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RWANDA ENVIRONMENT MANAGEMENT AUTHORITY (REMA)

FEASIBILITY STUDY, BASELINE STUDIES AND DETAILED DESIGNS FOR WETLAND REHABILITATION IN THE CITY OF KIGALI



Feasibility Studies, Baseline Studies and Preliminary Proposed Rehabilitation Designs Report – Final Version

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List of acronyms

BOD	Biochemical Oxygen Demand
CBD	Central Business District
COD	Chemical Oxygen Demand
CoK	City of Kigali
DO	Dissolved Oxygen
EDCL	Energy Development Corporation Limited
ESCP	Environmental and Social Commitment Plan
ESF	Environmental and Social Framework from the World Bank (2018)
ESIA	Environmental and Social Impact Assessment
ESMF	Environmental and Social Management Framework
ESMP	Environmental and Social Management Plan
GoR	Government of Rwanda
HCB	Hexachlorobenzene
IUCN	International Union for Conservation of Nature
KUUT/KUUP	Kigali Urban Upgrading Team/Project
LODA	Local Administrative Entities Development Agency
LVEMP II	Lake Victoria Environmental Management Project
MINALOC	Ministry of Local Government
MININFRA	Ministry of Infrastructure
MINISPORT	Ministry of Sports
NBS	Nature-Based Solutions
NUDOR	National Union of Disability Organizations of Rwanda
O&M	Operation and Maintenance
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated biphenyls
PID	Project Information Document
PPP	Public-Private Partnership
RAP/LRP	Resettlement Action Plan/Livelihood Restoration Plan
RECOR	Rwanda Environmental Conservation Organization
REMA	Rwanda Environment Management Authority
RFA	Rwanda Forestry Authority
RLMA	Rwanda Land Management and Use Authority
RTDA	Rwanda Transport Development Authority
RUDP II	Rwanda Urban Development Project, Phase II
RWB	Rwanda Water Resources Board
SWMMP	Stormwater management master plan
TOR	Terms of Reference
WASAC	Water and Sanitation Corporation

1. INTRODUCTION

This document is the Feasibility Studies, Baseline Studies and Preliminary Proposed Rehabilitation Designs Report for the project "Feasibility Study and Detailed Designs for Wetland Rehabilitation in the City of Kigali" (the "Study"). This project is part of the Rwanda Urban Development Project, Phase II (RUDP II). As part of this second phase, the Government of Rwanda (GoR) will receive funds from the World Bank, the Global Environmental Facility (GEF) and the Pilot Program for Climate Resilience and Nordic Development Fund (NDF).

This document is intended for Rwanda Environment Management Authority (REMA), the "Client" and the Implementing Agency of the Study.

This Study is part of Subcomponent 1b of the RUDP II and will support its implementation, the other RUDP II components are as follow:

- Component 1: Support to the City of Kigali
  - Subcomponent 1a: Integrated urban planning for resilient, inclusive infrastructure delivery
  - Subcomponent 1b: Evidence-based, sustainable wetland management, flood risk management and greenhouse gas monitoring in the City of Kigali
- Component 2: Support to Secondary Cities
  - Subcomponent 2a: Infrastructure and service delivery
  - Subcomponent 2b: Institutional capacity development
- Component 3: Institutional Capacity Development and Project Management
  - Subcomponent 3a: Institutional capacity development at national level
  - Subcomponent 3b: Project management
- Component 4: Contingency Emergency Response

REMA launched call for tender for the Study in February 2021 and IBC Group/SGI Ingénierie SA (the "Consultant") won the tender and signed a contract with REMA to undertake the Study in November 2021.

This final report is the second deliverable of the Study. It was undertaken after the Inception report, which was validated by REMA in March 2022 and completed after two validation workshops with stakeholders held in June and September 2022 and a high level consultative meeting held in October 2022 with the Minister of Environment, Minister in charge of emergency, Lord Mayor of CoK, Permanent Secretary of the ministry of infrastructure, Representative of Ministers, Director General of respective institutions, RUDP II Team REMA, and Consultant Team.

1.1 PROJECT RATIONALE

The City of Kigali (CoK) experiences frequent floods. High intensity storms lead to fast runoff along the steep slopes of Kigali, resulting in flash flooding in the city. Floods cause damage to people's homes and industrial properties, disruption of traffic flow and economic activity in the city. They increase water pollution through the spreading of contaminated water and garbage during rainfall. Furthermore, many urban poor populations tend to reside in low lying flood prone areas and reclaimed wetland areas, increasing their vulnerability to flooding of cropland.

According to the Project Information Document (PID) for the RUDP II, poorly managed urbanization is threatening the state of environment leading to increased vulnerability to flood risks, land degradation and biodiversity loss. In addition, the city's extensive network of wetlands has shrunk from 100 km^2 in 2013 to the current level of 72 km^2 due to encroachment by activities such as industry and urban agriculture. Reduce wetland surface, encroachment and the degradation of the state of wetlands have impaired their ability to buffer storm-water runoff and floods.

The Government of Rwanda (GoR), will address some of the flood hazards in Kigali through targeted investments in stormwater management and Nature-Based Solutions (NBS), including targeted wetland rehabilitation. REMA, the City of Kigali and other relevant stakeholders, identified five priority urban wetlands designated for rehabilitation: Rwampara, Gikondo, Rugenge-Rwintare, Kibumba and Nyabugogo Lower wetlands. These wetlands are hydro-connected and part of the Nyabugogo River Catchment.

In response to flooding challenges, this study evaluates possible wetland rehabilitations and NBS as a mean to mitigate floods and associated impacts.

The following table shows the wetlands, their surface, the main waterbody flowing through them and the administrative districts where they are located.

TABLE 1-1 WETLAND SURFACE AND ADMINISTRATIVE DISTRICTS

Wetland Name	River/Stream	Area (ha)	Administrative Districts
Gikondo	Rugenge	162	Kicukiro and Gasabo
Rwampara	Rwampara	65	Nyarugenge and Kicukiro
Rugenge-Rwintare	Rugenge-Rwintare	65	Nyarugenge and Gasabo
Kibumba	Kibumba-Rwezangoro	68	Gasabo
Nyabugogo Lower	Nyabugogo	131	Nyarugenge and Gasabo

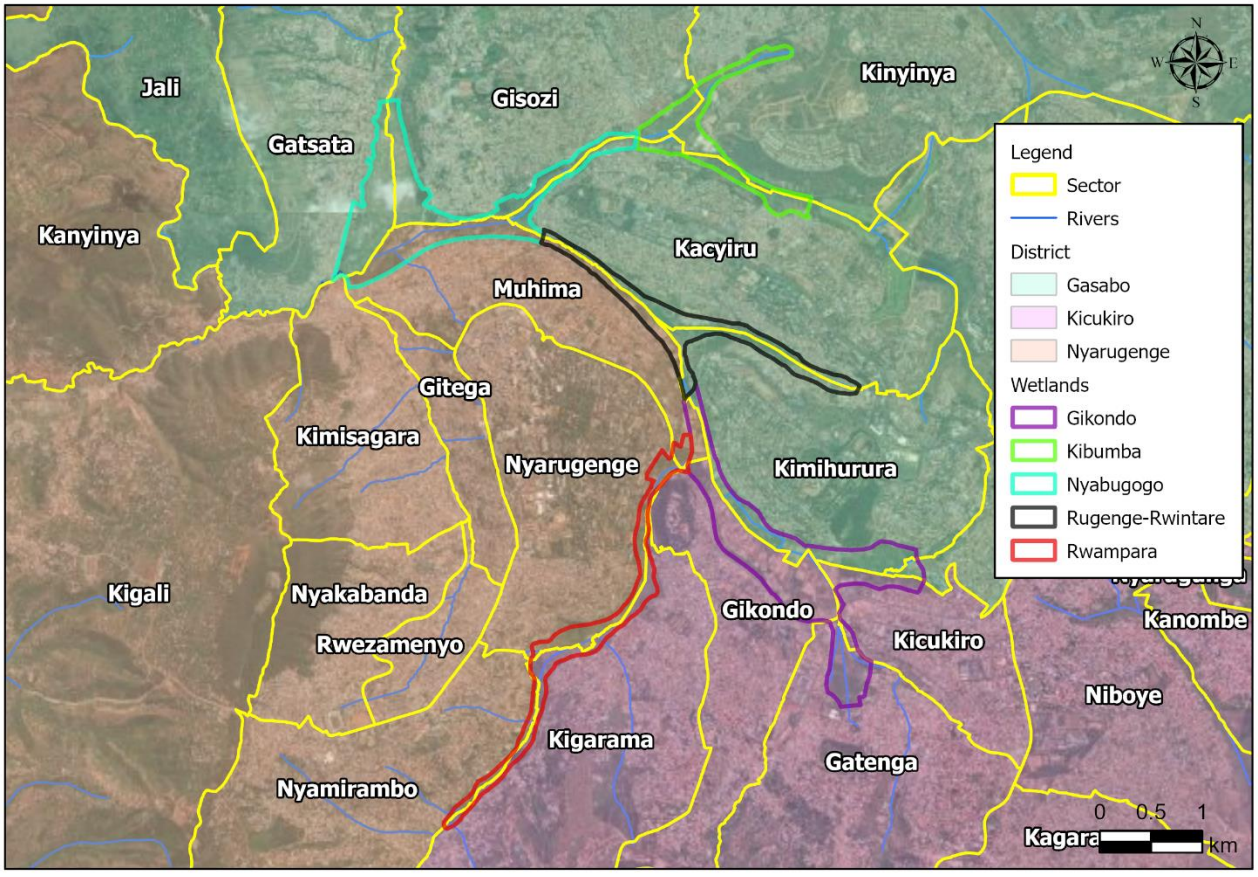


FIGURE 1-1 STUDY AREA AND ADMINISTRATIVE DIVISIONS (DISTRICTS AND SECTORS)

1.2 REMINDER OF THE REHABILITATION PROJECT'S OBJECTIVES

The main objectives of wetland rehabilitation as described in the study terms of references are as follow:

- Flood mitigation acknowledging climate changes.
- Improvement of wetlands' biodiversity.
- Water quality improvement.
- Enhancement of the city's landscape and development of recreational activities.

Whenever feasible, these objectives will be accomplished through Nature-Based-Solutions of wetland rehabilitation.

As demonstrated in this study report, these main objectives were also defined taking into account stakeholders' views and opinions and were finetuned through baseline studies.

1.3 REMIDER OF THE CONSULTANT'S ASSIGNEMENT AND OBJECTIVES

The Consultant's objective is to develop a wetland rehabilitation feasibility and detailed design to meet the project objectives. The Study is informed by both primary and secondary data and existing master plans of the water, wetland and urban planning sectors as well as the RUDP II activities.

The Consultant approach follows a logical framework which included studying the wetlands hydrology, hydraulic, functions and characteristics to develop wetland rehabilitation scenarios based on criteria and engagement with stakeholders. The Consultant has then designed the interventions based on a preferred option for each wetland.

This report is the second deliverable, the first being the Inception report which presented the methodological approach for the Study. After this report, the third deliverable will be the Detailed design and tender documents for wetland rehabilitation.

1.4 REPORT STRUCTURE

This report is composed of several chapters.

- Chapter 1: Introduction
- Chapter 2: Objectives of the Feasibility Studies, Baseline Studies and Preliminary Proposed Rehabilitation Designs Report
- Chapter 3: Methodological approach for rehabilitation scenarios
- Chapter 4: Baseline studies and context assessment
- Chapter 5: Assessment of wetland rehabilitation – Variant definition and comparison
- Chapter 6: Impact of the "flood hotspot Project" – CoK/YREC on the rehabilitation actions and variants
- Chapter 7: Comparison of development scenarios for the chosen variant
- Chapter 8: Preliminary proposed rehabilitation design of preferred options
- Chapter 9: Conclusion and way forward
- Chapter 10: References

2. OBJECTIVES OF THE FEASIBILITY STUDIES, BASELINE STUDIES AND PRELIMINARY PROPOSED REHABILITATION DESIGNS REPORT

This report studies the feasibility to develop a rehabilitation project in the five wetlands. It evaluates several rehabilitation scenarios based on a multicriteria approach. Selected criteria were developed based on collected primary data, review of bibliographical sources, and meetings with stakeholders.

The objectives of this study report are to:

- Present collected additional data necessary to identify and understand the main issues affecting the wetlands and constraints for rehabilitation. Collected data also aimed at fine-tuning flow and flood models that were previously developed for the 5 wetlands.
- Review past studies that have made recommendations for rehabilitation and build on them.
- Develop a multi-criteria approach for the selection of the most appropriate scenario.
- Develop rehabilitation actions based on different approach:
    - Ecological restoration, to enhance biodiversity in some areas of the wetland.
    - Nature-Based Solutions (NBS), to solve one or more local issues such as floods and water pollution.
    - Recreational and landscape features of the wetland to ensure that the wetlands are integrated in the urban setting providing direct benefits to the City of Kigali, citizen while allowing for the development of sustainable economic activities.
- Assess various scenarios using the multi-criteria approach and present a preferred scenario to REMA.

