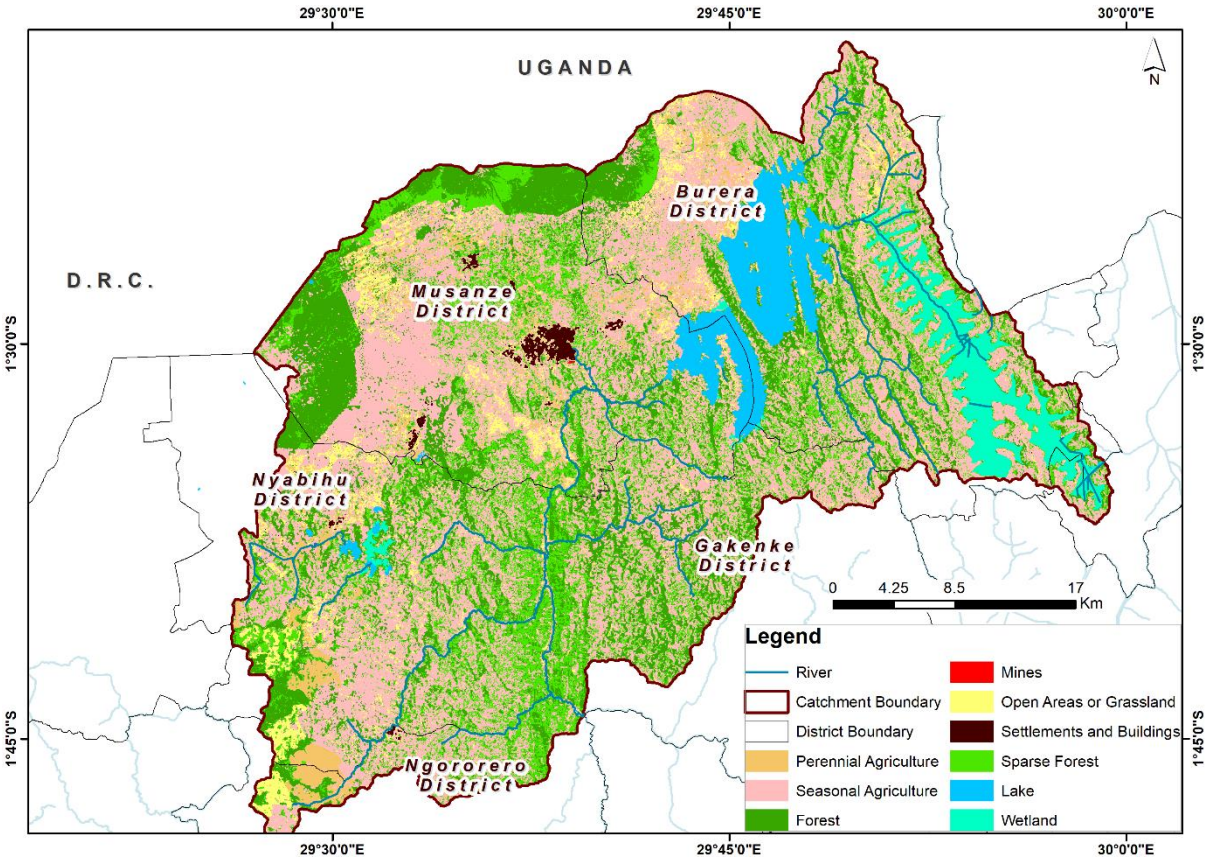

Figure 3: Spatial Distribution of Existing LULC in NMUK Catchment

3.5. Economic activities and basic services infrastructure

Nile Mukungwa catchment is home to part of the Northwest Volcanic Irish Potato Zone, once with highly fertile volcanic soils. Rain-fed agricultural production serves as the basis for rural household livelihoods. Irish potatoes, maize and beans are the

main crops in the catchments while the main cash crop is pyrethrum. Figure 4 below presents the socio-economic characteristics of Nile Mukungwa catchment.

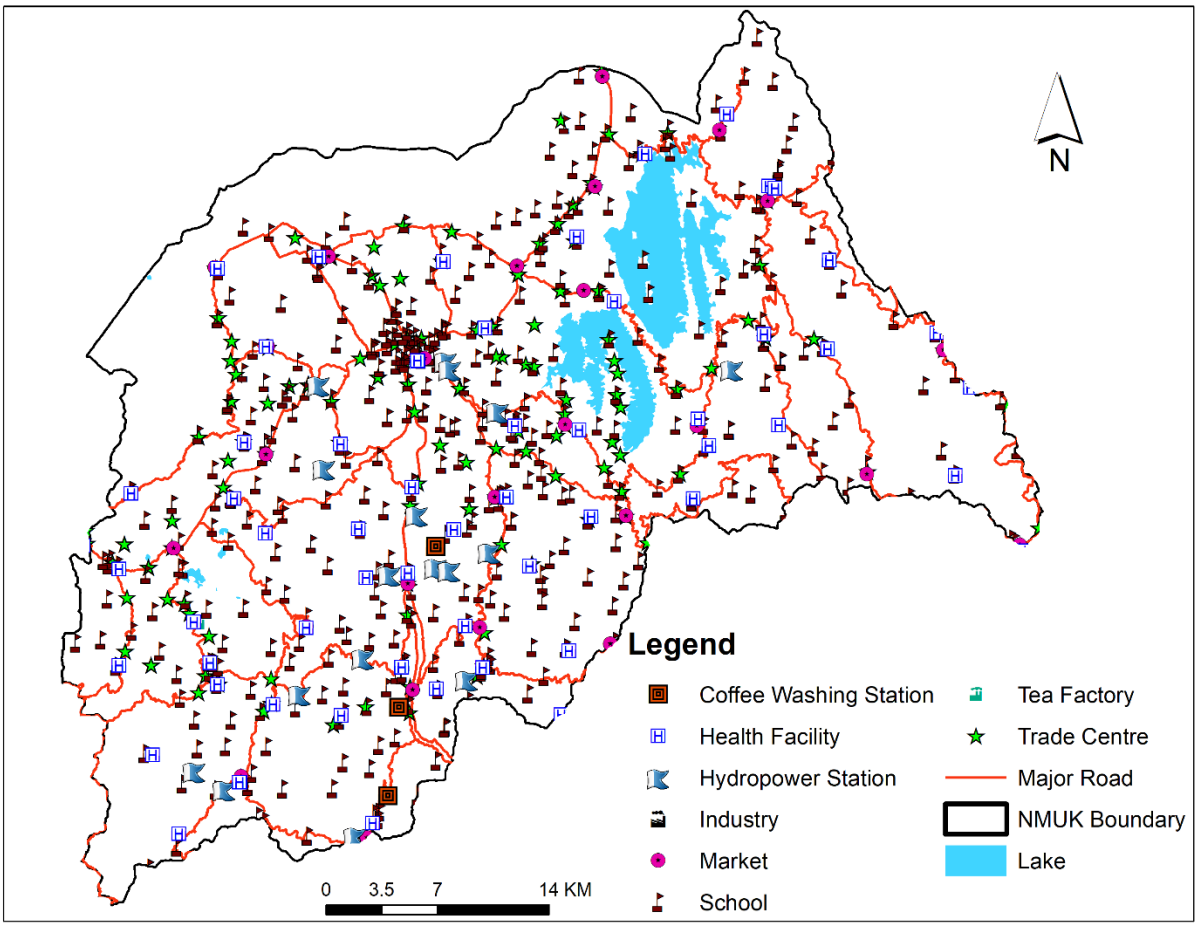

Figure 4: Socio-economic characteristics of Nile Mukungwa catchment

3.6. Hydrology

The Rwanda Water Resources Master Plan (2014) subdivided the Nile Mukungwa catchment into two level 2 sub-catchments as follows:

- The Rugezi-Burera-Ruhondo cascade of water bodies in the East comprising the Rugezi wetlands with the Burera and Ruhondo Lakes as a single management unit where agricultural, ecological/hydrological and hydropower interests need to be reconciled. This is the NMUK_1 subdivision most of which is administered by the Burera District.

- The remainder of the catchment (NMUK_2) features complex surface and groundwater interactions in the lava region and more regular interactions in the remainder of the catchment, supporting predominantly subsistence agriculture with an even for Rwandan standards, high population density. The upper reaches of this catchment is a reserved area (Volcano Park) which houses the world famous mountain gorillas and supports a successful high end tourism industry. The lava zone is predominantly located in the Musanze district, while the remaining area with mostly deeply wheathered soils from granite and schists is administered by the districts of Nyabihu and Gakenke.

The principal water resources in the catchment are as follows:

- the average annual rainfall is slightly above 1,315 mm/annum which equates to some 2,563 hm^3/annum from the total land surface area of 1,949 km^2.
- the average annual surface flow generated from this catchment stands at 28.7 m^3/s or some 900 hm^3/annum (905 hm^3/annum to be exact).
- the groundwater annual recharge / safe yield is about 630 hm^3/annum with a total storage of 4,870 hm^3 which gives a mean residence time of about 8 years.
- the Burera and Ruhondo lakes collect the surface runoff from about a third of the catchment area (682 km^2) and constitute an important surface water storage reservoir while reducing peak discharges.

3.7. Water Quality

3.7.1. Surface water quality

The status of water quality in Nile Mukungwa catchment is regularly monitored on three different locations: Upstream at Rugezi before its discharge into Lake Burera, Mukungwa at Nyakinama gauging station and downstream at Mukungwa before mixing with Nyabarongo. Trends in water quality show that the catchment is characterised by fewer suspended sediments at upstream (7 NTU at Burera Lake outlet and 43NTU at Nyakinama sampling station) but sediments enrichment increases while moving far downstream and attain the high level (6504NTU) after receiving Giciye river. In addition, water quality monitoring data show elevated nitrogen (4.794mg/L) at Mukungwa before meeting Nyabarongo, high chemical and biochemical oxygen demands and E.Coli ($5.2x10^3$ Cfu/100ml at Giciye) consequent to effluent discharges from urban centres and poor sanitation. The pH is also elevated at above 8.0 in most of water bodies of the catchment and this is due to the lithology of rocks with dominance of limestone. Key features of water quality are provided in the Table 1 below.

Table 1: Characteristics of water quality in Nile Mukungwa catchment

Sampling sites	D.O	TURB	COD	BOD	DIN	DIP	Pb	Zn	E.Coli
BURERA LAC	7.71	7	6.12	4.26	2.461	0.087	0.015	0.808	$2.3x10^2$
RUHONDO LAKE UPSTREAM	9.85	8	7.03	4.73	2.530	0.086	0.015	0.788	$3.3x10^2$
RUHONDO LAKE DOWNSTREAM	9.92	13	8.66	4.99	3.594	0.534	ND	0.942	$3.2x10^1$
MUKUNGWA AT HYDROPOWER	3.14	8	8.59	4.28	3.696	0.466	ND	0.436	$5.6x10^2$
MUKUNGWA AT NYAKINAMA	6.3	42	8.94	6	3.860	0.589	0.032	0.496	$6.3x10^1$
GICIYE BEFORE MUKUNGWA	7.7	2717	5.89	3.17	1.643	0.307	ND	0.538	$5.2x10^3$
MUKUNGWA AFTER GICIYE	7.52	4739	10.72	7.79	3.264	0.562	0.015	0.440	$8,2x10^2$
MUKUNGWA BEFORE NYABARONGO	7.44	6504	13.44	9.7	4.794	0.983	ND	0.331	$2.3x10^2$
Standards	**0-12**	**-**	**250**	**50**	**5**	**3.5**	**0.1**	**5**	**400**

3.7.2. Groundwater quality

Groundwater (springs) in Nile Mukungwa Catchment are mainly recharged by precipitation and varies from one place to another depending on the geological conditions. The precipitation falling in the high altitude areas in the northern part of the catchment infiltrates into the ground and mixes with lower altitude rainfall before it flows out as groundwater mainly in form of springs. The most dominant groundwater recharge mechanism therefore appears to be direct infiltration from precipitation through preferential flow paths in the soils and rocks. (RNRA/WSS, 2012). In general, the groundwater aquifer of Nile Mukungwa catchment is composed of alluvial aquifers, complex aquifer (volcanic rock), fractured aquifer (granite and gneiss), low permeable fractured aquifer (schist and micaschist), organo-sedimentary alluvial aquifer (low permeability, clay base), rermeable fractured aquifer (quarzite on schist base) and Semi-permeable fractured aquifer (schist, mica and quartzite) with dominance of Complex aquifer, fractured aquifer and Semi-permeable fractured aquifer and these types of rocks may variably impact on the quality of groundwater. The status of groundwater recharge level is regularly monitored at 3 locations as shown of the Figure 5 below, however there are few data on groundwater quality.

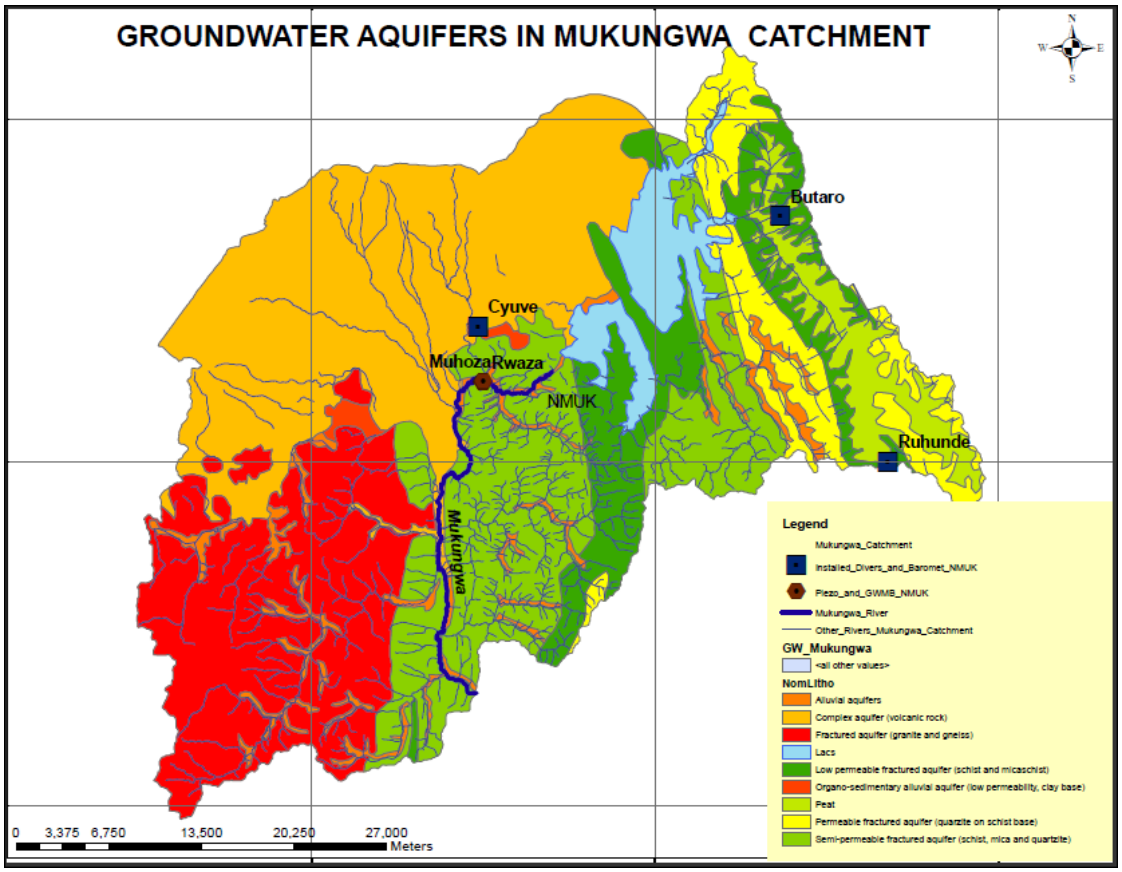

Figure 5: Location of groundwater recharge monitoring sites in Nile Mukungwa catchment

In a study (RNRA, 2016) carried out on 58 samples from boreholes drilled in Musanze& Nyabihu districts, parts of Nile Mukungwa catchment found levels of Cadmium, Chromium and Lead above permissible limits. For Cd it ranged between (0.00 – 0.06 mg/l) and 86% of sampling sites have a concentration higher than the standards for drinking water (0.003 mg/l) while 14% have a concentration below the recommended limit for drinking water. For Cr, it ranged between (0.00 – 0.26 mg/l), 40% of all sampling sites have a high concentration of Cr compared to the standards for drinking water (0.05 mg/l) while 60% have a low concentration of Cr while Pb the concentration ranged between (0.00 – 0.79 mg/l). 84% of all boreholes sampled have high concentration while 16% have a concentration below the standards limit for drinking water (0.01 mg/l). Arsenic concentration ranged between (0.00 - 49.76 µ g/L) and 10% of sampled sites have higher arsenic content compared to the standards for drinking water (10 µg/L) and 90% of sampled sites have a low arsenic content even nil. Despite the fact that the concentration of Arsenic found in this study are within drinking water guidelines (except for 6 sampling sites), values recorded show long term Arsenic exposure, even at lower or trace of Arsenic in drinking water may have adverse health effects, including increased risks of cancer in the skin, lung, bladder and kidney as well as other skin changes. Therefore, measures have to be taken, especially immediate closure of those 6 boreholes and regular monitoring of the remaining ones. Microbiological testing (fecal coliforms & E. coli), in all sampled sites no bacteria found In others sites the bacteria are nil which is corresponding to the recommended standards for drinking water.

CHAPTER 4. EMERGING POLLUTION ISSUES IN NILE MUKUNGWA

4.1. Introduction

Emerging pollution issues discussed in this chapter are pressures and threats to environment (with focus on water quality) that are assumed to be those things resulting from human actions (past, current and future), which have potential to impact water quality, along with natural phenomena and environmental factors. These include natural phenomena exacerbated by human interaction, inappropriate land management practices, and low enforcement of laws or misdirected policy settings.

4.2. Analysis of Policy and Legal Framework *for Development and Implementation of the Integrated Pollution Management Plan for Nile Mukungwa catchment*.

An enabling policy, legal and institutional framework is key to the development and subsequent implementation of the Integrated Pollution Management Plan for Nile Mukungwa catchment. These issues are explored in the sections below:

4.2.1. Policy Framework

a) Vision 2050

Vision 2050 is about ensuring high standards of living for all Rwandans and is aimed to shift Rwandan's from the current livelihood to the society everyone wants and proud to belong. In order to realize this Vision, the country will embark on economic transformation, social transformation and governance and justice. The country will increase momentum towards reaching upper middle income by 2030 and high income by 2050. This will require average annual growth of above 10% per cent. Therefore, the Vision 2050 provides the policy context for the plan. Nile Mukungwa Integrated Pollution Management Plan will contribute to this country ambition by progressively achieving pollution management to ensure high standard of living and environmental welfare

b) National Strategy for Transformation

The National Strategy for Transformation (NST1) which is also the Seven Year Government Programme (7 YRGM) is an implementation instrument for the remainder of Vision 2020 and for the first years of the journey under vision 2050. In order to achieve the high-level targets of Economic Transformation and prosperity, the contribution of Nile Mukungwa Integrated Pollution Management Plan to the targets of NSTP is included in the following **NST1 5.16** statement "*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*** *"*

c) National Environment and Climate Change Policy, 2018

The National Environment and Climate Change Policy provides strategic direction and responses to the emerging issues and critical challenges in environmental

management and climate change adaptation and mitigation. The policy goal is for "Rwanda to have a clean and healthy environment resilient to climate variability and change that supports a high quality of life for its society."

It sets up two key principles related to pollution management:

- Polluter Pays Principle according to which those responsible for environmental damage must be held liable for the repair caused to both the physical and human environments. They must also be held responsible for the costs of preventive measures to reduce or prevent further pollution and environmental damage.
- The Pollution Prevention Principle which anticipates problems and prevents negative impacts on the environment and people's environmental rights

Nile Mukungwa Integrated Pollution Management Plan will contribute to achieving the National Environment and Climate targets through the following key policy statements related to pollution management

- Prevent and promote integrated pollution control and waste management
- Promote the circular economy to advance sustainable consumption and production patterns:
- Promote green technologies and procurement: and
- Promote sustainable management of wetlands.

d) National Water Resources Management Policy, 2011

The overall goal pursued in this water policy is to manage and develop the water resources of Rwanda in an integrated and sustainable manner, so as to secure and provide water of adequate quantity and quality for all social and economic needs of the present and future generations, and ensure full participation of all stakeholders in decisions affecting water resources management. This plan will contribute to achieving the policy targets through the following strategic policy actions:

- Monitor and assess water resources to understand the water balance and to support water accounting, identify the spatial and temporal occurrence and distribution in the country;
- Formulate a water resources management strategy addressing, inter alia, watershed protection and provides mechanisms for the designation of special conservation and or protection zones; and
- Promote water conservation techniques and technologies, including rainwater harvesting, water recycling and other appropriate technologies.

e) National Sanitation Policy

The vision of National Sanitation Policy is to ensure sustainable, equitable and affordable access to safe sanitation and waste management services for all Rwandans, as a contribution to poverty reduction, public health, economic development and environmental protection while the mission is to promote, plan, build and operate services in a sustainable, efficient and equitable manner.

This plan will contribute to achieving the policy targets through the following policy objectives:

- Raise and sustain household sanitation coverage to 100 per cent by 2020, and promote hygiene behaviour change;
- Implement improved sanitation for schools, health facilities and other public institutions and locations;
- Develop safe, well-regulated and affordable off site sanitation services (sewerage and sludge collection, treatment and reuse/disposal) for densely populated areas;
- Enhance storm water management in urban areas to mitigate impacts on properties, infrastructure, human health and the environment5. Implement integrated solid waste management in ways that are protective to human health and the environment; and
- Ensure safe management of e-waste, industrial wastes, nuclear waste and health care waste.

f) Mining Policy, 2010

The Mining Policy covers wider aspects of regulation, institutional and investment framework for the mining industry, value addition and capacity building strategies as well as providing a clear plan of action to support the sub sector's growth.

This plan will contribute to the policy targets on improving the mining sector knowledge, skills and use of best use of best practices, especially the implementation of Model mining.

g) Urbanisation and Human Settlements Policy, 2015

This policy provides opportunities for alleviating pressure on rural land and biodiversity resources because increased urbanization raises challenges of utility supplies (water, energy, and housing) as well as waste disposal. This plan will contribute to this policy targets through addressing challenge related to waste minimization and promotion of green cities.

h) Industrial policy and Investment code, 2011

Environmental compliance advisory (especially relating to Environmental Impact Assessment), has been included among the services provided by the RDB, which is an opportunity to promote sustainable Environment and Natural Resources management. This plan will contribute to this policy targets through promoting resource efficient and cleaner production in industry sector.

i) Health Policy 2014 and Health Sector Strategic Plan

This objective of the Health Policy is centred on the reduction of burden of disease of the most important health problems in Rwanda – i.e., maternal and child health problems, infectious diseases and non-communicable diseases through access to primary health care. Both prevention and treatment and care services are included in these programmes, as well as interventions aimed at improving important health-determining factors, such as behaviour change communication, promotion of adequate nutrition, environmental health and sanitation, and access to safe water.

Policy directions with relevance to pollution management include:

- Environmental health interventions will be strengthened from the national to the village levels. Hygiene inspections will be decentralized to empower districts and sectors and the Community-Based Environmental Health Promotion Programme will be scaled up to be implemented country-wide.

Inter-sectoral collaboration between non-health departments and the MoH is essential for interventions targeting health determinants: water distribution and sanitation systems to meet essential health needs, public hygiene activities (domestic and health-care waste management, health inspections

4.2.2 Legal Framework

Table 2 below includes a summary of the relevant legislation related to pollution management.

Table 2: Summary of relevant pollution management legislation

Legislation	# and date	Relevance to pollution
The National Constitution	2003 (Amended in 2015)	The constitution of Rwanda guarantees the right to a clean environment for every citizen and other people living in Rwanda, and imposes on the state and population, the responsibility for keeping the environment clean and pollution-free. Article 23 states that everyone has the right to live in a clean and healthy environment while Article 53 of the amended Constitution states that everyone has the duty to protect, safeguard and promote the environment, that the State should ensure that the protection of the environment, and do so by means of a law that determines the modalities for the protecting, conserving and promoting the environment.
Law determining the use and management of water resources in Rwanda	Law N°49/2018 of 13/08/2018	This Law determines the use and management of water resources in Rwanda. It defines 'water' as a good belonging to the state public domain, recognizing the right to water for all. The Water Law provides a clear framework for the principles of integrated water resources management, including the prevention of pollution, and the principle of "user pays" and "polluter pays. It also

		provide that polluting water bodies by dumping, spilling or depositing chemicals of any nature above tolerable limit for human health or aquatic life, commits an offence (art.37) and set penalties for the defaulters
Law on environment	Law No 48/2018 of 13/08/2018	This Law determines modalities for protecting, conserving and promoting the environment. The law on environment gives effect to the National Environment and Climate Change Policy, which sets out how to transform into 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. It defines the responsibilities of citizen and state and set principles for exploiting natural resources such as land, water, forests and air as well as protecting biodiversity, among others. The law requires all project developers whose projects may have harmful effects on the environment to carry out environmental impact assessment (EIA) before launching them. Articles 17, 18, 19 and 20 provide guidance on conservation and protection of built environment, focusing on the management of liquid and solid wastes, management of hazardous and toxic wastes and the management of electronic wastes. Article 42, 43, and 45 provide for prohibited acts, including prohibited acts in wetlands and protected areas, prohibited emission of noise, prohibited acts in protection of biodiversity and prohibitions related to chemicals and wastes At last the law provides for administrative sanctions for all defaulters (from art.46 to art.60)

Law relating to the prohibition of manufacturing, importation, use and sale of plastic carry bags and single-use plastic items	Law N° 17/2019 of 10/08/2019	This Law prohibits the manufacturing, importation, use and sale of plastic carry bags and single-use plastic items. The law is expected to check the increasing habit of unnecessary consumption and disposal of single use plastic items which becomes a burden to the environment.
Law governing the preservation of air quality and prevention of air pollution in Rwanda	No. 18/2016 of 18/05/2016	This Law applies to all measures aimed at the preservation of air quality as well as all elements or activities likely to affect air quality or pollute the atmosphere. The law sets, amongst other, air quality standards, and describes compliance with minimum air quality standards, emission limits, specific tolerance limit of pollutants from industries, inspection of air pollutants from the transport sector, air pollutants from construction works, air pollutants from the storage of objects, air pollutants from waste incineration, and air pollutants from other sources. The law also makes provision for administrative sanctions.
Ministerial Order establishing the list of projects that must undergo environmental impact assessment, instructions, requirements and procedures to conduct environmental impact assessment	No 001/2019 of 15/04/2019	This Order establishes: 1° the list of projects that must undergo an environmental impact assessment before they obtain authorisation for their implementation; 2° instructions, requirements and procedures for conducting environmental impact assessment.
Ministerial Order **Determining the list of Water Pollutants**	No. 004/16.01 of 24/05/2013	This order defines a water pollutant and then provides a list of: Physico-chemical pollutants, organoleptic pollutants & Organic Pollutants; radionuclides; and Biological Pollutants.
Ministerial Order **Establishing Modalities of**	N° 006/2008	This ministerial order describes the modalities of inspecting companies or activities that pollute the environment.

Inspecting Companies or Activities that Pollute the Environment	of 15/08/2008	It describes, amongst other, the responsibilities of inspectors, search and seizure of pollution products, analysis of suspected products, and decisions that REMA can take.
The Code of Criminal Procedure	No. 30/2013 of 24/5/2013	The Code of Criminal Procedure currently in force has been enacted in 2013. It governs the procedures by which authorities investigate, prosecute, and adjudicate crimes which includes environment offences.

4.2.3. Standards and guidelines related to pollution management

4.2.3.1. Standards relevant to effluent discharges

Dischargers of domestic and industrial effluents must comply with Rwandan standards as specified by the Rwanda Standards Board.

Rwanda Standard RS 110 of 2016 provides the limits for the discharge of treated domestic wastewater effluent into the environment as well as the test methods that should be employed for the individual constituents.

Rwanda Standard RS 109 of 2009 specifies the limits for the discharge of treated industrial wastewater effluent into the environment as well as the test methods that should be employed for the individual constituents.

According to the EAC website, the EAC Secretariat is working to harmonise effluent discharge standards, strengthen the capacity of EAC Partner States in enforcement of pollution control laws and establish pollution monitoring system in the EAC, and urges Partner States to allocate more resources for the implementation of conventions to which they are party such as Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, and the Stockholm Convention on Persistent Organic Pollutants.

At EAC regional RECP meeting held in Nairobi in July 2016 for harmonizing GIS mapping report, all EAC countries represented by Directors of National cleaner production centres and RECP Experts agreed to apply regional EAC standards in order to harmonize limits used to assess industrial pollution levels (Niyonzima, 2017). The EAC standards "East African Industrial and Municipal Effluents Standards" was published in January 2016 (EAC Gazette, 2016. The Table3 below provides the Regional EAC standards used to assess industrial wastewater effluents.

Table 3: Regional EAC standards used to assess industrial wastewater effluents (MINICOM, 2017)

Minimum pollution load (Green)	Medium pollution load (Blue)	High pollution load (Red)

BOD < 30 mg/l	BOD between 31 – 250 mg/l	BOD > 500 mg/l
COD < 60 mg/l	COD between 61 – 500 mg/l	COD > 500 mg/l
TN < 10 mg/l	TN between 10 – 20 mg/l	TN > 20 mg/l
NO_3 < 5 mg/l	NO_3 between 5 – 10 mg/l	NO_3 > 10 mg/l
TP < 5 mg/l	TP between 5 – 10 mg/l	TP >10 mg/l

4.2.3.2. Standards relevant to air emissions

Emitters of air pollution in Nile Mukungwa catchment must comply with air emission standards set by Rwanda Standards Board. The Rwanda air quality law was promulgated in May 2016 and it is supported by the Rwanda Standards Board who has developed emission standards and air quality specifications that are applicable for Rwanda and aligned with East African Community standards. These include:

- *RS EAS 750 Air quality* – emissions to the air by cement factories – guidelines. This Rwanda Standard published in 2011 is identical to the first edition 2010 Regional Standard EAS 750/2010 Air quality - Emissions to the air by cement factories - Guidelines.
- *RS EAS 751 Air quality Air quality – specifications.* This Rwanda Standard published in 2011 is identical to the first edition 2010 of Regional Standard EAS 751/2010 Air quality - Specification.
- *RS EAS 752 Air Quality* – Tolerance limits of emission discharges to the air by factories. This Rwanda Standard published in 2011 is identical to the first edition 2010 of regional Standard EAS 752/2010 Air quality – Tolerance limits of emission discharged to the air by factories.
- *RS407-1 Emission limits* — Specification: Road Vehicles

The publication of these air quality guidelines and standards, aligned with EAC standards, demonstrates the good collaboration of the Rwanda Government with its East African Community partners.