The preferred option (called Variant) is presented with preliminary rehabilitation design (restoration treatment prescriptions). It was presented to stakeholders during two stakeholder workshops (one validation workshop in June 2022 after the submission of the draft Feasibility report and one in September 2022, after the submission of the pre-final report for the final validation of the selected variant). This final version of the report follows these workshops and the collected comments on the draft versions.

3. METHODOLOGICAL APPROACH FOR REHABILITATION SCENARIOS

3.1 INTRODUCTION

The methodological approach for wetland rehabilitation scenarios is based on several approaches:

- The review of guidelines of international best-practice for wetland restoration as presented in section 3.2.
- The review of previous studies that have developed some proposal for wetland rehabilitation (see section 4.14).
- The development of multiple criteria as presented in section 3.3, informed by an analysis of the context and current threats, wetland zoning, analysis of case studies, baseline studies and meetings with stakeholders (see chapter 4).
- The collection of comments from stakeholders during the three workshops (see section 5.12):
  - Inception workshop, the methodological approach was presented to REMA and stakeholders during a first workshop that took place in January 2022, at project inception.
  - Final validation workshop, for the selection of the preferred variant in June 2022.
  - Validation workshop, the draft-final feasibility was presented to REMA during a second workshop, the validation workshop in September 2022.
  - High level consultative meeting, with key ministries in October 2022.

3.2 STANDARDS OF PRACTICE FOR PLANNING AND IMPLEMENTING ECOLOGICAL RESTORATION PROJECTS

The methodological approach for the development of rehabilitation scenarios is aligned with international best-practice guidelines including the recently published International Principles & Standards for the Practice of Ecological Restoration (2019). This technical guideline on wetland restoration includes eight principles upon which wetland restoration shall be based:

- Principle 1: Ecological restoration engages stakeholders.
- Principle 2: Ecological restoration draws on many types of knowledge.
- Principle 3: Ecological restoration practice is informed by native reference ecosystems, while considering environmental change.
- Principle 4: Ecological restoration supports ecosystem recovery processes.
- Principle 5: Ecosystem recovery is assessed against clear goals and objectives, using measurable indicators.
- Principle 6: Ecological restoration seeks the highest level of recovery attainable.
- Principle 7: Ecological restoration gains cumulative value when applied at large scales.
- Principle 8: Ecological restoration is part of a continuum of restorative activities.

A review of the applicability of this guideline in the context of the Study is presented in the next table.

TABLE 3-1 APPLICABILITY OF THE ECOLOGICAL RESTORATION 8 PRINCIPLES

Explanations	How this principle has been integrated in the approach for this study on wetland rehabilitation
Principle 1: Ecological restoration engages **stakeholders**	
Recognizing the expectations and interests of stakeholders and directly involving them is key to ensuring that both nature and society mutually benefit. Stakeholders can help define the vision, targets, goals, objectives, and methods of	Engagement activities were undertaken throughout the study, including during stakeholder workshops. Several state institutions, NGOs and farmer cooperatives were individually met to collect opinions and suggestions on rehabilitation, and to

Explanations	How this principle has been integrated in the approach for this study on wetland rehabilitation
implementation and monitoring. Social challenges include identifying all relevant stakeholders and their specific needs and interests and achieving agreement among stakeholders with competing interests.	better identify the threats affecting wetlands and opportunities for development. The methodological approach and results are presented at chapter 4.12. Overall, engagement activities that were undertaken followed the Study TOR which required that engagement activities: • seek to determine the primary criteria and desired outcomes and aspirations of stakeholders to refine or adapt the early concept designs. • must inform scenario development.
Principle 2: Ecological restoration draws on many types of **knowledge**	
Practitioner knowledge, Traditional Ecological Knowledge (TEK), Local Ecological Knowledge and availability of scientific data on the efficacy and effects of restoration treatments should be determined at the project proposal stage.	Information was collected from primary data through surveys and sampling campaigns, and meetings with key informants. Return of experience of key experts were also helpful to understand issues at stake and propose feasible measures (see case study analysis at chapter 4.15). Since the project takes place in an urban setting, with severely modified and degraded wetlands, traditional knowledge is limited. However, meetings with stakeholders, cooperatives of farmers and wetland users helped to understand the various use of the wetlands and the history of these wetlands.
Principle 3: Ecological restoration practice is informed by native **reference** ecosystems, while considering environmental change	
Ecological restoration requires identifying the native ecosystem to be restored and developing reference models for planning and communicating a shared vision of project targets and goals. Optimally the reference model describes the approximate condition the site would be in had degradation not occurred. Reference sites: reference models should be based on the specific ecosystem attributes to be recovered. Understanding temporal dynamics these sites are environmentally and ecologically similar to the project site, but optimally have experienced little or minimal degradation. Information on past and current conditions at the site as well as consultation with stakeholders can assist in developing reference models, especially where nondegraded local reference sites are unavailable. Climate change needs to be recognized as part of the current environmental background condition to which many species will either adapt or go extinct.	Botanical surveys were undertaken in the 5 wetlands to characterize remnant wetlands, those that still hold ecological functions. In addition, a more pristine wetland was also characterized in the vicinity of the study area to understand plant species richness and to describe reference sites in area where the Project will aim at restoring biodiversity and ecological functions (the report is in appendix 2). Information on past and current conditions was mainstreamed by all expertise, including during surveys with farmers cooperatives and an in-depth analysis of the local context, land use and livelihood activities taking place in the wetlands. Previous studies were undertaken in the wetlands and allowed to completement data from surveys to better understand temporal dynamics and develop reference sites. Climate change and its potential effect were integrated in the flow and hydrology models (see section 4.8).

Explanations	How this principle has been integrated in the approach for this study on wetland rehabilitation
	However, as presented in the section on limitations (see next paragraph), not all sites are destined to be ecologically restored back to a reference model, since the project seeks to have multiple outcomes such as recreational, improvement of ecological and flood control functions.
Principle 4: Ecological restoration supports ecosystem **recovery processes**	
The most reliable and cost-effective way to initiate restoration is to harness the potential of remnant species to regenerate. An assessment is needed prior to planning appropriate treatments to determine the: (1) potential for regeneration after removal of the causes of degradation and (2) need to reinstate missing biotic and abiotic elements.	Botanical surveys allowed to identify native plant species based on their ability to sustain the conditions of the rehabilitated wetlands (the report is in appendix 2).
Principle 5: Ecosystem recovery is assessed against clear goals and objectives, using **measurable indicators**	
In the planning phase of restoration projects, the project scope, vision, ecological targets, goals, and objectives are identified, along with specific indicators to measure progress. In order to establish measurable indicators, it is key to undertake baseline inventory to describe current biotic and abiotic elements of the site, including its compositional, structural, and functional attributes, as well as external threats and pressures. The inventory process is therefore an important initial step to understand what is desirable and possible at a degraded site in terms of restoration targets, goals, objectives, and indicators.	Baseline activities and meeting with stakeholders and with REMA has allowed to fine-tune the project ecological targets and objectives both for the short and long terms (see section 4.16). Indicators were selected in the multi-criteria assessment by defining sub-criteria and providing a ranking system on how the wetland currently performs and will perform on the long-term after rehabilitation. The project scope and vision are presented in the Kigali City Wetland Master Plan.
Principle 6: Ecological restoration seeks the highest level of **recovery** attainable	
The method details the key ecosystem attributes for the evaluation of recovery: 1- Absence of threats 2- Physical conditions 3- Species composition 4- Structural diversity 5- Ecosystem function 6- External exchanges	Developed criteria for restoration of habitats and biodiversity (see section 3.3.2) are largely based on these “Key ecosystem attributes”. Key ecosystem attributes are used to characterize the reference ecosystem, as well as to evaluate baseline condition, set project goals, and monitor degree of recovery at a restoration site. The Study focused on habitats rather than on individual wildlife species. By focusing on habitats, faunal species richness will be improved.
Principle 7: Ecological restoration gains cumulative value when applied at **large scales**	
Many ecological processes function at landscape, watershed, and regional scales and degradation occurring at larger scales can overwhelm smaller	The current project is part of a larger program which, amongst other objectives, aim at improving other urban issues in the CoK (see section 4.1.1).

Explanations	How this principle has been integrated in the approach for this study on wetland rehabilitation
restoration efforts. One mechanism to scale-up ecological restoration is to ensure that projects are strategically integrated within larger restoration programs. Likewise, water security (in terms of quality, quantity and flows) is most effectively achieved by working at the landscape scale and linking terrestrial and aquatic systems. Formal protection of the site through legal tenure arrangements is also ideal.	However, the rehabilitation is targeting the 5 wetlands and not a larger wetland system.
Principle 8: Ecological restoration is part of a continuum of **restorative activities**	
Ecological restoration is one of the types of restorative activities that are part of a continuum of other restorative activities such as: • reducing societal impacts on ecosystem and ecosystem services • remediation of pollution • rehabilitation of land	The rehabilitation project will aim at solving several issues, in addition to the ecological degradation of wetlands. The project will develop NBS to mitigate the effects of several stressors. This principle is mainstream in the development of rehabilitation scenarios.

Limitations

The International Principles & Standards for the Practice of Ecological Restoration focusses specifically on restoring the ecological function of wetlands and is not well-adapted for wetlands in urban settings where multiple outcomes often need to be achieved during rehabilitation such as recreational, ecological and flood control. The methodological approach has therefore considered that not all surface of the wetland can be rehabilitated to restore ecological functions to a reference state since most of the wetland system is degraded and exploited beyond its regenerative capacity. Therefore, developed scenarios consider that the wetlands will serve one or several purposes (recreational, biodiversity, flood control, water filtering, sustainable agriculture) in line with Nature-Based Solutions (NBS) principles.

In addition, this rehabilitation project is targeting at 5 wetlands, not the entire wetland system of the Nyabugogo water shed. This limit is well delineated in the TOR.

This study recommended interventions consider both ecological rehabilitation and NBS. Rehabilitation entails that the wetland still holds some functions that need to be restored for biodiversity purposes to move a degraded ecosystem to a trajectory of recovery while NBS designate planned interventions to establish green infrastructures to mitigate societal challenges (such as flood control).

- NBS are defined by the IUCN as "*actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits*".
- Ecological restoration is defined by SER to include a continuum of restoration actions. "*The Restorative Continuum includes a range of activities and interventions that can improve environmental conditions and reverse ecosystem degradation and landscape fragmentation*."

Unlike, the International Principles & Standards for the Practice of Ecological Restoration, this rehabilitation project does not seek to remove all the causes of degradation, instead the project will develop NBS to mitigate some sources of degradation.

Another limitation is that this Study is a feasibility study and not a detailed design, targets, goals and objectives can be described in broad terms, but these will have to be fine-tuned at the detailed design stage.

3.3 METHODOLOGICAL APPROACH FOR THE MULTI-CRITERIA ANALYSIS

3.3.1 Principle of the funnel approach

Multiple criteria are developed to assess rehabilitation scenarios.

Pre-selection and proposal of scenarios has followed a "funnel approach", sorting out scenarios that do not meet minimum scores after screening them against criteria, as illustrated in the next figure.