4.2.3.3. Water quality guidelines

In order to assess the fitness for use of the rivers and streams in Nile Mukungwa catchment, it is recommended that a combination of guidelines be adopted based on full contact recreation and key aquatic ecosystem guidelines. Full contact recreation guidelines would be protective to children who play in streams and rivers, and farmers who get in contact with streams when they work their agricultural fields. Aquatic ecosystem guidelines would be protective to fish and aquatic organisms in streams. The following guidelines are recommended for assessing the water quality status of rivers. Only a limited set of constituents was selected to keep the index simple.

Table 4: Guidelines for assessing the status of rivers.

Constituent	Units	Ideal	Good	Fair	Poor
Physical requirements					
Water clarity	Secchi disk (m)	>3	2	1	<1
Turbidity	NTU	<10	80	150	>150
Dissolved oxygen	mg/l	>8	6	4	<4
Chemical requirements					
Chloride	mg/l	<2	6	10	>10
pH	pH units	6.5 – 8.5	5.75 – 8.75	5 - 9	<5 or >9
Electrical conductivity	mS/m	<70	85	100	>100
Microbial requirements					
Faecal coliforms	cfu/100ml	<130	165	200	>200
E coli	cfu/100ml	<130	165	200	>200

From the above analysis, it can be concluded that there exists an enabling policy and legal and regulatory framework for developing and implementing the Integrated Pollution Management Plan for the Nile Mukungwa catchment of Rwanda. Emerging issues are discussed in the paragraph below.

4.2.4. Issues in current policy, legal and regulatory framework

4.2.4.1. Planning processes that are not aligned with catchment governance

The Law determining the use and management of water resources in Rwanda (LAW N°49/2018 OF 13/08/2018) provides for establishment of permanent catchment committees. The exact composition and mandate of catchment committees will be laid down in the Ministerial Orders (which are currently under development). Meanwhile, the Integrated Pollution Management Plan for NMUK catchment has been using temporary arrangements where a Catchment Task Force composed of officials from the Districts, Water Users, Civil Society Organizations and private operators was set up to facilitated the development of this plan. In addition, current planning processes are district based where each district develop its own DDS, annual action plan and Imihigo without consultation with other districts within the catchment.

However, the implementation of this plan will require to have cross-sectoral cooperation at catchment scale, and to include both bottom-up and top-down participation, with emphasis on coordination across multiple scales. It is increasingly recognised that central government agencies cannot do everything and that some components of environment pollution are better handled by other actors. Catchment-based planning approach will offer much greater stakeholder engagement through agreement of a common vision and shared understanding of pollution management issues.

4.2.4.2. Lack of coordination, limited capacities and low awareness level on pollution issues

There are many committees in various sectors, including environmental committees, water committees, agricultural water user committees, forestry management

committees, Disaster Management Committees, health and hygiene committees etc. often with similar or overlapping roles and responsibilities for natural resources management. There is also limited capacities at decentralized level to promote pollution management measures.

In addition, the analysis of the existing policy and legal framework found some conflicting objectives in the programs for transformation of agriculture (e.g. objectives related to intensification in use of pesticides and fertilizers which conflict with objectives on improving water quality; as well, objectives for marshland reclamation which are potentially in conflict with objectives on wetlands protection) These soil intensive mechanisation measures are prioritised in agricultural mechanization strategies for Rwanda and in the national agriculture policy at the expense of the protection environment and natural resources management. Similarly, the national Environment and climate change policy seeks to aggressively promote protection of environment which may be at odds with agriculture transformation and economic development. These potential conflicts have to be carefully examined at local catchment level and interventions coordinated.

4.2.5. Recommendation on measures

If the current situation where sector ministries, agencies and districts are implementing their own plans in isolation, there will be a limited implementation of proposed measures and no specific integrated pollution management measures implemented. There is a need to move for a catchment based planning where plans are developed in participative and vertically and horizontally integrated manner, resulting in a coherent program of measures for each sub-catchment.

The catchment plans are developed in a participative and vertically and horizontally integrated manner, resulting in a coherent program of measures for each sub-catchment. Nile Mukungwa Catchment Committee need to be established and tasked with the implementation and monitoring of the IPMP and must ensure that there is coordination and cooperation between all role-players and engagement with stakeholders for the effective implementation of the plan. The Implementation Plan identifies lead institutions for various activities of the IPMP. The Catchment Committee's task will be to ensure these institutions integrate their responsibilities into their development plans, and monitor that the activities are implemented. At a minimum, Catchment committees will need to be supported technically and organizationally, by some form of a permanent secretariat (or Technical Committee) together with technical support from Rwanda Water Board.

4.3. Emerging urban and rural diffuse pollution issues in NMUK catchment

4.3.1. Identification and mapping of key activities and infrastructure, potential sources of pollution in Nile Mukungwa catchment

During discussions with the district officials and field visits, key pollution sources and concerns were identified. The list is by no means complete for all pollution

sources. However, it includes the most important source categories namely industrial sources, landfills, workshops and garages, informal settlements and slums, mining, etc. Key activities and infrastructure, potential sources of pollution are presented on Figure 6 below:

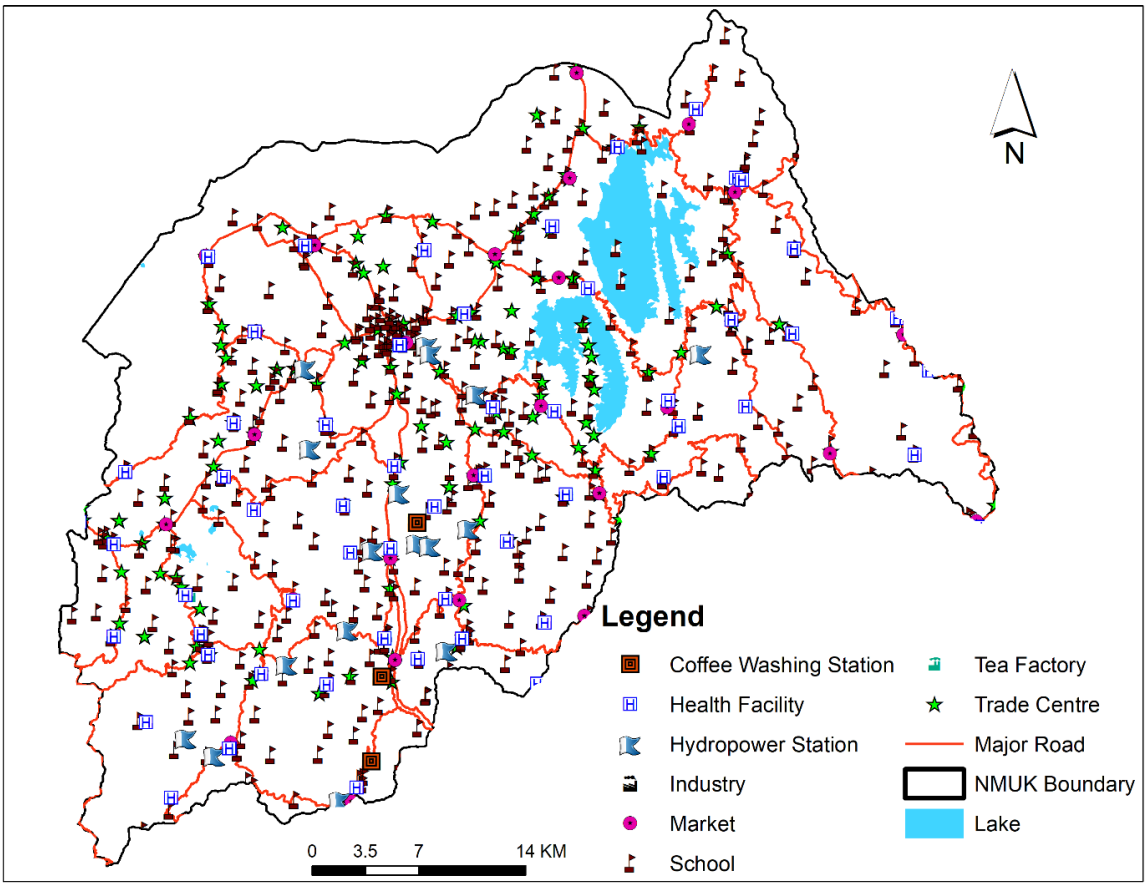

Figure 6*: Existing Socio-Economic Infrastructure associated with pollution*

Table 5: Number of Different Socio-Economic Infrastructure in NMUK Catchment

S/N	Socio-economic Infrastructure	Number
1	Health Centers	56
2	Trade Centers	135
3	Schools	392
4	Markets	23
5	Coffee Washing Stations	3
6	Industries	0
7	Tea Factory	2
8	Hydropower Station	18

4.3.2 Urban pollution issues

Except for Musanze town that is ranged among secondary cities, other districts are qualified as rural district and section below will focus on Musanze town while discussing urban pollution.

4.3.2.1. Contamination of water bodies and wetlands

Visual inspection during field visit and interview with district officials allowed the project team to identify the following pollution issues that contribute to the contamination of water bodies in Musanze town*:*

- ***Dense settlements and slums*** is a problem to the district because there is often limited or no sanitation services and solid waste removal. The result is that grey water is often discharged into stormwater drains that discharge into urban streams. Grey water is high in domestic cleaning agents, and high organic content which affects the dissolved oxygen concentrations in receiving waters. Open defecation and the disposal of sewage in areas with no sanitation services is a concern because it promotes the spread of pathogens and outbreaks of waterborne diseases.
- ***Brickmaking activities*** – brickmaking activities around the wetlands, especially around the outer edge of various wetlands and rivers is a concern because they are a source of fine sediments due the clay being used in the manufacturing of clay bricks, as well as air pollution from baking activities. Ash from the kilns is also a concern.
- ***Garages and hydrocarbon pollution*** – Hydrocarbon pollution is a concern in areas where there is a high concentration of garages and vehicle service centres. Used motor oil is often discarded onto the soil or into nearby ditches. Solid waste and oil leaks at the bus station is also a concern.
- **Downstream Hospital, police offices, hotels, etc and contamination of Kigombe River** – The Kigombe River was very clear during the field observation. However, it was observed that the hospital discharged their sludge directly in the drains that flow to Kigombe River. Similarly, the bus station also discharged their waste water directly to the drains that flows to the river. Dissolved oxygen concentrations were moderately high and would sustain aquatic organisms.
- ***Slaughterhouse Musanze*** - The slaughterhouse did not have a modern waste water system for treatment or disposal of waste water. The outlet channel from the slaughterhouse carried the waste water to different ponds where the waste water mixed with solid waste was left for drying (for dung, urines and solid wastes). The waste water infiltrates in the groundwater, this water is dark and smells like rotten eggs. And they said that sometimes with heavy rains, the ponds can be flooded and spill into nearby streams. The slaughterhouse and those waste water ponds are located just few meters from residential houses and people cook and eat just nearby the pond. The ponds were anoxic (no oxygen).

4.3.2.2. Littering of municipal solid wastes

- ***Cyuve landfill (Solid waste dumping site)*** – The dumping site had all the types of solid wastes and it was located in a residential area and nearby

Kiguhu marshland where the water sample was taken. There was no fence between the residential area and the dumping site and children are found playing at the dumping site and sorting through the waste. The natural springs in Kiguhu marshland were not clear (brown with oily sheen) and these springs provide water for the beans and Irish potatoes agricultural plots. This could indicate seepage from the solid waste site. Dissolved oxygen was low and not suited to maintain aquatic ecosystems. Solid waste disposal into water courses remain a problem, as is the design and operation of the Cyuve landfill and other informal disposal sites. The presence of organic matter in streams and rivers is a concern because it reduces the dissolved oxygen concentrations which was detrimental to aquatic organisms. Figure7 below presents issue with Cyuve landfill

Figure 7: Cyuve landfill (with livestock rearing in it and children in it)

- ***Downstream Tete a gauche/ Mwenge River*** - Mwenge River was very clear and fed with flows from a natural carbonated source of water found in 1907 by a Germany colonialist. Many people from the area collected domestic water from this source called "Amacyera". The area was clean but because many children play nearby the source, there were some plastic bottle and clothing fabrics that are left at the river banks but in general the river water was very clear. The dissolved oxygen concentration was acceptable for aquatic ecosystems.

- ***Nyamagumba Informal settlement/ Storm water drains*** - The storm water drains that passed nearby Nyamagumba informal settlement also passed through the bridge in town where solid wastes were dumped by people.

During heavy rain the drains filled with stormwater and carry all the solid waste a river downstream the city. There was also an old cemetery nearby Nyamagumba informal settlement. The dissolved oxygen was low and would not be suitable for aquatic ecosystems in the long term.

- ***Musanze informal dumping site*** - This informal dumping site was used by different institutions in town (hostels, police, motels, etc.) to dump septic tank sludge and other solid waste. The sludge water infiltrated into the groundwater. No water sample was taken at the site because the site was dry and only solid waste was visible.

Figure 8 below presents key pollution issues in Musanze town

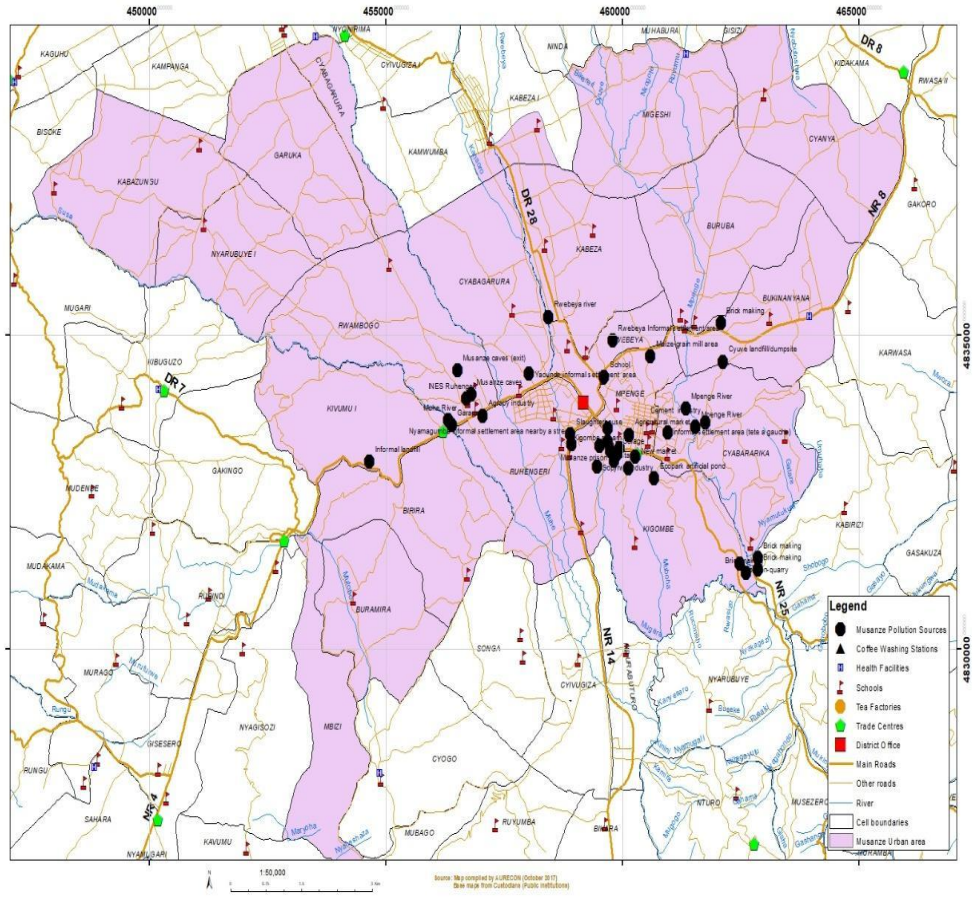

Figure 8: Pollution sources in Musanze town

4.3.2.3 Peri-urban diffuse sources of pollution

Peri-urban land use area has been extensively investigated during this task, however it is recognised as an important landscape component being the transition zone between rural and urban areas where the majority of development takes place and such is a principal source of intensive diffuse pollutant. Among key development activities in peri-urban areas of NMUK include small industrial zones, known as Agakiriro centres; quarries and unplanned settlement communities. Most of per-urban centres in NMUK are not serviced with solid wastes and wastewater treatment systems, becoming a principal source of diffuse pollutants with the range of rural

pollutants and some specific urban pollutant concentrations e.g. septic sewage. Therefore, concentration of pit latrines creates a potential water quality issues, especially with regard to seepage to groundwater and possibly to the base flow of waterways.