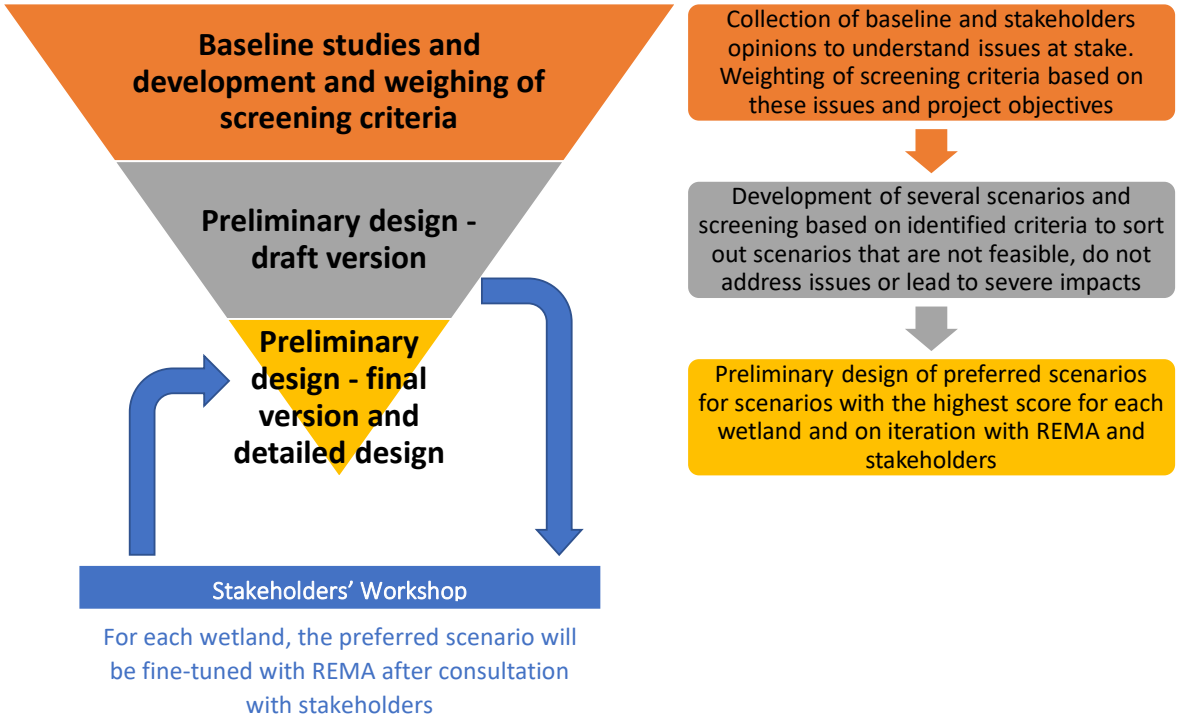


FIGURE 3-1 FUNNEL APPROACH

3.3.2 Defining and grouping criteria

Multiple criteria are developed to assess rehabilitation scenarios. Three categories of criteria are defined:

- **Project higher-level objectives criteria**: these are the dominant criteria that reflect the project's objectives. These criteria are used to assess both baseline situation and rehabilitation scenarios to compare the improvements.
- **Cost and technical criteria**: these criteria assess whether scenarios are economically or technically feasible. Since these criteria concern the rehabilitation state, they will only be used to assess rehabilitated scenarios.
- **Side-benefits and negative trade-offs criteria**: these criteria help to identify side-benefits and negative trade-offs from interventions. These include social impacts, such as impact on livelihood activities in the wetlands or environmental impacts and risks such as release of pollutants during excavations. Some of them are based on collected concerns from stakeholders. These criteria will only be used to assess rehabilitated scenarios.

3.3.2.1 Project higher-level objectives criteria

Defining Project higher-level objectives criteria was done through several approaches:

- Identification of key issues that affect wetlands (these are studied in section 4.4).
- Characterization of wetlands functions and ecosystem services.

- Discussion with stakeholders and REMA during the first and second workshop to identify core project objectives.
- Review of the terms of Reference (TOR) of the study.
- Assessment of targets, goals and objectives of the wetland rehabilitation which were determined after baseline (see section 4.16).

Based on this approach, four project higher-level objectives criteria where selected:

- **Flood mitigation**: flash floods cause devasting impacts on infrastructure and sometimes of human life and the natural flood buffering function of wetlands has been altered due to channelization of rivers, destruction of rivers floodplains to develop agriculture. The TOR also highlight that improved flood control performance is one of the key objectives of the rehabilitation project. Flood mitigation is a key ecosystem service that needs to be rehabilitated.
- **Biodiversity enhancement**: wetlands are severely degraded, some parts are even no longer holding any wetland functions, rehabilitation of wetlands will require to restore plant habitats and attract wildlife. The TOR also highlight that improved quality of habitats and biodiversity is one of the key objectives of the rehabilitation project. **Biodiversity criteria are derived from the proposed methodology in the International Principles & Standards for the Practice of Ecological Restoration (2019).**
- **Water quality improvement**: protecting water quality is key to sustain wetland on the long term, unfortunately, the lack of formal sanitation in many areas, and the absence of sewerage system affects the wetlands as all of them are located in depressions, collecting stormwater, domestic wastewater and surface runoffs. It is therefore important to restore the wetland to improve their natural filtering function, but also to design constructed wetlands and NBS to limit the inputs of pollutants and sediments in the wetlands. Water quality treatment is also one of the key objectives of the rehabilitation project according to the TOR.
- **Development of recreational activities and landscape**: the wetlands are urban spaces that need to provide benefits for citizens, both in term of recreational activities but also in terms of enhancement of the city's landscape. Studying landscape and recreational opportunities are required by the TOR. Stakeholders also highlighted that the wetlands rehabilitation projects shall provide opportunities for business development to bring incomes to the city.

3.3.2.2 Cost and technical criteria

These criteria are divided in two categories: investment cost and technical feasibility. They allow to evaluate whether scenarios are economically or technically feasible.

- Investment cost:
  - Capital cost to build the scenario
  - Cost to operate and maintain the scenario
- Technical feasibility:
  - Long term technical reliability
  - Convenience of operation and maintenance requirements.

These criteria are further detailed at section 3.3.5.

3.3.2.3 Side-benefits and negative trade-offs criteria

Criteria are divided in two categories: Side-benefits and Trade-offs. These criteria will evaluate what are the potential other benefits from the scenario in terms of economic development and social acceptability. They also will study, in broad terms, what are the potential impacts from the rehabilitation both for wetland users' livelihood and for the environment.

- Side benefits:
  - Potential for development of economic activities.
  - Social acceptability.

- Trade-offs:
  - Impact on livelihood activities.
  - Environmental impacts.

These criteria are further detailed at section 3.3.6.

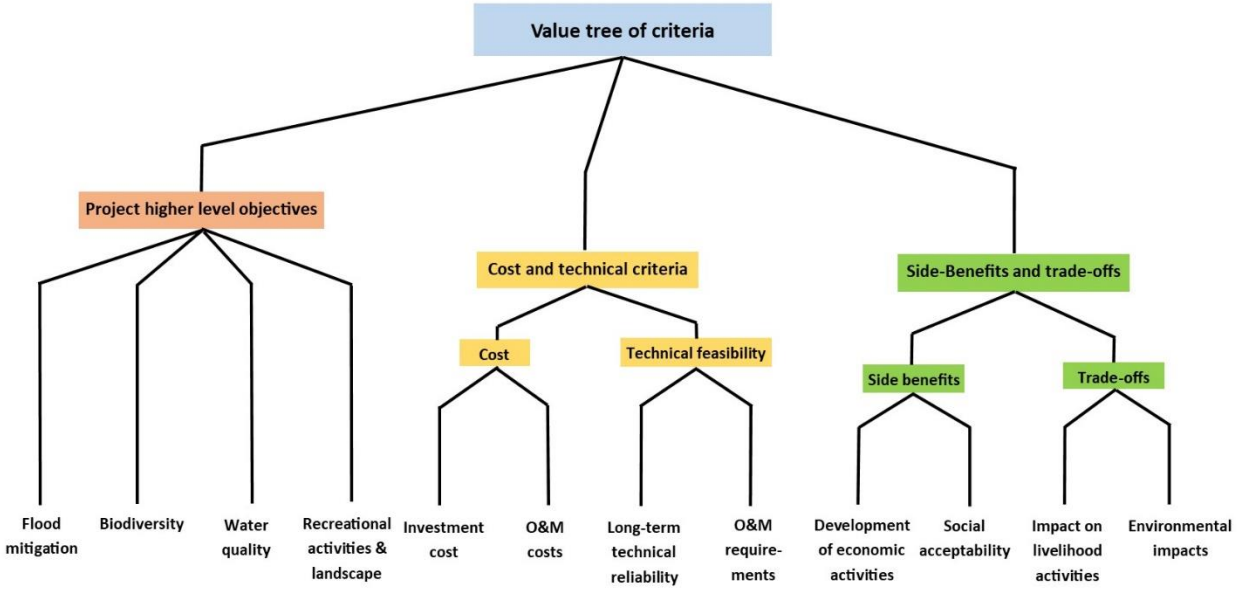


FIGURE 3-2 SELECTED CRITERIA

3.3.3 Selection of sub-criteria

In the same framework of multiple criteria methodology, the consultant elaborated 45 sub-criteria to analyses and rank each criterion.

The selection of sub-criteria has been established by each key expert in their respective field of expertise. Their selection is based on the experts' return of experience, on the evaluation of the local context in and around the 5 wetlands and on the review of available studies and bibliography on the 5 wetlands.

The principle is as follow: for each criterion, key experts selected a set of sub-criteria and described the ranking system that will be used for both the baseline situation and the rehabilitated scenarios. Ranking is from 1 to 10 as shown in the next table. **This ranking system has allowed to produce wheel charts illustrating the performance each rehabilitation scenario**.

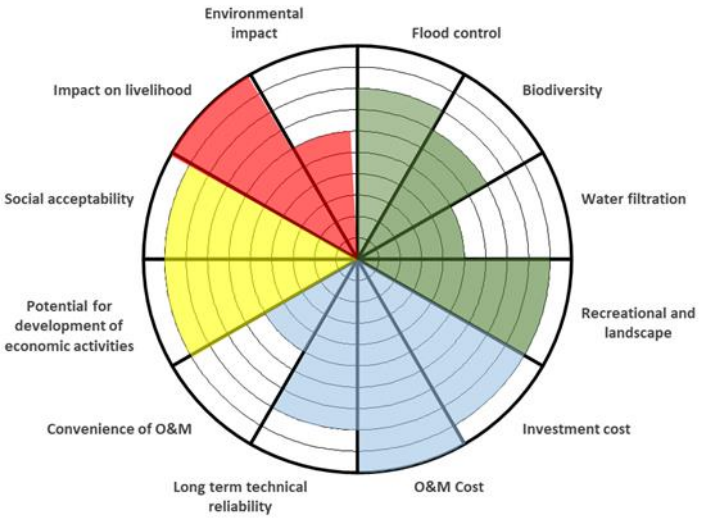


FIGURE 3-3 EXAMPLE OF WHEEL CHART

Each expert has developed a certain number of sub-criteria; however, their number only helps to fine-tune the assessment of the criteria and not to give more weight to one criterion at the expense of the others. For example, if the "Flood mitigation" criterion has 4 sub-criteria, it does not give it less weight than the "Recreational activities & landscape" criterion which has 5 sub-criteria. Weighting each criterion is done at scenario assessment chapter 5. Average score between sub-criteria is always a rounded figure.

Some criteria are used to describe how the wetlands perform at baseline (currently) for some criteria (project higher objectives) while other are only used to characterize the scenarios.

The following table shows an example of how each criterion and sub-criteria is used.

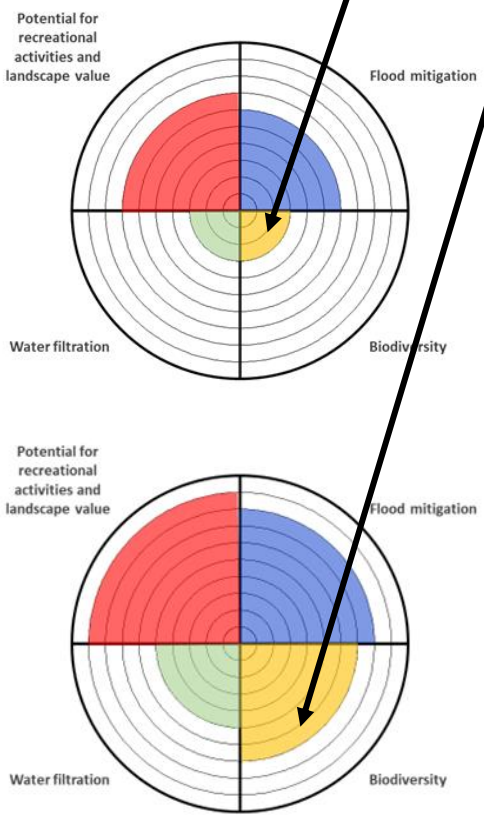
TABLE 3-2 EXAMPLE OF THE CRITERIA RANKING MATRIX

Criteria: XXX										
	Ranking system for this criterion									
Sub criteria	The wetland at baseline or after rehabilitation performs very well		The wetland at baseline or after rehabilitation performs well		The wetland at baseline or after rehabilitation does not show any negative of positive performance		The wetland at baseline or after rehabilitation do not perform well		The wetland at baseline or after rehabilitation performs very poorly	
Scores →	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
Sub-criteria 1										
Sub-criteria 2										
Sub-criteria 3										

The following table shows an example on how each criterion and sub criteria were used to establish a scoring system (from 1 to 10). The example is for Gikondo wetland, criterion "Biodiversity enhancement" with the 6 sub criteria. Biodiversity criterion has an average score of 3 at baseline and 7 under Variant 1 as shown in the following table and figure.

TABLE 3-3 GIKONDO AT BASELINE AND UNDER VARIANT 1

		Baseline	Variant 1
Criterion	**Biodiversity enhancement. Average score**	**3**	**7**
Sub criteria	Sub-criteria 1: Absence of threats	2	8
	Sub-criteria 2: Soil hydrologic conditions	5	7
	Sub-criteria 3: Species composition	1	7
	Sub-criteria 4: Structural diversity	1	9
	Sub-criteria 5: Ecosystem function	4	7
	Sub-criteria 6: External exchanges	3	6



3.3.4 Project higher-level objectives criteria

As highlighted above, four criteria are key for the project. These criteria are higher level objective criteria.

- Flood mitigation
- Biodiversity enhancement
- Improvement of water quality

- Development of recreational activities and improvement of the city's landscape.

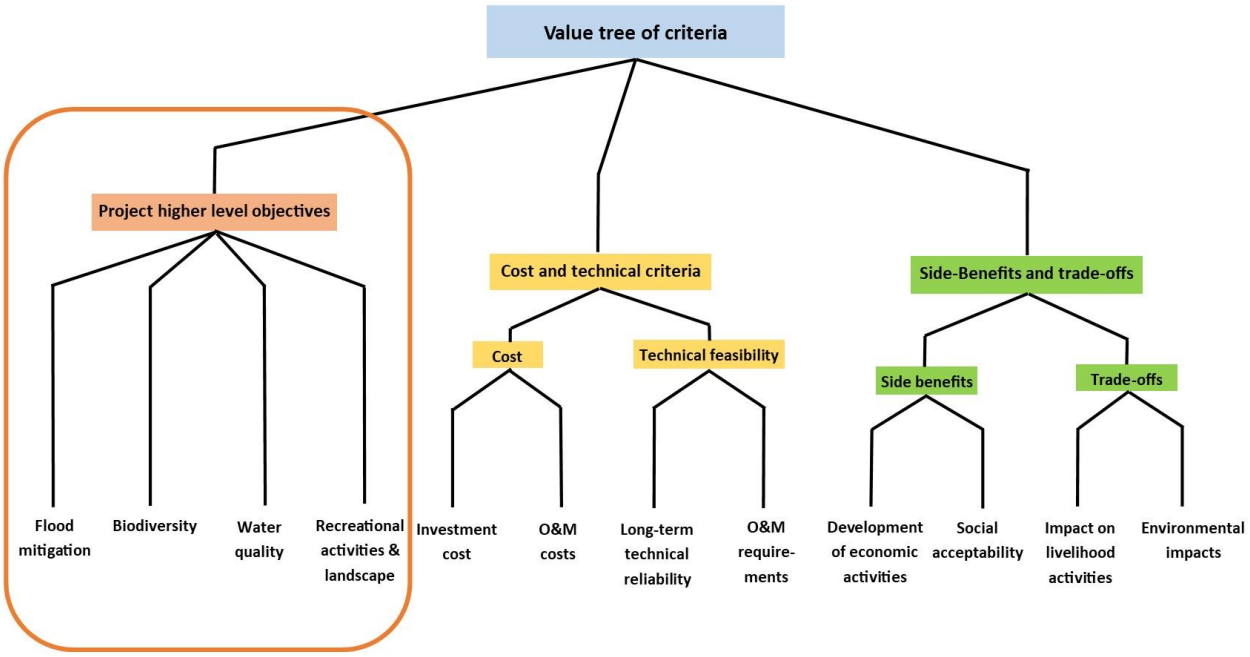


FIGURE 3-4 PROJECT HIGHER LEVEL OBJECTIVES

3.3.4.1 Flood mitigation sub criteria

The flood mitigation criterion is a project higher level objective criterion.

Flood mitigation criterion relates to hydraulic performance at infrastructure location (culverts and bridges). However, the ecosystem function of the wetlands in term of runoff reduction, groundwater recharge, water storage / retention, flood expansion area is evaluated in the “Biodiversity enhancement” criterion (section 3.3.4.2).

It will be used for both baseline assessment, to assess the current performance the drainage system (in which the wetlands play a role) and for to evaluate each scenario, to assess how will scenarios perform for this criterion.

Flood mitigation sub-criteria were developed by the hydraulic key expert. Sub-criteria are based on the height of water in meters for a rain of return time of 10 years on identified critical points such as bridges and roads located in the wetlands.

For this criterion, sub-criteria are different based on each wetland critical points at risk of floods. Evaluation is based on the hydraulic model in the framework of this study (see section 4.8).

The following tables present the sub-criteria and the ranking system for each wetland.



FIGURE 3-5 FLOOD FOCUS POINTS FOR GIKONDO

TABLE 3-4 FLOOD MITIGATION CRITERIA RANKING MATRIX-GIKONDO

Criterion: Flood mitigation for Gikondo										
Sub-criteria	Ranking system for this criterion									
	No flooding H=0m		**Very low intensity of flood** 0m < H ≤ 0.15m		**Low intensity of floods** 0.15m < H ≤ 0.5m		**Medium intensity of floods** 0.5m < H ≤ 2m		**High intensity of floods** H > 2m	
	10	9	8	7	6	5	4	3	2	1
Sub-Criteria 1: Water depth over road NR4	There is no flooding of infrastructure		Flooding occurs with no impacts on people or infrastructures		Flooding occurs with some impacts on people or infrastructures. Material damages are expected		People are at risk but only to a small extent; damage to infrastructure is to be expected		People are endangered even inside buildings; considerable damage to buildings and infrastructures is to be expected, leading to their destruction	
Sub-Criteria 2: Water depth over KK1 Avenue	There is no flooding of infrastructure		Flooding occurs with no impacts on people or infrastructures		Flooding occurs with some impacts on people or infrastructures. Material damages are expected		People are at risk but only to a small extent; damage to infrastructure is to be expected		People are endangered even inside buildings; considerable damage to buildings and infrastructures is to be expected, leading to their destruction	
Sub-Criteria 3: Water depth over KN14 Avenue	There is no flooding of infrastructure		Flooding occurs with no impacts on people or infrastructures		Flooding occurs with some impacts on people or infrastructures. Material damages are expected		People are at risk but only to a small extent; damage to infrastructure is to be expected		People are endangered even inside buildings; considerable damage to buildings and infrastructures is to be expected, leading to their destruction	
Sub-Criteria 4: Water depth over Muhazi	There is no flooding of infrastructure		Flooding occurs with no impacts on people or infrastructures		Flooding occurs with some impacts on people or infrastructures. Material damages are expected		People are at risk but only to a small extent; damage to infrastructure is to be expected		People are endangered even inside buildings; considerable damage to buildings and infrastructures is to be expected, leading to their destruction	

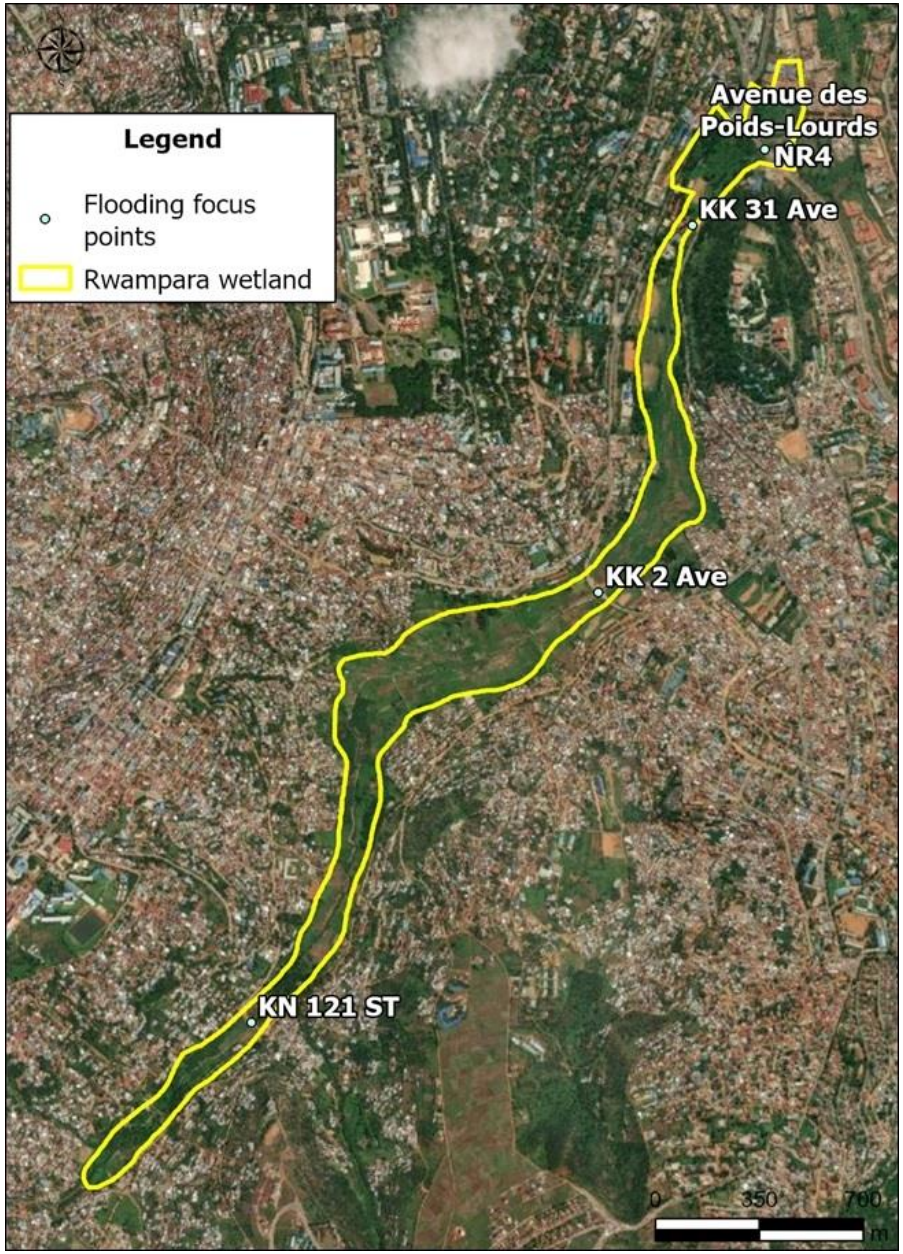


FIGURE 3-6 FLOOD FOCUS POINTS FOR GIKONDO

TABLE 3-5 FLOOD MITIGATION CRITERIA RANKING MATRIX-RWAMPARA

Criterion: Flood mitigation for Rwampara										
Sub-criteria	Ranking system for this criterion									
	No flooding H=0m		**Very low intensity of flood** 0m < H ≤ 0.15m		**Low intensity of floods** 0.15m < H ≤ 0.5m		**Medium intensity of floods** 0.5m < H ≤ 2m		**High intensity of floods** H > 2m	
	10	9	8	7	6	5	4	3	2	1
Sub-Criteria 1: Water depth over road KN 121	There is no flooding of infrastructure		Flooding occurs with no impacts on people or infrastructures		Flooding occurs with some impacts on people or infrastructures. Material damages are expected		People are at risk but only to a small extent; damage to infrastructure is to be expected		People are endangered even inside buildings; considerable damage to buildings and infrastructures is to be expected, leading to their destruction	
Sub-Criteria 2: Water depth over KK 2 Avenue	There is no flooding of infrastructure		Flooding occurs with no impacts on people or infrastructures		Flooding occurs with some impacts on people or infrastructures. Material damages are expected		People are at risk but only to a small extent; damage to infrastructure is to be expected		People are endangered even inside buildings; considerable damage to buildings and infrastructures is to be expected, leading to their destruction	
Sub-Criteria 3: Water depth over KK 31 Avenue	There is no flooding of infrastructure		Flooding occurs with no impacts on people or infrastructures		Flooding occurs with some impacts on people or infrastructures. Material damages are expected		People are at risk but only to a small extent; damage to infrastructure is to be expected		People are endangered even inside buildings; considerable damage to buildings and infrastructures is to be expected, leading to their destruction	
Sub-Criteria 4: Water depth over Avenue des Poids-Lourds NR4	There is no flooding of infrastructure		Flooding occurs with no impacts on people or infrastructures		Flooding occurs with some impacts on people or infrastructures. Material damages are expected		People are at risk but only to a small extent; damage to infrastructure is to be expected		People are endangered even inside buildings; considerable damage to buildings and infrastructures is to be expected, leading to their destruction	