4.3.3. Rural diffuse sources

4.3.1.1. General overview

Most rural population in Nile Mukungwa catchment depends on rain fed agriculture. Rained agriculture is predominant, but also intensive puddy irrigation and non-irrigated crops (e.g. maize) is found in the catchment in Nile Mukungwa valley. The different management activities associated with these different land uses result in different types and/or quantities of water quality pollutants.

Typical diffuse source pollutants in rural areas include sediment, nutrients (nitrogen and phosphorus) and pesticides, which are eroded and/or collected from land surfaces, typically in rainfall runoff, and carried to receiving waters e.g. streams, lakes, reservoirs and wetlands. This overland flow, also known as sheet or hillslope erosion, combines with gully erosion and streambank erosion to provide the majority of the total end of catchment pollutant loads

Movement of sediment and nutrients in rainfall runoff is a normal component of natural weathering and erosion processes. Additional inputs of bioavailable/soluble nutrients combined with land disturbance and inappropriate management practices often results in accelerated run off and erosion rates and the subsequent transport of sediment and nutrients to receiving waters, well above normal background levels. It is the delivery of sediment and nutrients to receiving waters at elevated levels (and for nutrients in forms that are bioavailable) that create threats to aquatic habitats and biodiversity and, in some cases, human health.

Sediment and nutrient pollutants, their sources and environmental threat rating are listed in Table 6.

Table 6: Main rural diffuse polluants

Pollutant	Source	Rating	notes
nutrients			
Nitrate (NO3)	Fertiliser	5	Low natural levels
Ammonia (NH4)	Fertiliser	2	Low natural levels
DON	Fertiliser	2	Moderate natural levels, slow turnover
PN	Fertiliser and erosion	4	Moderate natural levels, loss to sediments
Phosphate (PO4)	Fertiliser, salt licks	2	Low natural levels
DOP	Fertiliser	1	Moderate natural levels, slow turnover

PP	Fertiliser and erosion	3	Moderate natural levels, loss to sediments
Silicate (Si (OH)4)	Erosion	0	
Sewage	STP discharge, septics	5	Contains all N, P forms at high levels
Coarse (>63 µm)	Erosion	0	**No likely impact, forms delta fans**
Medium (2-63 µm)	Erosion	2	**Carried only short distance**
Fine (< 2µm)	**Erosion**	**4**	**Carried widely over shelf, especially after dry year**

Source: Mitchell et al 2007 (p.7)

Note: Rating is potential threat posed by the pollutant where 5 is greatest threat and 0 is no threat.

Unlike sediment and nutrients, pesticides are a water quality pollutant not measured against natural background levels, as there are no 'natural' background levels. Inappropriate management practices, increased stormwater run-off and accelerated erosion rates also affect the amount of pesticides reaching receiving waters. Pesticides that enter waterways become a water quality threat with a range of impacts depending on the pesticide type and concentration.

In addition to sediment and nutrients, a range of pollutant groupings relevant to rural areas were identified by Mitchell et al (2007) and are listed in Table6. The 'rural' pollutants are also applicable to Nile Mukungwa catchment given that rural land uses occupy the majority of the Nile Mukungwa catchment area.

Table 7: Other rural diffuse pollutants

Pollutant group	Specific pollutant and comments
Herbicides	Diuron, Atrazine, Ametryn, Hexazinone and 2,4-D are principally used in the sugar industry. Simazine used in forestry. Tebuthiuron used in grazing industry. Glyphosate and Paraquat used broadly in sugar cane and horticulture.
Insecticides	Organochlorines e.g. Endosulfan, and a variety of others are used principally in horticulture and, to a lesser extent, sugar cane. Chlorpyrifos used in sugar cane for cane grubs.
Non insecticide organochlorines	PCB's from industry (reduced use but residues may persist) and Dioxins from agriculture and industry. PAH's (polycyclic aromatic hydrocarbons) from cane firing, forest fires and oil spills.
DO reducing materials (organic material)	Manure principally from cattle grazing. Sewage from urban areas. Plant litter occurs naturally and is increased as byproducts of intensive agriculture.

Heavy metals	Cadmium and potassium from fertiliser and mercury from fungicide. Other trace elements.
Oil or hydrocarbons	Primarily from liquid fossil fuels and oil spills.
Salinity	Both dryland and irrigation salinity resulting from land clearing (dryland) and irrigation activities.
Antifoulants	Used primarily in the fishing industry at mooring sites (TBT is now banned).
Acid	Principally associated with disturbance of acid sulphate soils.

4.3.3.2 Flooding and sub-standard farming and mining practices aggravating soil erosion and pollution

In many areas of Nile Mukungwa catchment, especially in volcanoes area, heavy rainfall results in floods. Whereas the observed floods may appear similar in nature, the dynamics of floods in the volcanoes area are quite different according to their locations: classic torrential rivers in the Musanze urban area and Sebeya catchment, flooded endorheic areas (catchments without external outlet) in Byangabo sector. However, these life-giving natural water conduits always become disastrous whenever water overflows due to heavy rainfall. This overflowing causes erosion along river banks, destroying agricultural areas and other structures near to it.

Assessment of floods impacts carried out by MIDMAR in 2012, in Musanze district, found that many sectors (Muko, Busogo, Gataraga, Kinigi, Nyange, Musanze, Shingiro and Gacaca) were affected by floods while others were mostly affected by landslides (i.e Remera and Rwaza sectors.). Impact was that most of the houses collapsed, others damaged while the farmlands, roads and street slided. Floods and landslides were also frequent in all district of Nile Mukungwa catchment following the last heavy rains in 2019 and 2020 rain seasons.

These floods and landslides are generally associated with unsustainable agriculture that is carried out on the land that has a set of vulnerabilities including the hilly topography that covers the steep slopes of over 40% others between 20-40%, community houses located in steep mountain areas, where gravity is pronounced, the lack of rain water collection, rapid population growth as well as environmental degradation.

On the other hand, high population density in the catchment, combined with a high use of fuel wood for cooking and poor agricultural practices, leads to deforestation and over- exploitation of agricultural land. Due to a lack of adequate management, soils become depleted of nutrient and, especially in the western part of the catchment which has steep slopes, rates of soil loss are very high. Once the eroded soils enter waterways, they contribute to high sediment loads thereby, amongst other adverse impacts, they increase flood risk as they deposit in the riverbed and floodplains reducing flow capacity.

Farmers will need to be encouraged to adopt and utilise agro-forestry and other tree species e.g. fruit trees, on their farms. Combined with other tailor-made and

already popular soil and water conservation technologies, based on lessons from ongoing and past projects, this can curb the rates of deforestation, soil erosion, stream sedimentation and flood risk.

Sediment loads in rivers are further aggravated by mining activities throughout the catchment. Both formal licensed and informal, unlicensed, usually artisanal, mines use poor, environmentally damaging practices that lead to ingress of large quantities of sediment into watercourses. The contribution of mining activities to sediment loading in rivers is considered at least to be equal to the contribution made by agricultural soil erosion, and in some individual sub-catchments mines are the predominant source of sediments;

Illegal and unsustainable mining and quarries activities are widely spread Nile Mukungwa catchment and siltation due to mining activities was observed in many rivers in Mukungwa catchment.

4.3.3.3. Encroachment of national parks, wetlands, river banks which lead to pollution of water bodies

Sensitive ecosystems such as wetlands and river banks play an important role in water quantity and quality management; they contribute to water resources regulation to downstream water courses and water resources retention. In general, they are considered as water towers due to the role they play in conserving and filtering water resources.

Nile Mukungwa catchment hosts one of those sensitive ecosystems, the Rugezi wetland, that has been playing been playing a significant ecological, hydrological, socio-economic and historical and recreational role. Located in a highland area where floods and sedimentation are potential threats to water resources management, the Rugezi Marsh was regulating, retaining and filtering the water resources that flow into Lakes Bulera and Ruhondo downstream. However, due to the demographic pressure in the catchment and the country economic growth, the Rugezi Marsh is facing an environmental crisis related to marsh agricultural reclamation and drainage to increase the hydropower generation at Ntaruka and Mukungwa sites. Both activities have implied the degradation of the marsh water table, water quality and the decline of water level in the Lakes Bulera and Ruhondo. This degradation has complicated water resources management in Lakes Bulera and Ruhondo catchments and the cost to replace or rehabilitate the hydrological functions of Rugezi Marsh is putting a heavy burden to the government, local authorities and international organisations. Box 4.1 provides details on the issue and proposes best management options

BOX4.1: ECOSYSTEM RESTORATION AND SUSTAINABLE HYDROPOWER PRODUCTION: CASE OF RUGEZI MARSHLAND

1. Introduction

Rugezi wetland is a Ramsar site covering over 6,735 hectares and located in Burera District, Nothern Province of Rwanda, part of Nile Mukungwa catchment. It is an important ecosystem which hosts over 43 bird species, including endangered species such as Grauer's swamp warbler (Bradypterus graueri) and the grey crowned crane (Balearica regulorum) as well as threatened birds including the papyrus yellow warbler (Calamonastides gracilirostris).

Figure: Rugezi Wetland

2. Issue

Poor management of the upstream Rugezi Wetlands combined with the degradation of the surrounding Rugezi-Bulera-Ruhondo watershed due to human activities and reduced rainfall in recent years led to significant drop in the depth of Lake Bulera. Around years 2003-2004, the drop in Burera Lake water levels caused a steep decline in power generation at the Ntaruka hydropower station that was exacerbated in a major electricity crisis.

3. Measures

The Government responded to the crisis by halting drainage activities in the Rugezi Wetlands and banning agricultural and pastoral activities within and along its shores, as well as along the shores of nearby lakes Lakes Bulera and Ruhondo. with additional agricultural and watershed management measures including: building erosion control structures; planting a bamboo and grass belt around the Rugezi Wetlands; planting trees on surrounding hillsides; distributing improved cookstoves; and promoting both environmentally sound farming practices, and additional income-generating activities such as beekeeping. Today, the Ntaruka hydropower station has returned to full operational capacity while local livelihoods are, in the main, more secure. Restoration of Rugezi Marshland is a success story that guided the prioritisation of interventions during the development of this plan.

4.3.4. Impact: Physico-chemical and microbial contamination

Various investigations carried out on water quality in lava region found that there were very low concentrations of nitrate in the water sources. However, nitrate should be tested in future monitoring programs in order to evaluate its trend in groundwater since its occurrence can also be attributed to other factors like fertilizer and other agrochemicals application.

Some faecal coliform contamination was noted in the water sources (RNRA, 2014). This could be due to the fact that these sources are unprotected or open surface water bodies that are easily prone to pollution. It is highly recommended to boil any water that is to be used for drinking purposes. Fluoride and iron were the other health-based or aesthetic-based quality parameters considered. However, Low concentrations of fluoride were recorded. Arsenic is one of the most important health-based parameters, and was found in some boreholes in lava region (RNRA, 2016).However, the information gathered from health centres and the observations made during field investigations did not suggest/show any signs of arsenic poisoning amongst the communities that exploit the water sources.

The presence of some chemical constituents can be beneficial for agriculture, but when released to surface waters where they are not wanted can lead to eutrophication and generation of Biological Oxygen Demand (BOD). Nitrate levels were relatively low, even much lower than its natural occurrence value in water. The source pollution survey identified probable sources of nutrients as agricultural fields since application of NPK fertilizer was substantially evident and is expected to be on the increasing trend as demand for the staple food (Irish potatoes) on which they are mostly applied is expected to increase with an increasing population. Though pesticide application was evident, no study currently confirmed any pesticides in the stream/lake water bodies in Nile Mukungwa catchment. However, incident like the one occurred in October 2018 that induced a sudden death of fish in different water bodies in Nile Mukungwa demonstrates that monitoring efforts should be enhanced to predict or mitigate similar kind of incident, including pesticides pollution. Figure 9 below presents the pond with dead fish in Musanze District after discharge of unidentified source of chemical wastewater.

Figure 9: Ponds with dead fish stocks following mysterious discharge of chemicalsin Musanze District in 2018 (Source: New Times October 11, 2018)

4.3.5. Recommended measures

In order to improve or protect the quality of surface water or protecting the underlying aquifers, control of probable sources of pollution such as faecal coliforms/nutrients from pit latrines should be considered. As such, use of ecologically sustainable sanitation that promotes the recycling of nutrients for use as fertilizers in agriculture or gardening to avoid water pollution with nitrate and phosphorus should be promoted. The use of on-site methods of eco-san is likely to be beneficial in relation to preventing groundwater contamination because they have a low hydraulic load.

To minimize the pollution and contamination of the sources exploited for water supply, it was recommended to establish and maintain protection zones around each source. Such zones may cover an area of at least 50m by 50m around the water source as practiced in Uganda (MWLE, 2000). These zones should be fenced off and restrictions of farming and other activities barred from such areas.

In order to minimize agricultural pollution to open water bodies, erosion controls to reduce runoff flow and retain soils on agriculture fields should be utilized. Common techniques include terracing (as already being practiced), crop mulching, and crop rotation, planting perennial crops and installing riparian buffers as a possible way to prevent nutrients from travelling too far. Also a nutrient management system should be developed for farmers to implement. Such a system would be used by farmers to manage the amount, form, placement, and timing of the application of fertilizers. The purpose is to supply plant nutrients for optimum forage and crop yields, to

minimize nonpoint source pollution (runoff of pollutants to surface water) and contamination of groundwater, and to maintain and/or improve the condition of the soil.

Soil testing, is a technique that can help farmers optimize the amount of fertilizer applied to crops. By testing fields with this method, farmers and government will realize a decrease in fertilizer application costs, a decrease in NPK lost to surrounding sources, or both. By testing the soil and modeling the bare minimum amount of fertilizer needed, farmers reap economic benefits while the environment remains clean and pure. This would result in reduced use of fertilizers and hence reduction in the potential for groundwater pollution.

The role of the public is a major factor for the effective prevention of eutrophication, leaching or pollution in general. Programs should be instituted to promote participation in the recycling and elimination of wastes, to protect water quality within communities adjacent to critical water bodies.

At last, as an upstream catchment Nile Mukungwa water can have an effect on a range of people far beyond the catchment, therefore cooperation with other catchments is necessary to prevent the intrusion of contaminants that can lead to pollution. Other mitigation measures are as presented in Table 8 below

Table 8: Possible mitigation measures to reduce pollution in Nile Mukungwa catchment.

Sources of pollution	Possible mitigation measure
High priority	
Landfills and solid waste dumps	• Develop and implement an integrated waste management system
Seepage from septic tanks	• Constructing an urban centralised WWTP • Regulating construction of septic tanker
Grey water disposal into stormwater	• Constructing an urban centralised WWTP • Educating communities on the reuse of resources
Pollution from garages and workshops	• Enforcing and formulating regulations for the disposal of contaminated garage and workshop wastewater • Onsite treatment systems for water contaminated with waste, especially oil and grease.
Hotels / Hospitals	• Monitoring compliance to conditions specified in the EIA
Medium priority	
Stormwater drainage system	• Constructing systematic drainage channels • Greening on stormwater system and making use of natural treatment capacity of vegetation.
Industrial effluents	• Monitoring EIA compliance
Unpaved and poorly maintained urban roads	• Pave urban roads

Formal and informal abattoirs	• EIA compliance • Stop informal abattoirs
Low	
Informed sewage and greywater disposal into urban streams	• Centralized WWTP
Urban agriculture, wetland agriculture, and aquaculture	• Increase and encourage use of organic fertilizer • Using biodegradable pesticide
Fresh produce market/ poor solid waste management	• Proper management of waste at the market
WWTP effluent	• Encourage reuse of effluent for beneficial activities, e.g. irrigation of crops (but not crops that are eaten raw)

4.4. Mapping pollution hotspots

For a more comprehensive understanding of impacts of pollution sources on natural environment and to allow prioritisation of resources and actions, potential pollution sources were identified and mapped (Figure 10 above), then an overlay of identified sources of pollution with information on which environment resources may be affected (water bodies, wetlands, etc) was done and presented into the interactive maps as presented on Figure 10. Lists of pollution hotspots sites in Nile Mukungwa catchment is attached as Annex IV

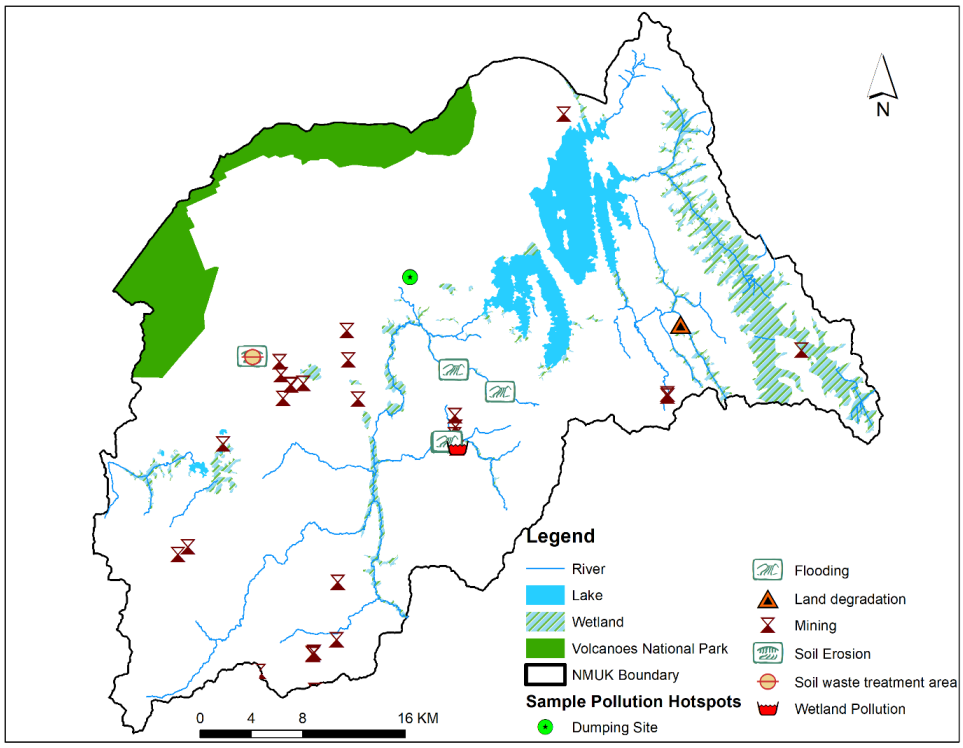

Figure 10: Key Pollution Hotspots in NMUK Catchments

4.5. Approaches to Integrated Pollution Management

Pollutants are produced through human activities and create long-term effects when released into ecosystems. Strategies for reducing these impacts can be directed at three different levels in the process: altering the human activity, regulating and reducing quantities of pollutant released at the point of emission, and cleaning up the pollutant and restoring ecosystems after pollution has occurred. Figure 11 shows the value and limitations of each of the three different levels of intervention.

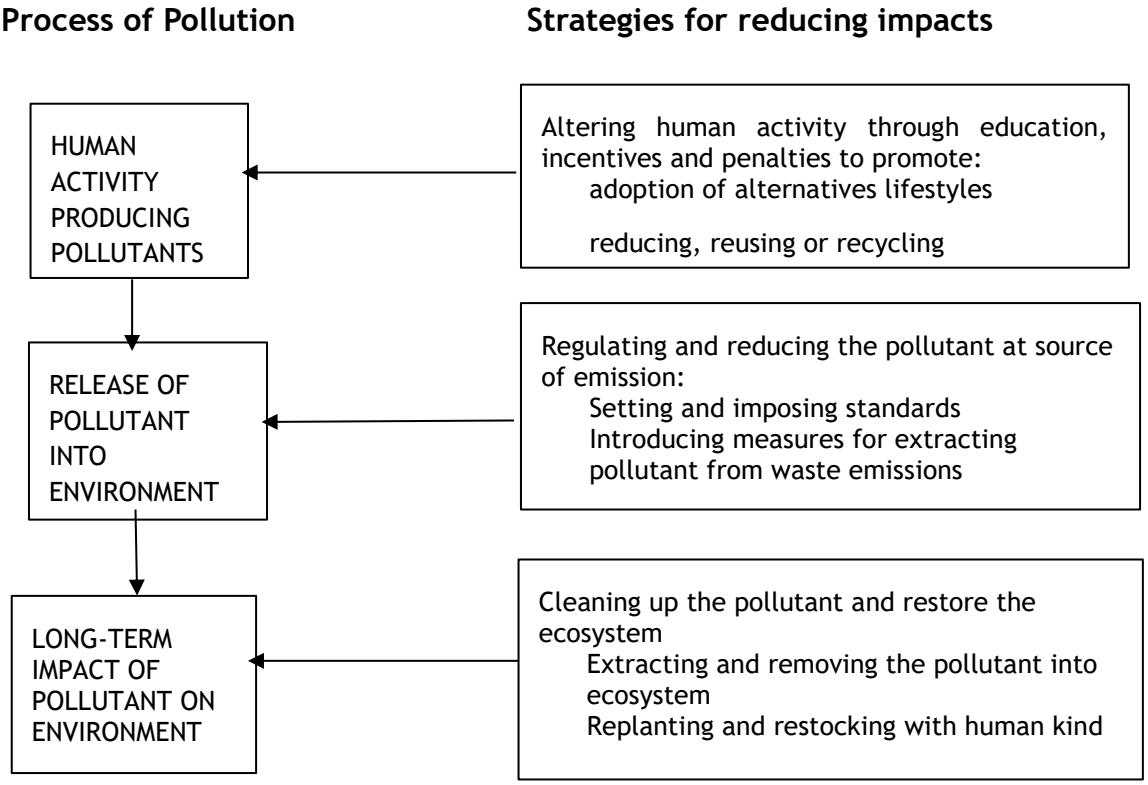

Figure 11: Approaches to integrated pollution management

4.5.1. Altering human activity

Changing Human actions has the greatest benefit overall, but is often the hardest to achieve and takes long term planning. If no pollution was produced in the first place there is no need for any intervention. Though often intervention is needed originally to help change the behaviours that contribute to pollution. This strategy depends very much on behavioural change of people, industry / business and Governments and can come into conflict with short term economic tensions

4.5.2. Regulating and reducing pollutant at source of emission

Reducing the amount of pollutant released into the environment has the next greatest impact. This help to control the source of the pollution rather than the effect of the pollution. This form of pollution management is built into government policies around the world where pollution regulation can have direct results. The Environment Organic Law (2005) was an early pollution legislation measure. While business and industry are often the main focus of pollution legislation, domestic

pollution may also be controlled by legislation. Many countries, especially in Europe have legislation that forces households to separate domestic waste so less waste enters landfill and recyclable products like PET bottles can be separated out easily.

Imposition of appropriate standard is also important for source emission standards. Applicable laws, standards and guidelines for pollution sources reduction in Rwanda were deeply analysed in point 4.2 of this plan.

4.5.3. Cleaning up the pollutant and restore the ecosystem

Cleaning up pollution problems is the least effective way of dealing with pollution. This is dealing with the problem after the problem has already caused damage. Much of the old industrialised world has inherited the problems created since the industrial revolution. Cleaning up an already damaged environment is often costly and can often take many years from inception to complete clean up. Though often where heavy industry has been in the past or with contaminants such as radiation the clean-up can only ever be limited

In case of urban stormwater discharges, the need for pollution reduction has led to an emphasis on a stormwater management approach that focuses on keeping pollutant out of receiving streams by upstream control; that is attenuation and treatment measures close to where the runoff is generated (Abbott Grobicki, 2001). Most urban stormwater management measures can be classified as structural or non-structural (Abbott Grobicki, 2001, Debo & Reese, 2003):

Non-structural BMPs are BMPs are almost exclusively focussed on pollution prevention and the objective is to minimise the pollutant load from urban areas. These include a variety of institutional and educational measures focussed on land development, public awareness to modify behaviour that contribute to urban pollution, detection of illicit wastewater discharges, and enforcement of ordinances designed to prevent the deposition of nutrient containing waste and products on urban landscapes. Non-structural BMPs are generally grouped into educational BMPs, planning and procedures BMPs, and site-based local control BMPs (Abbott Grobicki, 2001, Debo & Reese, 2003). Educational BMPs refer to measures that are devised to sensitise citizens about their role in water quality degradation, protection and enhancement. Planning & procedures refer to minimising urban stormwater pollution through effective planning procedures (e.g. master plans, comprehensive plans, and zoning ordinances) designed to promote improved water quality by restricting certain types of activities in sensitive areas. Site-based local controls refer to ordinances and by-laws that require the inclusion of buffer strips, preservation of riparian zones, minimising disturbance and impervious areas, and maximising open spaces.

Structural BMPs are generally measures that act as a backup for non-structural BMPs by providing attenuation or treatment facilities before transportation of polluted water to receiving streams and rivers. Structural BMPs can be grouped into storage practices, infiltration practices, and vegetative practices (Debo & Reese, 2003). Storage and detention BMPs refer to measures to collect urban runoff in wet ponds, dry basins or multi-chamber catch basins and slowly releasing to a receiving stream

or river or stormwater canal. Infiltration practices refer to BMPs that facilitate infiltration of urban runoff through the soil to groundwater. Vegetative practices refer to landscaping BMPs that enhance pollutant removal, maintain and promote natural site hydrology, promote healthy habitats and increase aesthetic appeal.

Currently, only structural management facilities were selective planting of bamboo within the riparian buffer zones to stabilise river banks, and enforcement of exclusion zone (buffer zones) around the main rivers.

4.6. Summary on Nile Mukungwa catchment pollution drivers, pressures, states and impacts

The DPSIR (Driving forces, Pressures, States, Impacts and Responses) approach was adapted from IWRM/W4GR Mukungwa Catchment Plan (2018-2024) developed by Rwanda Water and Forestry Authority in 2018. Table 9 below provides drivers, pressures, states and impacts of pollution in Nile Mukungwa catchment

Table 9: Drivers, Pressures, States and Impacts of pollution in Nile Mukungwa Catchment

Drivers	Pressures
• High population density • Economic development • Poverty • Low skills &awareness levels • Insufficient enforcement of environment laws and regulations on mining • Little knowledge, understanding &skills in agrochemicals/pesticides/herbices application best practices • Low capacity and skills in solid waste and wastewater management	• Siltation from mining exploitations • Soil over exploitation, land degradation & soil erosion • Limited management of solid and liquid wastes • Sub-standard farming & mining practices aggravating soil erosion and pollution
States	**Impacts**
• Planning processes non-aligned with catchment governance • Contamination of water bodies and wetland pollution • Littering of municipal solid wastes • Encroachment in sensitive ecosystems such as wetlands, natural reserves and river banks • Low skills & awareness levels	• Water borne diseases • Loss of public assets, habitation and crop lands in floodplains • Decline in power production following decease of lake water level

4.7. Opportunities

4.7.1. Past and ongoing soil conservation interventions

Lessons learnt Reforestation and other soil conservation inventions implemented by different projects (Adaptation Fund, PAREF, LVEMPII, LWH/RSSP, etc) in Nile Mukungwa catchment will serve as an opportunity to upscale future plans to reduce soil erosion and increase productivity.

4.7.2. Laws, regulations and standard

During the decades, the Government of Rwanda put in place different laws, regulations and standard on environment and natural resources protection, management and conservation that would be regarded as opportunities to improve pollution management in Nile Mukungwa . Limited enforcement capacity of the above legal instrument is still law in the catchment, for this opportunity to become effective, stakeholders need to join hands in improving enforcement of legislation, e.g. through water permitting and strengthening of field-level enforcement of environmental legislation.

4.7.3. Decentralised governance framework

Existing District authorities in Nile Mukungwa Catchment are regarded opportunity since they will coordinate the stakeholders with their boundaries towards a common goal. However,there is a need to establish the Catchment Committee for Nile Mukungwa catchment bringing together key stakeholder with better knowledge of environmental and socio-econmic problems of the catchment (as provided by the law). One operational, the committee is well placed to enhance environment protection measures if they are supported. Working together with District authorities, they will facilitate local communities' participation and allow the building of local capacities for provision of services that are more consistent with the local requirements.

CHAPTER 5. INTEGRATED POLLUTION MANAGEMENT PLAN

5.1. Introduction

The preceding chapters provided a characterisation of pollution situation in Nile Mukungwa catchment and identified specific issues and challenges being experienced. This chapter sets out the Vision, goals and objectives to address these issues and to ensure the sustainable management of natural resources going forwards. The goals and objectives are generic for all catchment included in this project. However, the targets and activities are specific to the Nile Mukungwa catchment.

5.2. Vision, goals and objectives

The vision statement has been formulated so as to ensure that it is broad to allow for wider interpretation and buy-in from various stakeholders. A generality has also been incorporated to give it a long lifespan and allow its constituent medium term plans to remain relevant to the long-term goal and objectives of the plan.