FIGURE 3-7 FLOOD FOCUS POINTS FOR RUGENGE-RWINTARE

TABLE 3-6 FLOOD MITIGATION CRITERIA RANKING MATRIX-RUGENGE-RWINTARE

Criterion: Flood mitigation for Rugenge-Rwintare										
Sub-criteria	Ranking system for this criterion									
	No flooding H=0m		**Very low intensity of flood** 0m < H ≤ 0.15m		**Low intensity of floods** 0.15m < H ≤ 0.5m		**Medium intensity of floods** 0.5m < H ≤ 2m		**High intensity of floods** H > 2m	
	10	9	8	7	6	5	4	3	2	1
Sub-Criteria 1: Water depth over KG 3 Avenue	There is no flooding of infrastructure		Flooding occurs with no impacts on people or infrastructures		Flooding occurs with some impacts on people or infrastructures. Material damages are expected		People are at risk but only to a small extent; damage to infrastructure is to be expected		People are endangered even inside buildings; considerable damage to buildings and infrastructures is to be expected, leading to their destruction	
Sub-Criteria 2: Water depth over Rugenge road	There is no flooding of infrastructure		Flooding occurs with no impacts on people or infrastructures		Flooding occurs with some impacts on people or infrastructures. Material damages are expected		People are at risk but only to a small extent; damage to infrastructure is to be expected		People are endangered even inside buildings; considerable damage to buildings and infrastructures is to be expected, leading to their destruction	
Sub-Criteria 3: Water depth over road KN 21	There is no flooding of infrastructure		Flooding occurs with no impacts on people or infrastructures		Flooding occurs with some impacts on people or infrastructures. Material damages are expected		People are at risk but only to a small extent; damage to infrastructure is to be expected		People are endangered even inside buildings; considerable damage to buildings and infrastructures is to be expected, leading to their destruction	
Sub-Criteria 4: Water depth over KN 8 Avenue	There is no flooding of infrastructure		Flooding occurs with no impacts on people or infrastructures		Flooding occurs with some impacts on people or infrastructures. Material damages are expected		People are at risk but only to a small extent; damage to infrastructure is to be expected		People are endangered even inside buildings; considerable damage to buildings and infrastructures is to be expected, leading to their destruction	



FIGURE 3-8 FLOOD FOCUS POINTS FOR KIBUMBA

TABLE 3-7 FLOOD MITIGATION CRITERIA RANKING MATRIX-KIBUMBA

Criterion: Flood mitigation for Kibumba										
Sub-criteria	Ranking system for this criterion									
	No flooding H=0m		**Very low intensity of flood** 0m < H ≤ 0.15m		**Low intensity of floods** 0.15m < H ≤ 0.5m		**Medium intensity of floods** 0.5m < H ≤ 2m		**High intensity of floods** H > 2m	
	10	9	8	7	6	5	4	3	2	1
Sub-Criteria 1: Water depth over road KG 550	There is no flooding of infrastructure		Flooding occurs with no impacts on people or infrastructures		Flooding occurs with some impacts on people or infrastructures. Material damages are expected		People are at risk but only to a small extent; damage to infrastructure is to be expected		People are endangered even inside buildings; considerable damage to buildings and infrastructures is to be expected, leading to their destruction	
Sub-Criteria 2: Water depth over KG 15 Avenue	There is no flooding of infrastructure		Flooding occurs with no impacts on people or infrastructures		Flooding occurs with some impacts on people or infrastructures. Material damages are expected		People are at risk but only to a small extent; damage to infrastructure is to be expected		People are endangered even inside buildings; considerable damage to buildings and infrastructures is to be expected, leading to their destruction	
Sub-Criteria 3: Water depth over road KG 449	There is no flooding of infrastructure		Flooding occurs with no impacts on people or infrastructures		Flooding occurs with some impacts on people or infrastructures. Material damages are expected		People are at risk but only to a small extent; damage to infrastructure is to be expected		People are endangered even inside buildings; considerable damage to buildings and infrastructures is to be expected, leading to their destruction	
Sub-Criteria 4: Water depth over KG 33 Avenue	There is no flooding of infrastructure		Flooding occurs with no impacts on people or infrastructures		Flooding occurs with some impacts on people or infrastructures. Material damages are expected		People are at risk but only to a small extent; damage to infrastructure is to be expected		People are endangered even inside buildings; considerable damage to buildings and infrastructures is to be expected, leading to their destruction	



FIGURE 3-9 FLOOD FOCUS POINTS FOR NYABUGOGO

TABLE 3-8 FLOOD MITIGATION CRITERIA RANKING MATRIX-NYABUGOGO LOWER

Criterion: Flood mitigation for Nyabugogo Lower										
Sub-criteria	Ranking system for this criterion									
	No flooding H=0m		**Very low intensity of flood** 0m < H ≤ 0.15m		**Low intensity of floods** 0.15m < H ≤ 0.5m		**Medium intensity of floods** 0.5m < H ≤ 2m		**High intensity of floods** H > 2m	
	10	9	8	7	6	5	4	3	2	1
Sub-Criteria 1: Water depth over KG 14 Avenue	There is no flooding of infrastructure		Flooding occurs with no impacts on people or infrastructures		Flooding occurs with some impacts on people or infrastructures. Material damages are expected		People are at risk but only to a small extent; damage to infrastructure is to be expected		People are endangered even inside buildings; considerable damage to buildings and infrastructures is to be expected, leading to their destruction	
Sub-Criteria 2: Water depth over Nyabugogo	There is no flooding of infrastructure		Flooding occurs with no impacts on people or infrastructures		Flooding occurs with some impacts on people or infrastructures. Material damages are expected		People are at risk but only to a small extent; damage to infrastructure is to be expected		People are endangered even inside buildings; considerable damage to buildings and infrastructures is to be expected, leading to their destruction	

3.3.4.2 Biodiversity enhancement sub criteria

The biodiversity enhancement criterion is a project higher level objective criterion. It relates to the performance of the wetland to sustain viable plant communities and biodiversity.

It is used for both baseline assessment, to assess the current performance of the wetland and for to evaluate each scenario, to assess how will scenarios perform for this criterion.

Biodiversity sub-criteria were developed by the Wetland key expert. Sub-criteria are largely based on the International Principles & Standards for the Practice of Ecological Restoration which has developed “Key ecosystem attributes”. Key ecosystem attributes are used to characterize the reference ecosystem, as well as to evaluate baseline condition, set project goals, and monitor degree of recovery at a restoration site.

These “Key ecosystem attributes” are used as sub-criteria:

- Sub-criteria 1: Threats: Direct or indirect threats on the ecosystem. To simplify the analysis of threats, two parameters were selected to facilitate comparison between wetlands:
  - Soil artificialization integrating threats related to illegal dumps, urbanization, land clearing, embankments.
  - Agriculture integrating threats related to dewatering, drainage, siltation, fertilization, amendment, application of phytosanitary products, presence of invasive species, agricultural overexploitation.
- Sub-criteria 2: Soil hydrologic conditions: The hydrological functioning (flooding regime) of the wetland necessary to maintain the target ecosystem is defined in terms of the frequency of flooding (never, exceptionally, regularly and permanently) and the extent (partially or totally). This flooding is related to water inflow/outflow: rivers, springs, groundwater, floodwaters, runoff, precipitation, evaporation...
- Sub-criteria 3: Species composition: Native species characteristic of the appropriate reference ecosystem are present, whereas undesirable species are absent.
- Sub-criteria 4: Structural diversity: Appropriate diversity of key structural components, including demographic stages, trophic levels, vegetation strata and spatial habitat diversity are present.
- Sub-criteria 5: Ecosystem function: Appropriate levels of growth and productivity, nutrient cycling, decomposition, species interactions and recruitment of species. For this sub-criterion, biological functionality is taken into account with the parameters "reception of animal and plant species by natural habitats" and "ecological connection of natural habitats" which are linked to the improvement of biodiversity. This sub-criteria also integrates the hydraulic functionality taking into account groundwater recharge, water storage / retention, flood expansion area. This function is treated under the Biodiversity criteria because it is of paramount significance to sustain biodiversity as hydraulic behavior dictates the potential of the wetland to shelter specific plants and fauna. This functionality assesses the wetland hydraulic function, which is different from the flood mitigation criteria at infrastructure (section 3.3.4.1).
- Sub-criteria 6: External exchanges: The ecosystem is appropriately integrated into its larger landscape or aquatic context through abiotic and biotic flows and exchanges.

Evaluation is based on botanical surveys undertaken in the framework of this study (see Appendix 2) and collected biodiversity information in the wetland from bibliographical sources.

The following tables present the sub-criteria and the ranking system.

TABLE 3-9 BIODIVERSITY ENHANCEMENT CRITERIA RANKING MATRIX

Criterion: Biodiversity enhancement										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
Sub-criteria 1: Threats	No threats (use or management) on the entire wetland		One or more threats (use or management) on less than 25% of the total wetland area		One or more threats (use or management) on 25 to 50% of the total wetland area		One or more threats (use or management) on 50 to 75% of the total wetland area		One or more threats (use or management) on more than 75% of the total wetland are	
Sub-criteria 2: Soil hydrologic conditions	Soil permanently or regularly waterlogged over the entire surface of the wetland		Soil permanently or regularly waterlogged over part of the wetland surface		Exceptionally waterlogged soil over the entire surface of the wetland		Exceptionally waterlogged soil over a portion of the wetland area		Wetland soil never waterlogged	
Sub-criteria 3: Species composition	Over 80% of the total wetland area is covered by native hygrophilous plant species		60-80% coverage of the total wetland area by native hygrophilous plant species		40 to 60% of the total wetland area covered by native hygrophilous plant species		Cover between 10 and 40% of the total surface of the wetland by native hygrophilous plant species		Less than 10% of the total wetland area is covered by native hygrophilous plant species	
Sub-criteria 4: Structural diversity	Presence of native natural habitats in three plant strata (trees, shrubs and grasses) on more than three quarters of the wetland area		Presence of native natural habitats in three plant strata (trees, shrubs, grasses) on more than half of the wetland area		Presence of native natural habitats in two vegetation strata (trees, shrubs, grasses) on more than half of the wetland area		Presence of native natural habitats in one or two plant strata (trees, shrubs, or grasses) on more than half of the wetland area		Presence of native natural habitats in one or two vegetative strata (tree, shrub or herbaceous) on less than half of the wetland area	
Sub-criteria 5: Ecosystem function	Cumulative evaluation of the biological and hydraulic functionalities categorized as very high		Cumulative evaluation of the biological and hydraulic functionalities categorized as high		Cumulative evaluation of the biological and hydraulic functionalities categorized as medium		Cumulative evaluation of the biological and hydraulic functionalities categorized as low		Cumulative evaluation of the biological and hydraulic functionalities categorized as very low	
Sub-criteria 6: External exchanges	Absence of fragmentation and multiple ecological connections (watercourses, hedges, woodlands...)		Partial fragmentation and multiple ecological connections (watercourses, hedges, woodlands...)		Partial fragmentation and single ecological connection (watercourse, hedges, afforestation...)		Strong fragmentation and unique ecological connection (watercourses, hedges, woodland...)		Strong fragmentation and lack of ecological connection	

3.3.4.3 Improvement of water quality sub criteria

Improvement of water quality criterion is a project higher level objective criterion. It relates to the capacity of the wetlands to naturally filter pollutants and settle suspended sediment in surface water.

It will be used for both baseline assessment, to assess the current performance of the wetland and for to evaluate each scenario, to assess how will scenarios perform for this criterion.

Water quality sub-criteria were developed by the Team leader and key experts. Sub-criteria consider internal factors leading to wetland pollution mainly nonpoint sources of pollution such as agriculture and the use of fertilizers and pesticides. Sub-criteria also consider external factors leading to pollution, both point source such as discharge of raw sewage in the wetland, discharge of process water from industries and nonpoint sources such as runoff during heavy rain bringing turbidity and used oil in the wetlands. External factors also consider sewerage coverage (planned), density of population around the wetland and land use. Lastly, the sub-criteria assess the natural filtration function of the wetland, such as sediment trapping and pollutant assimilation (nitrate denitrification, plant assimilation of nitrogen, phosphorus adsorption and precipitation, plant assimilation of orthophosphates, contribution to the abatement of micropollutants).

Evaluation is based on collected information from various sources, including information on drainage and sewerage system from WASAC, field visits that have allowed to characterize sources of pollutions and bibliographical review of previous studies in the wetland system.

The following tables present the sub-criteria and the ranking system.

TABLE 3-10 IMPROVEMENT OF WATER QUALITY CRITERIA RANKING MATRIX

Criterion: Improvement of water quality										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
Sub-criteria 1: Source of pollution inside the wetland	The wetland is free from current and past activities that generate(d) diffuse pollution		Sources of pollutions are limited to a few areas inside the wetland		The wetland is utilized by one type of activity known to generate water pollution covering significant parts of the wetland		The wetland is utilized by several activities that are known to generate water pollution covering significant part of the wetland		The wetland is heavily utilized by several activities that are known to generate water pollution, signs of erosion and past pollution is prevalent	
Sub-criteria 2: External sources of pollution flowing in the wetland (point source and nonpoint source)	The wetland is free from external pollution		The wetland receives external pollution, but these are treated prior to their discharge		The wetland receives external pollution, but these are treated at their point of discharge or in part treated prior to their discharge		The wetland receives untreated external pollution		The wetland receives high volume of untreated external pollution	

Sub-criteria 3: Quality of surface water flowing in the wetland	The quality of surface water is excellent with no water pollution	The quality of surface water is good with low water pollution	The quality of surface water is medium but affected by limited types of pollution (turbidity, high organic or high inorganic pollution)	The quality of surface water is poor because of several types of pollutions (turbidity, high organic or high inorganic pollution)	The quality of surface water is highly polluted because of high concentration of several types of pollutions (turbidity, high organic or high inorganic pollution)
Sub-criteria 4: Natural filtration function of the wetland	The natural filtering function of the wetland performs very well	The natural filtering function of the wetland performs well	The natural filtering function of the wetland does not perform well to trap sediment or to assimilate pollutants	The natural filtering function of the wetland neither performs well to trap sediment nor to assimilate pollutants	The wetland does not have any natural filtering functions

3.3.4.4 Development of recreational activities and improvement of the city's landscape sub criteria

Development of recreational activities and improvement of the city's landscape criterion is a project higher level objective criterion. It relates to the aesthetic and recreational value of the wetland.

It will be used for both baseline assessment, to assess the current performance of the wetland and for to evaluate each scenario, to assess how will scenarios perform for this criterion.

Development of recreational activities and improvement of the city's landscape sub-criteria were developed by the Urban landscape architect key expert.

Evaluation is based on the Urban landscape architect assessment, return of experience and bibliographical review of previous studies in the wetland system.

The following factors and attributes will be used as sub-criteria. The explanations for the choice of each sub-criterium is also indicated below.

- Sub-Criteria 1 — Quality of the natural landscape/environment: the increase of the quality of natural landscapes occurs where there are occurrences such as topographical irregularities, diversity of land uses and green cover, etc. As the wetlands are essentially low areas, this sub-criterion will focus on the characteristics of the green cover and diversity of land uses.
- Sub-Criteria 2 — Quality of the anthropic landscape/cultural environment: cultural environments refer to the occurrence of spaces shaped by human uses and activities, it can encompass constructions and built environments of many kinds such as monuments, bridges, roads, heritage buildings, etc. In the case of the wetlands this sub-criterion will be measured by the occurrence and/or proximity to designed structures and/or landscaped areas (such as memorials, parks, etc.) as well as buildings or areas characterized by human activities of special interest (craft making workshops, i.e. wood workshops, urban incubators, etc.).
- Sub-Criteria 3 — Exposures and visual clearances / perceptions: the level of visual intrusion resulting from the presence of human activities and/or screening forests can have a direct impact on the nature and composition of the physical components related to the landscape. The occurrence of closed views (deep and narrow valleys, the presence of walls, gated properties and/or built-up areas, etc.) can affect negatively the quality of the landscape while panoramic views and/or wide clearings allow for the composition of different layers of perspective and have a positive impact.
- Sub-Criteria 4 — Occurrence and level of continuity of green routes (walking/cycling circuits): occurrence, within the wetland, of walking or cycling circuits. The level of continuity will be measured by the existence of deep linear circuits without interruptions as well as potential for connectivity between two or more wetlands or green areas.
- Sub-Criteria 5 — Occurrence and/or proximity of recreation facilities (including educational and touristic activities): occurrence, within the wetland or on close proximity, of sports centers, linear parks, botanical gardens, green paths, playgrounds, touristic facilities (hotels, restaurants, etc.), education facilities (university, schools, etc.). Due to their potential to concentrate economic activities and attract a large flux of people, the proximity to business and/or administrative clusters will also be considered in this sub-criterium

The following tables present the sub-criteria and the ranking system.

TABLE 3-11 DEVELOPMENT OF RECREATIONAL ACTIVITIES AND IMPROVEMENT OF THE CITY'S LANDSCAPE CRITERIA RANKING MATRIX

Criterion: Development of recreational activities and improvement of the city's landscape										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
Sub-Criteria 1: Quality of natural landscape / environment	Remarkable high-quality landscape (i.e proximity to natural heritage)		Homogeneous high-quality landscape (i.e. presence of native green cover)		Homogeneous landscape		Monospecific green cover		Scattered monospecific green cover/ brownfield	
Sub-Criteria 2: Quality of anthropic landscape / cultural environment	Several heritage buildings, parks, gardens, or areas of interest occur in the wetland and a several occur nearby		Some heritage buildings, parks, gardens, or areas of interest occur in the wetland and a several occur nearby		No heritage buildings, parks, gardens, or areas of interest occur in the wetland, but some occur nearby.		Only one or two heritage buildings, parks, gardens, and/or areas of interest occur in the wetland or nearby		No heritage buildings, parks, gardens, and/or areas of interest of interest in the wetland or nearby.	
Sub-Criteria 3: Exposures and visual clearances / perceptions	Remarkable panoramas and highly exposed area: direct visibility (residential/commercial areas or road)		Exposed area: partial visibility (residential/commercial areas or infra)		Open landscape/diffuse urban presence		Semi-open landscape with diffuse built-up areas		Enclosed landscape (walls/physical barriers/built up areas)	
Sub-Criteria 4: Occurrence and level of continuity of green routes	Very high occurrence of pedestrian trails/routes that allow for continuous crossing of the wetland without any interruptions or barriers.		Occurrence of continuous pedestrian trails/routes with a few light ruptures (waterways crossed by bridges that are in poor state)		Occurrence of scattered pedestrian trails/routes with some ruptures		Occurrence of scattered pedestrian trails/routes with strong ruptures or barriers (canyons, large infrastructure works as drainage canals)		No pedestrian trails/routes and/or very strong ruptures (gated properties, enclave areas, etc.)	
Sub-Criteria 5: Occurrence and/or proximity of recreation facilities (including educational and touristic activities)	Several facilities within the wetland (clusters) and/or within less than 200m distance from its limits		At least one facility within the wetland and/or several attractions within less than 500m distance from its limits and well connected to the wetland		Several facilities within less than 500m distance from its limits and but poorly connected to the wetland		Few scattered facilities in the wetland and/or at a distance of more than 1km from its limits		No facilities occur in the wetland or within 1km distance from its limits	

3.3.5 Cost and technical criteria

These criteria are divided in two categories: investment cost and technical feasibility. They allow to evaluate whether scenarios are economically or technically feasible.

- Investment cost:
  - Capital cost to build the scenario
  - Cost to operate and maintain the scenario
- Technical feasibility:
  - Long term technical reliability
  - Convenience of operation and maintenance requirements.

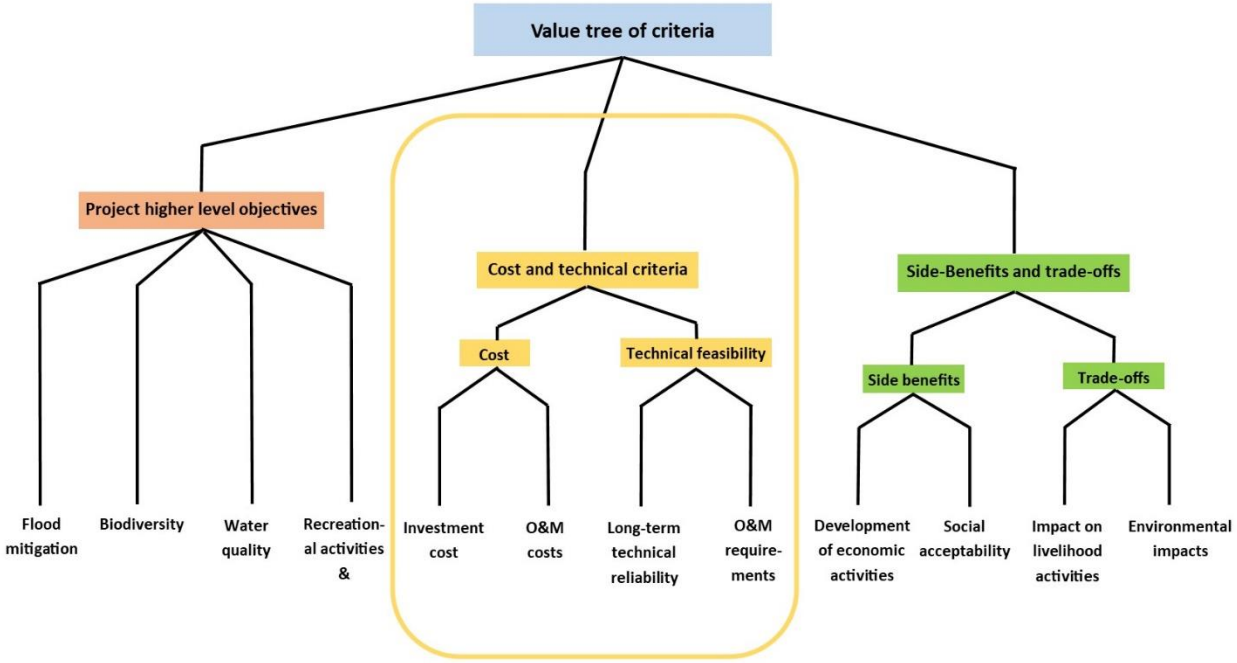


FIGURE 3-10 COST AND TECHNICAL CRITERIA

3.3.5.1 Investment cost: Capital cost to build the scenario

This criterion is necessary to assess how cost-effective is the scenario and to assess if rehabilitation requires substantial interventions and therefore capital investments.

These costs exclude contingencies that could originate from unfinished activities in the wetland such as the presence of foundations that may need to be removed. Presence of utilities to temporarily remove or relocate will be assessed in the preferred scenario at detailed design.

Evaluation is based on the cost estimate developed for each action and the gauge is solely used to compare scenarios. It is established based on the lower and higher costs for each scenario (see action sheets chapter 6). **Since these relates to costs, the ranking system is inverted, the higher the score, the higher the cost.**

The following tables present the sub-criteria and the ranking system.

TABLE 3-12 COST TO BUILD THE SCENARIO CRITERIA RANKING MATRIX

Criterion: Investment cost; Capital cost to build the scenario										
Sub-criteria	Ranking system for this criterion									
	Very high performance in term of cost (not expensive)		High performance in term of cost		Medium performance in term of cost		Low performance in term of cost		Very low performance in term of cost (very expensive)	
	1	2	3	4	5	6	7	8	9	10
Sub-criteria 1: Cost to build the scenario	Less than 1.5 million USD		From 1.5 million to 4 million USD		From 4 to 6 million USD		From 6 to 8 million USD		Above 8 million USD	

3.3.5.2 Investment cost: Cost to operate and maintain the scenario

This criterion is necessary to assess how cost-effective is the scenario and to assess the costs to operate and maintain the scenarios. These costs O&M such as removing accumulated sediments, dredging work, harvesting invasive plants, to replanting, maintenance of recreational facilities, and general landscaping. This criterion evaluates what will O&M require in term of cost without considering human resources. **This O&M cost are integrated for a 10-year period in the Action sheets** (see chapter 6). **Since these relates to costs, the ranking system is inverted, the higher the score, the higher the cost.**

Evaluation is based on typical requirements for O&M of the scenario, on return of experience and on bibliographical review of previous studies (some of them are presented in this report). The gauge is established based on maintenance cost established in scenario analysis (see chapter 6).

The following tables present the sub-criteria and the ranking system.

TABLE 3-13 COST TO OPERATE AND MAINTAIN THE SCENARIO CRITERIA RANKING MATRIX

Criterion: Investment cost; Cost to operate and maintain the scenario	
Sub-criteria	Ranking system for this criterion

	Very high performance in term of cost (not expensive)		High performance in term of cost		Medium performance in term of cost		Low performance in term of cost		Very low performance in term of cost (very expensive)	
	1	2	3	4	5	6	7	8	9	10
Sub-criteria 1: Cost to operate and maintain	Less than 50.000 USD a year		From 50.000 USD to 60.000 USD a year		From 60.000 USD to 70.000 USD a year		From 70.000 USD to 780.000 USD a year		More than 80.000 USD a year	

3.3.5.3 Technical feasibility: Long term technical reliability

This criterion is necessary to assess the capacity for the scenario to function in the long term.

While the flood mitigation criterion is based on projected hydraulic conditions, this criterion will assess the capacity of the scenario in the long term, and its ability to function in degraded conditions and to sustain any changes in the watershed such as climate change, increase in runoff, stormwater and increase in pollution. This criterion also evaluates the reliability of the scenario under low flows, seasonal variations, flash floods and high flow conditions.