Scoping workshop that brought together representatives of all the districts in the catchment and national institutions discussed and agreed on common key pollution issues and opportunities. Major pollution management issues in Nile Mukungwa catchment include planning processes that are not aligned with catchment governance, inadequate management of liquid wastes and inadequate solid waste collection and illegal dumping that lead to contamination of water bodies, inadequate separation and valorization of organic and other landfilled at the Cyuve landfill in Musanze, sub-standard farming & mining practices aggravating soil erosion and pollution,encroachment of national parks, wetlands, river banks & pollution of water bodies, lack of data on pollution, little knowledge, understanding and skills in agrochemicals/ pesticides/herbicides application best practices as well as little knowledge & understanding of environment laws and regulatory instruments. The opportunities include past and ongoing sustainable land management &soil conservation interventions, existence of laws, regulations and standards on pollution management as well as decentralized governance framework that facilitate the participation of local communities during the implementation of the plan.

Following the scoping workshops held with stakeholders, consultancy team synthesized the workshop messages and outcomes and then formulated an agreed vision for the Nile Mukungwa catchment as follows:

"A well-managed and eco-friendly catchment that welcomes eco-tourists and supports sustainable development through green infrastructure"

Moving from vision to actions, it is necessary to prioritize a limited number (typically three to ten) of core concerns around which to formulate actions. In this plan, core concerns are referred to as strategic areas. The strategic areas make it easier to set objectives for integrated pollution management and develop strategies and specific interventions to achieve the catchment plan objectives. The strategic areas group and categorise the issues being faced for pollution management and possible solutions.

Three Strategic Areas or goals for the catchment plan are:

Goal 1: Enhance governance of pollution management at catchment level.

In order to manage catchment pollution, there is a need to be alignment and coordination at catchment and district level of plans and strategies to ensure that pollution and protection of the residents, and the environment is considered in all activities undertaken by the district. This goal will be achieved through the following objectives and activities:

Objective 1.1. Strengthen District Authorities to enforce pollution control guidelines and standards

This objective will be achieved through the following key activities:

i. Support District Authorities to enforce regulations on pollution control; and
ii. Support joint inspections of environment polluting activities in Nile Mukungwa catchment.

Objective 1.2. Establish coordination mechanisms for pollution management at catchment level

This objective will be achieved through the following key activities:

i. Establish Nile Mukungwa catchment committee;
ii. Operationalise Nile Mukungwa catchment Technical Committee;
iii. Support integrated planning at catchment level and
iv. Support regular coordination meetings of water committee, environment committee and water users' organisations.

Goal 2: Efficient and effective pollution management in Nile Mukungwa catchment

There is a need for districts to be more adaptive in their management of pollution. This will require increasingly identification and implementation of efficient and effective management practices to minimise the impacts of rural and urban pollution. It would also require the strengthening of compliance and enforcement activities within catchment areas. This goal will be achieved through the following objective and goals:

Objective 2.1. Support effective pollution management in Urban and per-urban areas of NMUK

This objective will be achieved through the following key activities

i. Develop sewerage systems and wastewater treatment plants;
ii. Support sludge treatment facilities operation &maintenance of sludge treatment facilities;
iii. Invest in ecological sanitation to enhance the recycling of nutrients;
iv. Support resettlement of population in high risk zones;
v. Support small industries &SMEs to implement cleaner production measures;
vi. Support rainwater harvesting on rooftops of settlement areas;
vii. Construction of water drainage to capture road drainage & settlements;

viii. Support the valorisation and recycling of municipal solid wastes as well as remediation of close dumping sites;
ix. Promote voluntary clean-up activities through community work initiatives and local NGOs; and
x. Multiply inspections for environmental compliance in mining sector

Objective 2.2. Effective management of rural pollution

i. Support the implementation of sustainable mining practices/Model mining
ii. Enhance payment of ecosystem services in NMUK for catchment protection
iii. Multiply inspections for environmental compliance in mining sector
iv. Support sustainable conservation of protected areas
v. River bank protection along all rivers and wetlands in NMUK
vi. Increase awareness and education on environment protection

Goal 3: Effective information and knowledge management

The old adage that you cannot manage what you do not measure holds true. This goal requires a renewed and strengthened drive to improve monitoring networks in catchment areas and to strengthen and consolidate information management systems. Adaptive management is based upon the support of monitoring networks and systems. This goal also includes building capacity in integrated pollution management through education, training, and knowledge transfer.
Strategic goals are supported by specific objectives and targets.

Objective 3.1. Ensure continuous Monitoring of urban and rural pollution

i. Conduct a feasibility study on status of wastewater treatment options for small industries and SMEs with/without wastewater treatment facilities in NMUK
ii. Integrated key urban hotspot monitoring points to national sampling program
iii. Support groundwater monitoring network in lava region
iv. Conduct a research study on adequate techniques and time for application of human excreta as organic manure

Objective 3.2. Building capacity in pollution management

i. Develop training package on urban and rural pollution and BMPs;
ii. Conduct trainings, awareness raising and capacity building among farmers on smart agriculture ; and
iii. Disseminate policies, laws and regulatory instruments on environment protection, sustainable mining and smart agriculture

5.3. Implementation arrangements

Effective implementation of this Integrated Pollution Management Plan will depend on how planned activities are owned by Districts within the catchment and how best planning processes are coordinated and harmonized. The Ministry of Environment is the primary coordinating government organ of pollution issues and will ensure a well coordination and synchronization of planning activities at national levels to avoid unnecessary duplication and conflicts that may arise. However, the Ministry of Local Government will coordinate the integration of actions in this plan into District

Development Strategy, Annual Plans and Imihigo. The implementation mechanisms of the pollution management plan at national and catchment levels are outlined in the following sections.

5.3. 1. Stakeholders' analysis

The stakeholder analysis showed that the following key stakeholders will take part in implementation of the plan:

- Institutions at national level, in the form of line ministries and their authorities / agencies, including the significant projects and programmes carried out under their auspices;
- Parastatal utilities for water supply, sanitation or electricity;
- Decentralised entities such as district authorities, as the main catchment level plan owners, represented by their members of the Catchment Committee;
- NGOs and INGOs, active in the districts;
- Communities; and
- Private sector stakeholders.

The above stakeholders can be classified into three broad categories according to the role they are expected to play, the level of influence they are expected to exert within the framework for designing and implementation of the catchment plan, and their role in the stakeholder engagement strategy:

5.3.1.1. Primary stakeholders: Include local farmers, herders, fishermen etc., all of whom derive their livelihoods from land or water resources, or whose activities directly rely or impact on land and water resources. They are sometimes grouped into water user organisations within and downstream of the catchment and business entities directly affected by catchment management.

5.3.1.2. Secondary stakeholders: These are individuals, institutions or organisations that are intermediaries in catchment plan development and implementation. Secondary stakeholders are "indirectly affected" by outcomes in the catchment and include District authorities, NGOs, WASAC, RURA, REG and key projects such as IUCN and LAFREC II. The catchment committee are the focal points for this group. Although only indirectly affected by the outcomes, secondary stakeholders are powerful and often highly involved in the catchment pollution planning process, and should remain so during the plan implementation;

5.3.1.3. Tertiary stakeholders: These are referred to external stakeholders and usually only play an advisory, approval or advocacy role. They include the institutions at national level, the development partners, and technical ministries which formulate policies, plans and programs relevant to the catchment plan (e.g. MoE, MINAGRI, MINALOC, MININFRA, etc). The apex bodies for water management, such as the Water Inter Ministerial Committee and National Water Consultative Committee, are also included in this category and play a critical role in approval of the catchment plan.

5.3.2. Roles and Responsibilities of key stakeholders

This Integrated Pollution Management Plan includes certain roles and responsibilities for various institutions which are has a stake in pollution management in Rwanda. These include: Ministry of Environment (MoE), Ministry of Agriculture and Animal Resources (MINAGRI), Ministry of Infrastructure (MININFRA), Ministry of Finance and Economic Planning (MINECOFIN), Ministry of Local Government (MINALOC), Rwanda Environment Management Authority (REMA), Rwanda Development Board (RDB), Rwanda Water Board (RWB), Rwanda Utilities Regulatory Agency (RURA), Ministry of Trade and Industry (MINICOM); Ministry of Health (MoH) among others. A wide variety of capabilities and expertise can be provided by the other institutions/organisations in support of implementing the plan's recommendations. Some of the diverse institutions/organisations that can be involved include the Districts in the catchment, Development Partners (e.g. World Bank), User Communities, Non-Governmental Organizations (NGOs), the private sector and Community Based Organisations. Table 10 provides details on institutions analysis and their roles in pollution management. Table 12 provides a summary on the lead, co-lead, support and analysis of roles and responsibilities for all identified institutions/organisations. A lead or co-lead designation means that the institutions/organisations noted would be responsible for leading the implementation of the activity but the actual work can be done by the lead group and/or others in a cooperative effort. The co-lead and other designations can also provide management support and/or technical assistance for actions led by the lead institution.

Table 10: Institutions with important roles in Pollution Management

No	Institution	Function
Policy institutions		
1	Ministry of Environment (MoE)	Ensure that environment and pollution control policies and strategies are passed by Cabinet and communicated to stakeholders. The Ministry of Environment will provide policy oversight to the plan implementation including enforcement of accountability and continued alignment to high level political interests
2	Ministry of Local Government (MINALOC)	Facilitate the management of efficient and effective decentralized government systems capable of law enforcement and delivery of required services to the local communities
3	Ministry of Agriculture and Animal Resources (MINAGRI)	In its mandate of increasing agricultural and animal production, modernising farming, ensuring food security and promoting surplus for the market, and given the close link between agriculture and the catchment management, especially for land husbandry, irrigation feeder roads improvement and fertilisers application in farms, this Ministry will be involved in promoting policies and strategies for soil conservation and agrochemicals/pesticides application best practices.

4	Ministry of Infrastructure (MININFRA)	MININFRA will facilitate implementation of the IPMP at catchment level and at national level through policy and standards formulation on integrated Municipal solid wastes and liquid wastewater management and participation in the programme steering committee, and at local level in the catchment;
5	Ministry of Trade and Industry (MINICOM)	Policy formulation and promotion of investments in cleaner production by the private sector for industries and manufacturing.
Financing institutions		
6	Ministry of Finance and Economic Planning	Mobilization and allocation of financial resources including co-ordination of donor inputs
7	Rwanda Green Fund (FONERWA)	Funds Mobilization and investment in the best public and private projects that have the potential for transformative change and that align with Rwanda's commitment to building a strong green economy.
8	Development partners	LDCF, World Bank, German Embassy, Embassy of the Kingdom of Netherlands and other regional or international environment management partners on the ground and those not on the ground but with interest in pollution management in Nile Mukungwa catchment will be critical to the success of the plan implementation. Their experience in pollution management and control links to potential financiers or financing capability will be very important for the implementation of the plan.
Regulatory Institutions		
9	Rwanda Environment Management Authority (REMA)	Key areas of intervention relate to prevention of soil erosion, deforestation, pollution and water contamination. REMA should support LODA in ensuring that the focus on LED does not negatively impact on the environment, including through destruction or depletion of natural resources, and should work towards promoting innovation and green enterprises
10	Rwanda Utilities Regulatory Agency (RURA)	Enforcement of compliance by public utilities with the laws governing their activities, mainly liquid and solid wastes collection, transportation & disposal
11	Rwanda Standard Board (RSB)	Provision of standards based solutions for a safe and stable environment.
Implementation & Services institution		
12	Rwanda Water Board	The Rwanda Water Board leads management and promotion of water Resources. RWB establishes strategies related to the protection of catchments and coordinate the implementation of erosion control and water quality monitoring actions, including implementation of catchment management plans.
13	LODA	The Local Government Development Agency plays a unique and essential role in supporting and promoting local economic development across Rwanda. As a

		central agency but with staff at district level and providing funding to improve development at the local level, LODA has a key role in supporting LED. In close collaboration with MININFRA &MoE LODA will ensure that projects needed in the catchment are designed and executed in a sustainable manner(i.e without or low adverse environment impacts)
14	WASAC	WASAC: is responsible for ensuring access to clean water and adequate sanitation infrastructure. WASAC is therefore a key player in catchment plan implementation especially with regard to achieving safely managed water and wastewater. In addition, WASAC will contribute through supporting the rehabilitation of buffer zones around water sources.
15	RDB	RDB is responsible for supporting private investment and business development in Rwanda, including through addressing the needs of companies and investors. In catchment pollution management plan implementation, RDB will lead attraction of investors in waste management infrastructure development and be consulted for approving Environmental Impact Assessments and mitigation plans for all pollution management projects at catchment level.
16	RAB	Given its responsibility to implement the national policy of agriculture and animal husbandry, RAB will ensure the promotion of agriculture and husbandry practices that minimise the impacts of diffuse agricultural pollution of water, land and air
17	NIRDA	Promote the use of environmentally friendly and resource efficient technologies and services in pollution management at catchment level
18	Districts	Implementation of the government policies and laws. Districts in Nile Mukungwa catchment will be sole organs to lead the implementation of this plan.
19	PSF	Design, construction, operation and maintenance of pollution management infrastructure and equipment. Provision of other commercial services, e.g. mobilization of financial resources for waste management infrastructures.
20	Non-Governmental Organizations (NGOs)	NGOs operating in Nile Mukungwa catchment will supplement the public sector efforts in pollution management through conduct training and capacity building for communities

5.4. Financing of the Plan

Acquisition of adequate resources is a prerequisite for the successful implementation of this plan. Rwanda Environment Management Authority (REMA)

and the Ministry of Environment who are the primary coordinating institution responsible for the implementation of the Pollution Management Plan should be the vehicle for the mobilization of the necessary resources. These resources shall be mobilized from national sectoral budgets, bilateral and multilateral donors and the private sector. Support from organizations such as GCF, World Bank, GEF and SIDA and others with a long history of support in the conservation and sustainable development projects in Rwanda will be critical in providing the funding to implement the plan.

5.5 Actions cost estimates

The budget estimate for the implementation of this plan based on the strategic activities is presented in Table as Annex I. Funds for the implementation of the plan is expected to come from the government budget, grants and donor agencies. An explanation on how the cost estimates was made is attached as Annex II

5.6. Prioritization of Actions and Schedule

Effective implementation of the Nile Mukungwa Pollution Management Plan is enhanced by the prioritization and scheduling of all recommended actions. In order to accomplish this, a priority rating system and implementation schedule parameters were considered for each action.

Factors included as part of the prioritization rating system include importance, coverage under existing programs, timing and sequencing, and ease/difficulty of implementation of the recommended actions. For each factor, professional judgment and experience were used to consider the following types of priority information:

i. *Importance* - Recognizing that all recommended actions are essential for sound pollution management, which actions are most critical or critical versus others that are important?
ii. *Coverage Under Existing Programs* - What are the significant pollution management needs that either have little or no, limited, or incomplete coverage under existing programs?
iii. *Timing and Sequencing* - Are there any considerations, such as developmental time for programs and regulations that require actions to be phased in over time? Do any of the plan's recommendations rely upon another action(s) to be done first?
iv. *Ease/Difficulty of Implementation* - Given the many parameters to be considered for implementation, which actions are relatively easy versus difficult? Some of the parameters to consider include technology available, staffing, in terms of manpower and subject matter expertise, competing program priorities and workload, legal or policy constraints, and public support.

Each recommended action was evaluated, using the factors listed above, to determine ratings of top priority, high priority, and priority. The importance factor was given added weight by requiring an action to be rated as a top or high priority in importance before it can have an overall rating of top or high priority, respectively.