Evaluation is based on projected influence of climate change, on a review of the hotspot study, on discussion with stakeholders (such as WASAC), and on review of other studies (some of them are presented in this report).

The following tables present the sub-criteria and the ranking system.

TABLE 3-14 LONG TERM TECHNICAL RELIABILITY CRITERIA RANKING MATRIX

Criterion: Technical feasibility; long-term technical reliability of the scenario										
Sub-criteria	Ranking system for this criterion									
	Very high performance in the long term		High performance in the long term		Medium performance in the long term		Low performance in the long term		Very low performance in the long term	
	10	9	8	7	6	5	4	3	2	1
Sub-criteria 1: capacity of the scenario to sustain seasonal variation of flows (low flows, high flows, flash floods, climate change)	The scenario will perform very well in low and high flows caused by seasonal variation or climate change		The scenario will perform well in low and high flows caused by seasonal variation or climate change		There is a risk that the scenario will not perform well in low and high flows caused by seasonal variation or climate change		The scenario will most likely not perform well during low and high flows caused by seasonal variation of climate change		The scenario will not perform well during low and high flows caused by seasonal variation or climate change	
Sub-criteria 2: capacity of the scenario to function in the long term when faced with increasing level of pollution in the water or	The scenario will show very good performance in the long term when faced with water quality changes		The scenario will show good performance in the long term when faced with water quality changes		The scenario will show very medium or varying performance in the long term when faced with water quality changes		The scenario will show poor performance in the long term when faced with water quality changes		The scenario will show very poor performance in the long term when faced with water quality changes	

increasing erosion from the watershed					

3.3.5.4 Technical feasibility; Convenience of operation and maintenance requirements of the scenario

This criterion is necessary to evaluate whether O&M will be technically difficult. This criterion assumes that self-reliant and low maintenance are paramount principles that should govern rehabilitation works. The more cumbersome O&M will be, the more the scenario will be at risk of being gradually left to degrade.

Evaluation is based on return of experience, review of bibliographical data and on an assessment of risks related to O&M activities.

The following tables present the sub-criteria and the ranking system.

TABLE 3-15 CONVENIENCE OF O&M REQUIREMENTS CRITERIA RANKING MATRIX

Criterion: Technical feasibility; Convenience of operation and maintenance requirements of the scenario										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
Sub-criteria 1: Proven approach in the local context	There are locally successful returns of experience		There are limited locally successful returns of experience, but this activity has been successful in other contexts		There is no return of experience locally		There is no local successful return of experience		There is no local return of experience, and this scenario represent a risk due to lack of local experience	
Sub-criteria 2: Potential for natural regeneration (passive restoration) and self-maintenance	Passive restoration. Very good potential of remnant species to naturally regenerate. The scenario is self-reliant		Passive restoration. Good potential of remnant species to naturally regenerate. The scenario is self-reliant		Potential for natural regeneration is medium. Assisted regeneration could be necessary. The scenario is not self-reliant		Potential for natural regeneration is low. Assisted regeneration will sometimes be necessary. The scenario is not self-reliant		Potential for natural regeneration is absent. Assisted regeneration will always be necessary. The scenario is not self-reliant	

3.3.6 Side-benefits and negative trade-offs criteria

Criteria are divided in two categories: Side-benefits and Trade-offs.

- Side benefits:
  - Potential for development of economic activities.
  - Social acceptability.
- Trade-offs:
  - Impact on livelihood activities.
  - Environmental impacts.

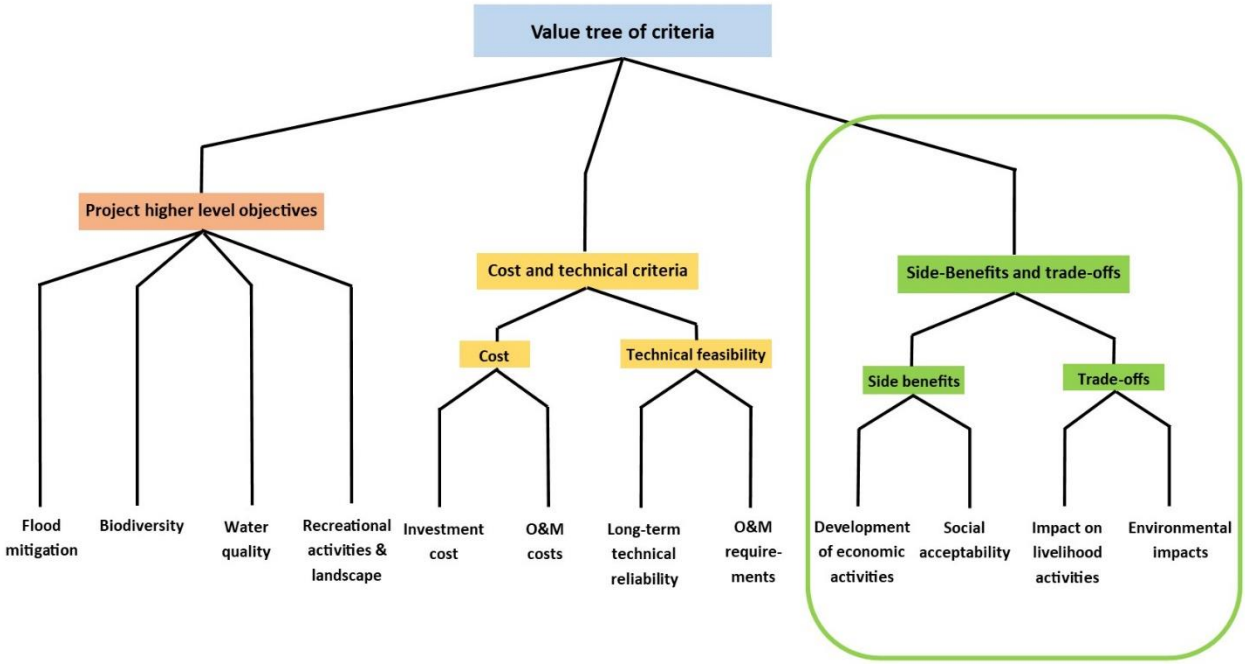


FIGURE 3-11 SIDE-BENEFITS AND TRADE-OFFS CRITERIA

3.3.6.1 Side benefits: Potential for development of economic activities

This criterion evaluates the potential for business development in the wetland, to develop wetlands for various economic activities, to bring incomes to the City of Kigali.

One sub-criteria is developed:

- Sub-criteria 1: Land use and other socioeconomic factors in the vicinity of the wetland is favorable to business development.

This sub-criteria evaluates conditions which allow for the development of businesses and sustainable tourism (restaurant, recreational parks, entry fees, rental space for events, nature observation). This sub-criteria is informed by expert judgement and informed by the city's master plan or other urban planning documents. Evaluation is also based on consultation of master plans, district development strategies, discussion with stakeholders and return of experience of the team of experts. It is also based on the number of suitable areas for business opportunities in the wetlands.

The following tables present the sub-criteria and the ranking system.

TABLE 3-16 POTENTIAL FOR DEVELOPMENT OF ECONOMIC ACTIVITIES CRITERIA RANKING MATRIX

Criterion: Side benefits; Potential for development of economic activities										
Sub-criteria	Ranking system for this criterion									
	Very good potential		Good potential		Limited potential		Low potential		No potential	
	10	9	8	7	6	5	4	3	2	1
Sub-criteria 1: Land use and other socioeconomic factors in the vicinity of the wetland is favourable to business development	Land use in the vicinity of the wetland is very favourable for business development		Land use in the vicinity of the wetland is favourable for business development		Land use in the vicinity of the wetland is neither favourable nor unfavourable for business development		Land use in the vicinity of the wetland shows unfavourable conditions for business development		Land use in the vicinity of the wetland shows very unfavourable for business development	

3.3.6.2 Side benefits; Social acceptability

This criterion evaluates social acceptability from local institutions and based on planned development in or close to the wetland to ensure that the proposed scenarios are widely accepted.

- Sub-criteria 1: Collected opinions from stakeholders. This sub-criteria is important to assess how acceptable will the scenarios be for a wide range of institutions and stakeholders.
- Sub-criteria 2: Effects from the scenarios on planned development in or close to the wetlands. This sub-criteria is informed by an assessment of how the rehabilitation project may interfere with other projects or programs.

Evaluation is based on collected discussions with institutions that are concerned by the project to rehabilitate the wetlands. During meetings with institutions, the team has used a questionnaire to collect opinions and comments on the fate of the wetland.

The following tables present the sub-criteria and the ranking system.

TABLE 3-17 SOCIAL ACCEPTABILITY CRITERIA RANKING MATRIX

Criterion: Side benefits; Social acceptability										
Sub-criteria	Ranking system for this criterion									
	Very good social acceptability		Good social acceptability		Medium social acceptability		Low social acceptability		Very low social acceptability	
	10	9	8	7	6	5	4	3	2	1
Sub-criteria 1: Collected opinions from stakeholders	The outcome of rehabilitation is well accepted by a wide range of stakeholders and considers their concerns and opinions		The outcome of rehabilitation is well accepted by many stakeholders and considers their concerns and opinions		The outcome of rehabilitation is well accepted by some stakeholders, but some stakeholders have raised concerns		The outcome of rehabilitation is not well accepted by most stakeholders, and many have raised concerns		The outcome of rehabilitation is not well accepted by most stakeholders, and most have raised concerns	
Sub-criteria 2: Effects from the scenario on planned development in or close to the wetlands	The scenario does not interfere with any planned development		Some planned developments may take place in or close to the wetland but is/will not be impacted by the scenario		The scenario interferes with planned developments and may require minor adjustments		The scenario interferes with planned development(s) and will require important adjustments		The scenario contradicts planned development(s) and adjustments are not possible	

3.3.6.3 Trade-offs; Impact on livelihood activities

This criterion evaluates, in broad terms, the potential impacts of the rehabilitation scenarios on local livelihood activities in the wetlands, which are dominated by small-scale agricultural activities but also include fish farming, bamboo plantations and plant nurseries. It will show the significance of impacts on traditional agriculture in the wetland and on other livelihood activities.

Evaluations is based on the agricultural surveys that were undertaken amongst cooperatives of farmers (see appendix 3 for the report).

The following tables present the only sub-criteria and the ranking system. **Since these relates to negative impacts, the ranking system is inverted, the higher the score, the higher the impact.**

TABLE 3-18 IMPACT ON LIVELIHOOD ACTIVITIES CRITERIA RANKING MATRIX

Criterion: Trade-offs; Impact on livelihood activities										
Sub-criteria	Ranking system for this criterion									
	No impact		Low impact		Medium impact		High impact		Major impact	
	1	2	3	4	5	6	7	8	9	10

Sub-criteria 1: Impact on cropland and fish farms	The scenario does remove any existing cropland and fish farm	The scenario will remove less than 25% of existing cropland and fish farms	The scenario will remove between 25 and 50% of existing cropland and fish farms	The scenario will remove between 50 and 75% of cropland and fish farms	The scenario will remove between 75 and 100% of existing cropland and fish farms

3.3.6.4 Trade-offs; Environmental impacts

This criterion evaluates, in broad terms, the potential impacts of the rehabilitation scenarios on local environmental conditions. It will show whether there are any negative trade-offs with the rehabilitation, for example the risk of releasing contaminated soil in the water during earth and water works, the risk of having an increase of malaria and other water borne diseases. The risk related to floods for community safety is addressed under the Flood Control criteria (see section 3.3.4.1).

The evaluation is based mainly on secondary sources and a review of previous studies that have evaluated the presence of contaminated soil but also on collected concerns by stakeholders. Once the preferred option will be selected, additional baseline surveys will be undertaken to fine the characterization of soil contamination. **Since these relates to negative impacts, the ranking system is inverted, the higher the score, the higher the impact.**

The following tables present the sub-criteria and the ranking system.

TABLE 3-19 ENVIRONMENTAL IMPACT CRITERIA RANKING MATRIX

Criterion: Trade-offs; Environmental impacts										
Sub-criteria	Ranking system for this criterion									
	No risk		Low risk		Medium risk		High risk		Major risk	
	1	2	3	4	5	6	7	8	9	10
Sub-criteria 1: Risk of releasing pollutants present in soil in the water	Local soils do not to contain any pollution		There are no risks of release of pollutants present in soil		There are some risks of release of pollutants, however these are hypothetical		There are risks of release of pollutants due to presence of polluted soil, however excavation will be limited		There are proven evidence of soil pollution and excavation will represent a risk of release of these pollutants	
Sub-criteria 2: Risk of increase in water-borne disease	There is no risk of increase in water-borne diseases		There are very limited risks of increase in water-borne diseases		There are some risks of increase in water-borne diseases		Increase of the prevalence of water-borne is expected		Strong increase of the prevalence of water-borne disease is expected	

4. BASELINE STUDIES AND CONTEXT ASSESSMENT

4.1 RELATIONSHIP TO OTHER PROJECTS AND PROGRAMS

The 5 wetlands are located in an urban area, it is therefore important to have an in depth understanding of other projects that may influence their rehabilitation. The following sections describes these ongoing or planned projects.