Table 11: Ratings System for Essential Pollution Management Actions in NMUK

Rating Factor	High Priority (H)	Medium Priority (M)	Low Priority (L)
Importance	Most critical	Critical	Important
Coverage Under Existing Programs	Little or no coverage	Limited coverage	Incomplete coverage
Timing and Sequencing	No other action required	Other short-term action(s) required	Other long-term action(s) required
Ease/Difficulty of Implementation	Expect fairly easy implementation	Expect fairly easy implementation, but some difficulties possible	Expect some difficulty in implementation

The specific implementation schedule for each element of the management plan is dependent on the priority and resources given to the elements. For the purpose of this management plan, implementation scheduling was addressed by grouping actions under the following three time frames. Again, professional judgment and experience were used to assign schedule time frames.

i. *Short-Term Actions* - Those actions of any priority level that should be initiated and/or effectively implemented within one or years.

ii. *Medium-Term Actions* - Those actions of any priority level that should be initiated and/or implemented within two years and above but full implementation of these actions may not take more than 4 years.

iii. *Long-Term Actions* - Those actions of any priority level that should take from three years and above to initiate and effectively implement.

An example of a medium-term action is ongoing program changes such as those that require new information or a complementary study is to be undertaken before implementation. Short-and long-term actions, will require positive program and budget decisions in the future. Rwanda Water Board and REMA will take a proactive approach to implementing the plan's recommendations in a timely manner. It is anticipated that the other lead stakeholders also will be proactive in plan implementation. Table 10 below presents the Integrated Pollution Management Plan actions prioritization, scheduling and roles and responsibilities of different stakeholders

Table 12: Nile MUKUNGWA IPMP actions prioritization, scheduling and key stakeholders

	Status	Challenge/Issue	Recommended action	Prioritisation	Sequ
Enhance governance of pollution management at catchment level.					
1	Planning processes non-aligned with catchment governance	Inadequate measures by District authorities to enforce pollution control guidelines and standards	Support District Authorities to enforce the Rwandan industrial effluent standards.	Medium	Short
			Support joint inspections of environment polluting activities in Nile Mukungwa catchment	High	Short
		Uncoordinated planning processes at catchment level	Establish Nile Mukungwa catchment committee;	High	Short
			Operationalise Nile Mukungwa catchment Technical Committee	High	Short
			Support integrated planning at catchment level	High	Medi
			Support regular coordination meetings of water committee, environment committee and water users organisations	Medium	Medi
Goal 2: Efficient and effective pollution management in Nile Mukungwa catchment					
2	Contamination of water bodies and wetland pollution by illicit discharge of inadequately treated wastewater	Inadequate management liquid wastes	Develop sewerage systems and wastewater treatment plants	High	Long-
			Support sludge treatment facilities operation &maintenance	High	Long-
			Invest in ecological sanitation to enhance the recycling of nutrients	High	Short
			Support resettlement of population in high risk zones	High	Long-

			Support small industries &SMEs to implement cleaner production measures	Medium	Long-
			Support rainwater harvesting on rooftops of settlement areas	Medium	Conti
			Construction of water drainage to capture road drainage & settlements	High	Conti
			Multiply inspections for environmental compliance in mining sector	High	Conti
3	Littering of municipal solid wastes	Inadequate separation and valorization of organic and other landfilled at the Cyuve landfill in Musanze	Support the valorisation and recycling of municipal solid wastes as well as remediation of close dumping sites	High	Mediu
			Promote waste-to-resource initiatives including composting, biogas to energy, plastic recycling for construction materials etc.	High	Short
		Inadequate solid waste collection and illegal dumping	Promote voluntary clean-up activities through community work initiatives and local NGOs	High	Short
4	Encroachment to sensitive ecosystems such as wetlands, natural reserves and river banks	Sub-standard farming & mining practices aggravating soil erosion and pollution	Support the implementation of sustainable mining practices/Model mining	High	Long-
			Enhance payment of ecosystem services in NMUK for catchment protection	Medium	Conti
			Multiply inspections for environmental compliance in mining sector	High	Short
		Encroachment of national parks, wetlands, river banks & pollution of water bodies	Support sustainable conservation of protected areas	High	Long-
			River bank protection along all rivers and wetlands in NMUK	High	Conti
			Payment of Ecosystem services	Medium	Conti

			Increase awareness and education on environment protection	Medium	Conti
Goal 3: Effective information and knowledge management					
6	Low skills & awareness levels	Lack of data on pollution	Conduct a feasibility study on status of wastewater treatment options for small industries and SMEs with/without wastewater treatment facilities in NMUK	High	Short
			Conduct a research study on adequate techniques and time for application of human excreta as organic manure	Medium	Mediu
			Support groundwater monitoring network in lava region	High	Short
			Integrate key urban hotspot monitoring points to national sampling program	Medium	Short
		Little knowledge, understanding &skills in agrochemicals/ pesticides/herbicides application best practices	Develop training package on urban and rural pollution and BMPs.	Low	Short
			Conduct trainings , awareness raising and capacity building among farmers on smart agriculture	Medium	Conti
		Little knowledge & understanding of environment laws and regulatory instruments	Disseminate policies, laws and regulatory instruments on environment protection, sustainable mining and smart agriculture	Medium	Short

CHAPTER 6. MONITORING AND EVALUATION

6.1. Framework for Pollution Management Plan Monitoring and Evaluation

The monitoring and evaluation system will be based on the indicators defined in the log frame (Table annex I). The monitoring system will function as a management tool to report progress, constraints, and deviation from annual activities against Annual Plan targets, as well as to review and adapt, where necessary, the program strategies. Furthermore, it will function as a mechanism to proceed with timely and punctual data collection.

The overall responsibility for monitoring and evaluation will rest with the Authority in charge of Environment Pollution Control, the Rwanda Environment Management Authority but sources data during monitoring and reporting under this Plan entail the following mechanisms:

6.1.1. Sector level targets and indicators: Information for the indicators set by the plan will come primarily from the districts with REMA to ensure quality assurance. Information will also be drawn from national institute of statistics in Rwanda (NISR) for surveys, censuses and abstracts as well as from databases of key line sectors, such as health, agriculture, disaster management, land, environment, etc.

6.1**.2. Reports of Major Water Users**

RSB, WASAC, EDCL, RAB and processing industries may have good water quality data for various water uses included in their annual reports.

6.1.3. Decentralized entities *M&E systems*

District annual performance contracts (*imihigo)* provide another important source of information and will be reviewed on a quarterly basis. Districts have targets relating to soil erosion control, protection and rehabilitation of buffer zones, effluent discharge and environment inspection, in their *imihigo* and District Development Strategies (DDS).

***6.1.4*. Private sector, civil society and NGOs reporting systems**: The current legal framework requires these stakeholders to report regularly on their activities, and the districts in which they work must certify their good cooperation and conduct. This compels them to work within existing development priorities and share information about their work.

6.2. Indicators, data collection and reporting

Data collected will be organized into quarterly and annual reports. Additionally, data collected will be used to expand the Water Information System of Rwanda Water Board as well as the RBME of the Ministry of Environment.

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ANNEX I: NILE MUKUNGWA CATCHMENT INTERVENTIONS LOG FRAME

Goal 1: Enhance governance of pollution management at catchment level.						
Objective	**Activities**	**Indicators**	**Target**	**Timing**		
				2021/ 2022	2022 / 2024	2025 - 2030
Objective1. Strengthen District Authorities to enforce pollution control guidelines and standards	Enforcement of Rwandan industrial effluent standards.	% of industries complying with Rwandan industrial effluent standards	80% of SMEs are complying	X	X	X
	Support joint inspections of environment polluting activities in Nile Mukungwa catchment	Number of joint inspections conducted	2 joint inspections/year	x	X	X
Objective 1.2. Establish coordination mechanisms for pollution management at catchment level	Support integrated planning at catchment level	Number planning meetings	2 meetings/year (2 technical committee meeting+1 general assembly)	X	X	X
	Establish the catchment committee and support its operationalisation	Operational catchment committee	Mukungwa catchment commitee	X		
	Operationalise Nile Mukungwa catchment Technical Committee	Number of Catchment Technical Committee meetings per year	3 coordination meetings per year	x	x	x
	Support regular coordination and environment committee meetings with water users organisations	% of water users organisations operational	100% of water users organisations are operational	X	X	X
Goal 2: Efficient and effective pollution management in Nile Mukungwa catchment						
Objective2. 1: Support effective pollution management in Urban and per-	Develop sewerage systems and wastewater treatment plants	(i)% of districts in NMUK catchment with semi-centralised wastewater treatment plants	(i) 20% of districts (Musanze)	X X	X X	X X

urban areas of NMUK		(ii)% of IDPs and trading centres with wastewater treatment facilities	(ii) 100% of IDP villages and 80% of trading centres with WWTPs			
	Support operationalisation and maintenance of sludge treatment facilities	% of districts in NMUK with operational FSTP	FSTP in Musanze is operational and maintained	X	X	
	Invest in ecological sanitation to enhance the recycling of nutrients	Number of HHs with ecological sanitation toilets	400 HHs and 20 Public places	X	X	X
	Support resettlement of population in high risk zones	% of population in high risk zones relocated	80% of population in high risk zones relocated	X	X	X
	Support small industries &SMEs to implement cleaner production measures	% of small industries& SMEs implementing cleaner production measures	60% of small industries & SMEs	X	X	X
	Support rainwater harvesting on rooftops of settlement areas	% of settlements with RWH infrastructure	100% of public buildings &schools, 60% of trading centres & 90% individual houses newly developed	X	X	X
	Support the valorisation and recycling of municipal solid wastes as well as remediation of close dumping sites	% of districts with engineered landfills providing sustainable waste valorisation service	45% of districts (Musanze and Nyabihu)	X	X	X
Objective 2.2: Effective management of rural pollution	Support sustainable conservation of protected areas	Number of Ha newly protected	Additional 100 Ha of river banks and wetlands protected	X	X	X
		Amount of money spent to	US$ 30,000/Year	X	X	X

		support cooperatives in buffer of Rugezi wetland and Volcano park buffer zones supported				
	Develop a programme on nutrient management techniques through soil testing in order to achieve optimal fertilizer application to crops by farmers	Programme operational	1 programme is implemented in NMUK		X	X
	Support the implementation of sustainable mining practices/Model mining	% of mining companies supported	10% of companies supported	X	X	X
	Multiply inspections for environmental compliance in industries and mining sector	% mining operators and industries complying with guidelines	80% are complying	X	X	X
Goal 3: Effective information and knowledge management						
Objective : Ensure continuous Monitoring of urban and rural pollution	Conduct a feasibility study on status of wastewater treatment options for small industries and SMEs with/without wastewater treatment facilities in NMUK	% of industries complying with Rwandan industrial effluent standards	Inventory report	X		
	Integrated key urban hotspot monitoring points to national sampling program	Number of urban hotspots integrated into national water quality monitoring programme	4 new monitoring sites (2 in Musanze, 1 in Nyabihu & 1 in Burera)	X	X	X
	Support groundwater monitoring network in lava region	.Number of regularly monitored for water quality boreholes in NMUK	5 boreholes are regularly monitored	X	X	X
	Conduct a research study on adequate techniques and time for	Research report	Article is published	X	X	X

	application of human excreta as organic manure					
3.2: Building capacity in urban and rural pollution management	Develop training package on urban and rural pollution and BMPs.	Training document	Training Manuel	X		
	Conduct trainings , awareness raising and capacity building among farmers on smart agriculture	Number of farmers trained	500		X	X
	Disseminate policies, laws and regulatory instruments on environment protection, sustainable mining and smart agriculture	Number of material disseminated	1000	X	X	X
Total						

ANNEX II: NOTE ON IPMP BUDGET/COSTING ESTIMATION

Item/	Unit	Quantity	Unit Price (US$)	Total Indicative costs (US$)	Source of data
Inspections to enforce EAC industrial and incinerator air emission standards.	Number	80	280	22,400	Ministerial Instructions (N°001/15/10/ TC DU 20/07/2015)
Define legal framework and institutionalise catchment office	Number	50	160	8,000	Estimated based on Hotel Contracts
Support integrated at catchment level (planning meetings)	Number	30	160	4,800	Estimated based on Hotel contracts
Support regular coordination and environment committee meetings with water users organisations	Number	80	160	12,800	Estimated based on Hotel contracts
Support the operation and management of sewerage systems and wastewater treatment plants	Number	1	33,000,000	33,000,000	WASAC Estimates
Support the management of sludge management and treatment facilities	Number	1	5,000,000	5,000,000	WASAC Estimates
Support resettlement of population in high risk zones	Number of HH	200	7,500	1,500,000	Adaptation Fund Project
Support small industries &SMEs to implement cleaner production measures	Persons trained	100	105	10,500	Based on W4GR estimates
Strengthen the national vehicle inspection canter's capacity to implement new standard on Road	Equipment purchased	N/A	N/A	300,000	Expert judgement

Vehicle Emission Limits					
Promote local vehicle assembly including introduction of incentives to promote electric vehicles	Incentives	N/A	N/A	15,600,000	Estimates/ MININFRA
Support increased access and use of LPG in urban and peri-urban household and improved cooking stoves and alternative fuels in rural areas for cooking	HHs	170,500	63	40,170,000	Estimates/MoE
		1,030,000	39	10,656,250	Estimates/MoE
Implement air pollution control guidelines	Number of inspections	40	280	11,200	Ministerial Instructions (N°001/15/10/ TC DU 20/07/2015)
Support rainwater harvesting on rooftops of settlement areas	Number ($5m^3$)	60	420	25,200	RWH project/RWFA
Construction of water drainage to capture road drainage & settlements	m	1000	32	32,000	Expert judgement
Enforce oil separation at all garages and vehicle workshops	Number	20	2500	50,000	Expert judgement
Support construct of a designed landfill that makes provision for waste separation and recycling	Number	2	2,000,000	4,000,000	Estimates from WASAC
River bank protection along all rivers and wetlands in	Ha	120	220	26,400	REMA SAP
Support the implementation of sustainable mining practices/Model mining	Persons trained	200	105	21,000	W4GR project

Enhance payment of ecosystem services	Number of Cows	100	520	52,000	Reference price on local market
	Number of goats	2000	60	120,000	Reference price on local market
	Projects supported	10	20,000	200,000	Reference to LVEMPII project
Implementation of measures proposed for Gikondo and Nyabugogo systems catchment management plan	N/A	N/A	N/A	37,000,000	REMA/LVEMPII Project
Multiply inspections for environmental compliance in mining sector	Number	100	280	28,000	Ministerial Instructions (N°001/15/10/ TC DU 20/07/2015)
Inventory of small industries and SMEs with/without wastewater treatment facilities	Reports	1	60,0000	60,000	Comparison with similar projects
Enforce continuous monitoring of vehicle emissions through regular standardised tests.	Project	1	40,000	40,000	Expert judgement
Integrated key urban hotspot monitoring points to national sampling program	Number	160	5200	83,200	UR contracts with RWFA
Develop training package on urban and rural pollution and BMPs.	Consultancy	1	40,000	40,000	Similar Consultancy
Conduct trainings , awareness raising and capacity building among farmers on smart agriculture	Number	200	105	20,400	W4GR Project
Conduct capacity building in sustainable mining approach/Model mining among mining operators	Number	200	105	20,500	W4GR Project

Disseminate policies, laws and regulatory instruments on environment protection, sustainable mining and smart agriculture	Number	1000	30	30,000	Expert judgment

ANNEX III: VISUAL ASSESSMENT OF POLLUTION STATUS IN NILE MUKUNGWA

Photo 1&2: URUGEZI DOWNSTREAM (at RUSUMO)

This sampling point is considered as the starting point of Mukungwa catchment. The Rugezi swamp is a RAMSAR site; there are no agriculture activities in the swamp. The swamp is protected at the world level. It's a biodiversity conservation region. The water from Rugezi swamp enters in Burera Lake, it is also considered as Burera lake inlet. No pollution observed at this site, only observation of black color of water due to organic matter from the swamp.

Photo 3: BURERA LAC

Burera lake is a volcanic lake. One side is protected by volcanic rocks. At the other side the banks are protected by natural forest. At sampling point there is no erosion observed only one source of pollution may be the transport by boat in the lake. The policy of buffer zone in Burera lake is respected.

PHOTO 4: RUHONDO DOWNSTREAM

At this site the banks are not protected and can be polluted by agriculture activities. At the site we observed water hyacinth pollution. Buffer zone was not respected by agriculture activities.

PHOTO5: MUKUNGWA AT NYAKINAMA

This site indicates the status of Mukungwa river after receiving kigombe river from musanze town. The water was more turbid due to erosion from mountains and pollution from musanze town. The river at the site pass in the agriculture activities (sugar cane, beans,…) and people on the mountains grow different types of crops like banana,…etc.

PHOTO6: GICIYE RIVER BEFORE MUKUNGWA

At this site we observe a high level of sand mining activities. The river was polluted by these activities. This river was polluted also by mining activities upstream in Ngororero and Nyabihu district. The river banks are not protected and are destroyed by flood. During the rainy season it is obvious that the flood exist in that swamp area.

PHOTO 7:

Downstream Cyuve landfill

PHOTO 8: MWANGE RIVER

Mwenge River is very clear River and flows from a natural carbonated source of water found in 1907 by a Germany colonialist. Many people from the area come fetch the water in that source called “Amacyera”

The area is clean but because many children play nearby the source, there are some plastic bottle and clothing fabrics that are left at the river banks but in general the river is very clear.

Picture 1: Mwenge Source discovered in 1907

Picture 2: People fetching water at the source

Picture 3: Mwenge River where the water sample was taken

Picture 4: Downstream Mwenge River

Picture 5: Upstream Mwenge River

PHOTO9: SLAUGHTERHOUSE-MUSANZE

1) The slaughterhouse does not have a modern waste water system for treatment or disposal of waste water from the facility. The outlet channel from the slaughterhouse carries the waste water to different ponds where the waste water mixed with solid waste is left for drying (for dung, urines and solid wastes). The waste water infiltrates in the groundwater, this water is dark and smells like rotten eggs. And they said that sometimes with heavy rains, the ponds can be flooded.
2) The slaughterhouse and those waste water ponds are located just few meters from residential houses and people cook and eat just nearby the pond.

Picture 1: One waste water pond nearby a residential house

Picture2: Pond where the water sample was taken.

Picture 3: Waste water from the slaughterhouse that infiltrates into groundwater without being treated

Picture 4: Slaughterhouse

PHOTO10 : STORMWATER DRAINS _NYAMYUMBA

The storm water drains that passes nearby Nyamagumba informal settlement also passes through the bridge in town where also the solid wastes are dumped by people. During heavy rain those drains are filled with water and carry all the solid waste a River downstream the city. There is also an old cemetery nearby Nyamagumba informal settlement.

Picture 1: Sampled water from the storm water drain in Nyamagumba

Picture 2: Solid wastes in the storm water drain

Picture 3: all the storm water upstream passes here during heavy rains

Picture 4: cemetery nearby the storm water drain

ANNEX IV: LISTS OF POLLUTION HOTSPOTS SITES IN NILE MUKUNGWA CATCHMENT

IV.1. Coffee washing stations

S/N	Name	DISTRICT	SECTOR	CELL	OWNER_NAM	WATER_SOU	BRAND_DEP	ENVIRO_PR	Village	X	Y
1	Rusasa Cws	GAKENKE	Rusasa	Nyundo	Mugabarigira Herimas	Natural Spring	Penagos	Natural seepage	Gisovu	29.6482	-1.61354
2	Matyazo CWS	NGORORERO	Matyazo	Gitega	Cooperative Matyazo coffee	Natural Spring	Ecoflex Penagos	Filtering System	Kabara	29.62128	-1.75498
3	Vunga coffee	NYABIHU	Shyira	Kanyamitama	Cooperative Vunga Coffee	Natural Spring	Ecoflex Penagos	Natural Seepage	Kazirankora	29.62751	-1.70495

IV.2. Hydropower Stations

S/N	Site_name	F3	District	Sector	X	Y	Est_Max_Ca
1	Gaseke	Gaseke	Gakenke	Rusasa	464133	9821571	500
2	Gaseke	Gaseke	Gakenke	Busengo-Cyabingo-Rusasa	460776	9820590	100
3	Giciye	Giciye	Nyabihu	-	456215	9814912	4000
4	Janja	Janja	Gakenke	Gatonde	462724	9813558	200
5	Kabaya	Giciye	Nyabihu	Muringa	447479.4	9806669	216.6048
6	Karuruma	Karuruma	Burera	Gitovu-Gisarabuye	479376	9833037	100
7	Mpenge 1	Mpenge 1	Musanze	Ngera	461380	9833552	100
8	Mukungwa	Mukungwa	Musanze	-	464659	9830391	2500
9	Mukungwa III + IV/ Nyundo	Mukungwa III + IV/ Nyundo	Gakenke	-	459566	9823895	2000
10	Musarara	Musarara	Musanze	-	461608	9820419	438

11	Mutobo	Mutobo	Musanze	Busogo-Gataraga-Kimonyi-Shingiro	453411	9832063	500
12	Nyabeshaza	Nyabeshaza	Musanze	Busogo-Kimonyi-Muko-Nkotsi	453759	9826815	100
13	Nyamyotsi I	Nyamyotsi I	Nyabihu	Rugera	457853	9820150	100
14	Nyamyotsi II	Nyamyotsi II	Nyabihu	Rugera	457853	9820150	100
15	Ruhanga	Ruhanga	Nyabihu	Muringa	445590.9	9807805	105.948
16	Rungu	Rungu	Ngororero	Hindiro-Kabaya-Matyazo	455690	9803739	100
17	Sotiru	Sotiru	Musanze	Muhoza	461658	9833053	500
18	Tubuye	Giciye	Nyabihu	Rurembo	452212.8	9812659	809.9666

IV.3. Mining sites

S/N	Latitude	Longitude	Company_Co	District	Sector__s_	Cell	Mine_Site	Mine_type
1	29.7675	-1.38083	New Bugarama Mining (NBM)	Burera	Kagogo	Kiringa	Bugarama	Wolfram
2	29.60889	-1.71083	African Primary Tungsten (APT)	Nyabihu	Nyabihu	Shyira	Shyira	Wolfram
3	29.52861	-1.61333	TUHAGERE	Rutsiro	Congo Nil	Bugina	Rukaragata 2	Mixed(Cassiterite & Coltan) & Wolfram
4	29.69083	-1.60667	Mugabonake Jeanne	Gakenke	Cyabingo	Rukore	Cyabingo	Mixed(Cassiterite & Coltan)
5	29.62306	-1.58167	Burera Minerals Deposit Company (BMDC)	Musanze	Nkotsi	Gashinga	Buhanga	Cassiterite & Wolfram
6	29.59139	-1.76167	COMIKABA	Ngororero	Kabaya	Busunzu	Nyagahondo 3	Wolfram
7	29.59139	-1.76111	COMIKABA	Ngororero	Kabaya	Busunzu	Nyagahondo 2	Coltan
8	29.59222	-1.76028	COMIKABA	Ngororero	Kabaya	Busunzu	Nyagahondo 1	Cassiterite

9	29.60806	-1.75139	COMIKABA	Ngororero	Matyazo	Rutare	Rwamabuye	Wolfram
10	29.69139	-1.60139	Great Lakes Minerals	Gakenke	Cyabingo	Rukore	Rukore	Mixed(Cassiterite & Coltan)
11	29.57583	-1.57139	MINECA	Musanze	Busogo	Kigasa II	Nyabami	01°34'17"
12	29.56917	-1.56444	MINECA	Musanze	Busogo	Nyagisozi	Kirago	Wolfram
13	29.57056	-1.58111	MINECA	Musanze	Busogo	Kigasa II	Maryohe	Coltan
14	29.57639	-1.57194	MINECA	Musanze	Busogo	Kavumu	Kiremya	Wolfram
15	29.56806	-1.55528	MINECA	Musanze	Busogo	Kigasa II	Kigasa	Coltan
16	29.58472	-1.57056	MINECA	Musanze	Nkotsi	Mubago	Nyarubingo	Mixed(Cassiterite & Coltan)
17	29.84	-1.57944	DUSUZUMIMIRIMO	Gakenke	Gasenyi	Rutabo	Bututsi	Wolfram
18	29.84	-1.57806	UBUKUNGU	Gakenke	Kamubuga	Rukore	Runyempundu	Wolfram
19	29.69111	-1.59333	Ntiruhungwa Jean de Dieu	Gakenke	Cyabingo	Rukore	Murehe	Mixed(Cassiterite & Coltan) & Wolfram
20	29.49694	-1.69111	Alfa Minerals Suppliers	Nyabihu	Muringa	Gasura	Rwantobo	Cassiterite & Coltan & Wolfram
21	29.50389	-1.68583	Alfa Minerals Suppliers	Nyabihu	Muringa	Kibisabo	Gatare 2	Cassiterite & Coltan & Wolfram
22	29.61528	-1.53333	Songa Minerals Enterprise	Musanze	Muko	Songa	Kanyana	Wolfram
23	29.61639	-1.55417	Songa Minerals Enterprise	Musanze	Muko	Songa	Mubago	Wolfram
24	29.93417	-1.54722	COOREMIBU	Burera	Kivuye	Nyiratabа	Nyabyondo	Wolfram
S/N	Latitude	Longitude	Company_Co	District	Sector__s_	Cell	Mine_Site	Mine_type

1	29.7675	-1.38083	New Bugarama Mining (NBM)	Burera	Kagogo	Kiringa	Bugarama	Wolfram
2	29.60889	-1.71083	African Primary Tungsten (APT)	Nyabihu	Nyabihu	Shyira	Shyira	Wolfram
3	29.52861	-1.61333	TUHAGERE	Rutsiro	Congo Nil	Bugina	Rukaragata 2	Mixed(Cassiterite & Coltan) & Wolfram
4	29.69083	-1.60667	Mugabonake Jeanne	Gakenke	Cyabingo	Rukore	Cyabingo	Mixed(Cassiterite & Coltan)
5	29.62306	-1.58167	Burera Minerals Deposit Company (BMDC)	Musanze	Nkotsi	Gashinga	Buhanga	Cassiterite & Wolfram
6	29.59139	-1.76167	COMIKABA	Ngororero	Kabaya	Busunzu	Nyagahondo 3	Wolfram
7	29.59139	-1.76111	COMIKABA	Ngororero	Kabaya	Busunzu	Nyagahondo 2	Coltan
8	29.59222	-1.76028	COMIKABA	Ngororero	Kabaya	Busunzu	Nyagahondo 1	Cassiterite
9	29.60806	-1.75139	COMIKABA	Ngororero	Matyazo	Rutare	Rwamabuye	Wolfram
10	29.69139	-1.60139	Great Lakes Minerals	Gakenke	Cyabingo	Rukore	Rukore	Mixed(Cassiterite & Coltan)
11	29.57583	-1.57139	MINECA	Musanze	Busogo	Kigasa II	Nyabami	01°34'17"
12	29.56917	-1.56444	MINECA	Musanze	Busogo	Nyagisozi	Kirago	Wolfram
13	29.57056	-1.58111	MINECA	Musanze	Busogo	Kigasa II	Maryohe	Coltan
14	29.57639	-1.57194	MINECA	Musanze	Busogo	Kavumu	Kiremya	Wolfram
15	29.56806	-1.55528	MINECA	Musanze	Busogo	Kigasa II	Kigasa	Coltan
16	29.58472	-1.57056	MINECA	Musanze	Nkotsi	Mubago	Nyarubingo	Mixed(Cassiterite & Coltan)

17	29.84	-1.57944	DUSUZUMIMIRIMO	Gakenke	Gasenyi	Rutabo	Bututsi	Wolfram
18	29.84	-1.57806	UBUKUNGU	Gakenke	Kamubuga	Rukore	Runyempundu	Wolfram
19	29.69111	-1.59333	Ntiruhungwa Jean de Dieu	Gakenke	Cyabingo	Rukore	Murehe	Mixed(Cassiterite & Coltan) & Wolfram
20	29.49694	-1.69111	Alfa Minerals Suppliers	Nyabihu	Muringa	Gasura	Rwantobo	Cassiterite & Coltan & Wolfram
21	29.50389	-1.68583	Alfa Minerals Suppliers	Nyabihu	Muringa	Kibisabo	Gatare 2	Cassiterite & Coltan & Wolfram
22	29.61528	-1.53333	Songa Minerals Enterprise	Musanze	Muko	Songa	Kanyana	Wolfram
23	29.61639	-1.55417	Songa Minerals Enterprise	Musanze	Muko	Songa	Mubago	Wolfram
24	29.93417	-1.54722	COOREMIBU	Burera	Kivuye	Nyiratabа	Nyabyondo	Wolfram

IV.4. Petrol stations

S/N	Latitude	Longitude	District	Sector	Cell	Name
1	-1.41661	29.84127	Burera	Butaro	Rusumo	Butaro
2	-1.50974	29.64625	Musanze	Muhoza	Kigombe	Nyamuremure
3	-1.50917	29.64576	Musanze	Muhoza	Mpenge	Rukoro
4	-1.49831	29.62672	Musanze	Cyuve	Rwebeya	Mubuga
5	-1.61258	29.50672	Nyabihu	Mukamira	Jaba	Rwanyirangeni
6	-1.50092	29.61919	Musanze	Musanze	Cyabagarura	Bukane
7	-1.34505	29.7429	Burera	Cyanika	Kamanyana	Gasovu
8	-1.49817	29.63006	Musanze	Cyuve	Rwebeya	Mubuga
9	-1.74355	29.54276	Ngororero	KABAYA	Kabaya	Kimisagara
10	-1.38109	29.74282	Burera	Cyanika	Gisovu	Rutango
11	-1.61425	29.50181	Nyabihu	Mukamira	Rugeshi	Kazibake
12	-1.50891	29.63956	Musanze	Muhoza	Kigombe	Nduruma
13	-1.50951	29.64726	Musanze	Muhoza	Cyabararika	Bwuzuri
14	-1.50847	29.64074	Musanze	Muhoza	Mpenge	Gikwege
15	-1.55599	29.55485	Musanze	Busogo	Gisesero	Gahanga
16	-1.49991	29.6236	Musanze	Muhoza	Ruhengeri	Muhe
17	-1.50347	29.6354	Musanze	Cyuve	Rwebeya	Mubuga
18	-1.52567	29.66211	Musanze	Muhoza	Kigombe	Kiryi