4.1.1 Other RUDP II Projects

One important study is currently taking place in the catchment as part of component 1 of the RUDP II, the "*Feasibility Study, Preliminary Design, Detailed Engineering Design and Elaboration of Tender Documents for the 6 Flood Risk Hotspots in CoK*".

The 5 wetlands are linked with the flooding hotspots and as such any recommendations from the six flood risk hotspots will have implications for the wetland rehabilitation project.

The overall goal of the flood risk hotspots assignment is to prepare detailed designs for several prioritized interventions in Kigali to reduce flood risks at currently known flooding hotspots in critical sub-catchments.

Identified in the figure below, 7 of these hotspots overlap with the wetland rehabilitation project: Rwandex, Rwampara, Rugenge, Kanago, Cadillac and Kinamba.

As sizing hydraulic infrastructures (bridges and culverts) is entirely part of the flood risk hotspots assignment, the Feasibility Study has not described precisely the infrastructure rehabilitation at these hotspots but has studied the interactions between the hotspot study and the rehabilitation project (see chapter 6).

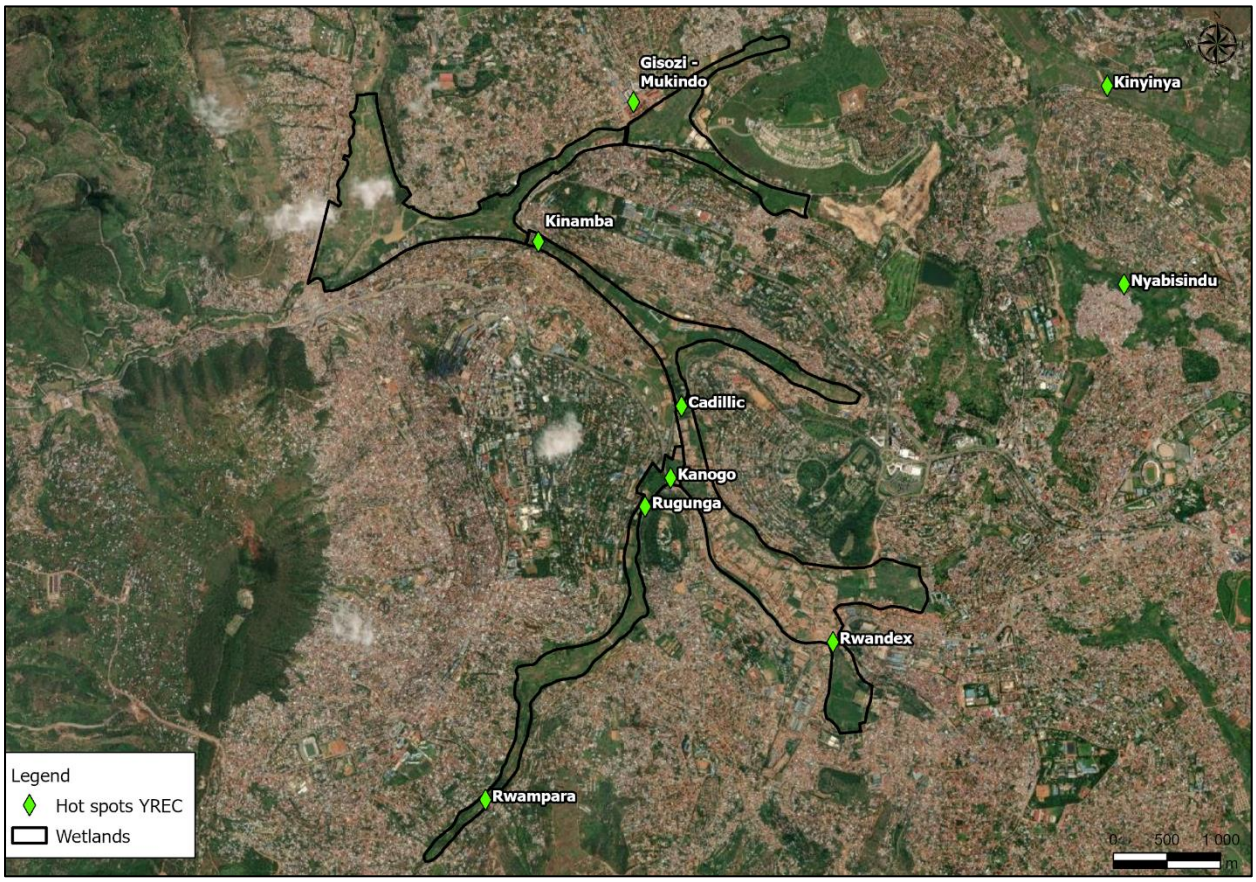


FIGURE 4-1 LOCATION OF THE FLOODING HOTSPOTS PART OF THE YREC STUDY

Another study may interact with the Study, the "Community Facilitation, Planning, Engineering Design, Bid Document, Environmental and Social Impact Assessment and Resettlement Action Plan Preparation for Infrastructure Upgrading in 4 Unplanned Settlements in City of Kigali". This study aims at improving basic infrastructure and services in four unplanned settlements in the CoK. Interventions under this project include

development of access roads, water supply, drainage, paved footpaths, street-lighting, decentralized liquid waste management systems, public space and recreational spaces, including green infrastructures. According to REMA's this study was completed.

Lastly, the Environmental and Social Impact Assessment (ESIA) for this Project was initiated at time of the production of this FS report. Its recommendations, if revelant, will be integrated in the Detailed design.

4.1.2 Stormwater Water Management Master Plan

The latest wastewater and stormwater master plan still in effect for the city of Kigali has been developed in 2008. The following call for tender has been launched recently: "Development of an Integrated Storm Water Management Master Plan for Kigali" by the CoK.

First, it has been verified that no hydraulic infrastructures have been planned and not yet constructed into the wetlands according to the last SWMMP. Moreover, as the new Storm Water Management Master Plan (SWMMP) will start after this study, the new hydraulic infrastructures planned will be designed according to an integrated storm water management approach to be integrated into the new SWMMP.

4.1.3 Kigali Wastewater Project

The CoK intends to develop the Kigali Central Sewerage Project to improve collective sanitation services through consumer connections to a networked sanitation service within the city of Kigali, along with the construction of a wastewater treatment plant. Such development will be positive for the wetland systems as untreated sewage is often discharged in them.

The trunk sewer and footprint of the treatment works have been designed to initially collect and treat sewage from areas designated 1a and 2a which correspond to the urban area adjacent to the southern part of Nyabugogo, Rugenge-Rwintare and a small part of Rwampara wetlands. This project will therefore have positive impacts on water quality in these three wetlands.

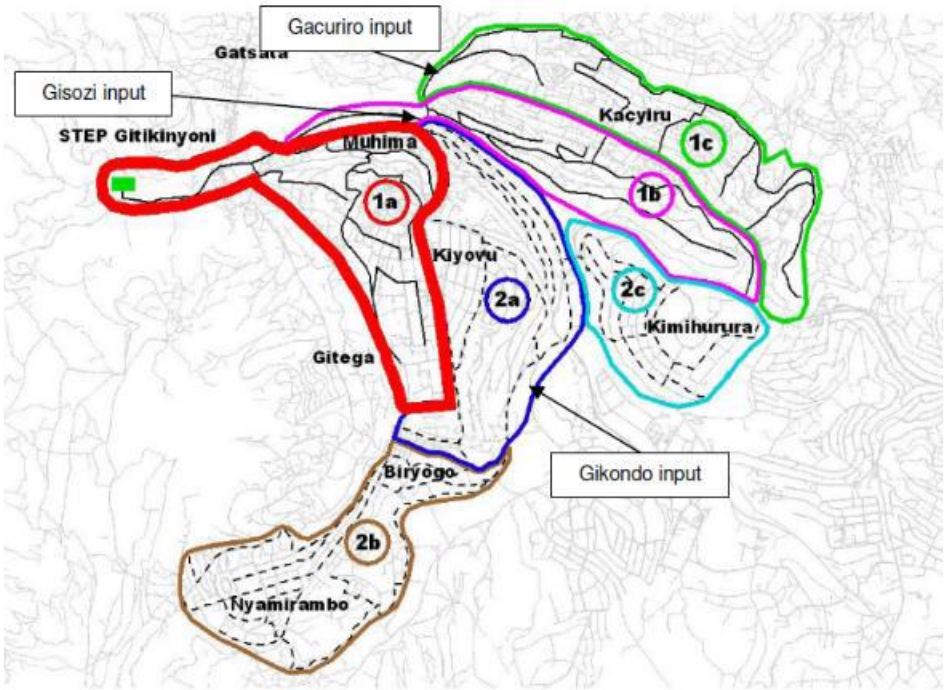


FIGURE 4-2 AREAS DESTINED TO BE COVERED BY THE SEWERAGE

4.1.4 Private initiatives for recreational parks

Wandaland Waterpark Kigali is a private initiative for an amusement park project that intends to be installed in Gikondo main branch on a 8.5 ha piece of land selected by the City of Kigali as shown in the following figure. The park will include wave pools, miniature golf, restaurants as well as constructed wetlands and stormwater retention basin for the filtration of water. It will also include pedestrian paths and market vendors for local food

and crafts. The project is still at its conceptual stage of development as technical studies and environmental impact assessment have not been undertaken.



FIGURE 4-3 WANDALAND WATERPARK

This project is not part of this Study and are solely presented for information. In the absence of any technical data, it is impossible to assess whether it represents any risks for the rehabilitation of wetlands. Whenever relevant, a brief analysis is made on the impact of such project on the desired outcomes for rehabilitation (see assessment of landscape).

4.1.5 City of Kigali initiatives for recreational areas

According to the Central Business District (CBD) Urban Design & Regulations, Kigali Master Plan 2050, the CoK has the intention to develop the Nyabugogo wetland front, which is currently completely disconnected from the CBD and the view is interrupted by structures at the edge of KN7 Rd.

Two areas inside the wetlands are aimed for development according to this document:

- Kimicanga Garden (site 1 in the figure below). The area is about 8.4 Ha located inside Rugenge-Rwintare wetland. It will be an urban park.
- Wetland Front (site 7 in the figure below). The area will spread on 5 km along the existing KN7 Rd, in front of the Nyabugogo wetland. It will cover 20 ha. It aims at introducing suitable mix of uses (commercial, recreational and tourism) along Nyabugogo and introducing sustainable economic activities with the wetland and its buffer zone to enhance connectivity and integration with the CBD.

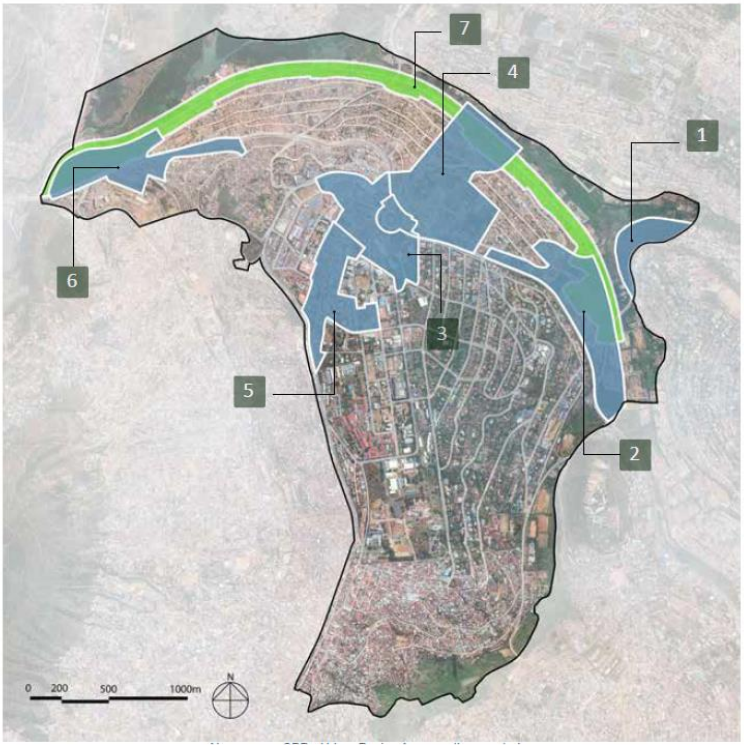


FIGURE 4-4 AIMED DEVELOPMENT UNDER THE URBAN DESIGN & REGULATIONS, KIGALI MASTER PLAN 2050

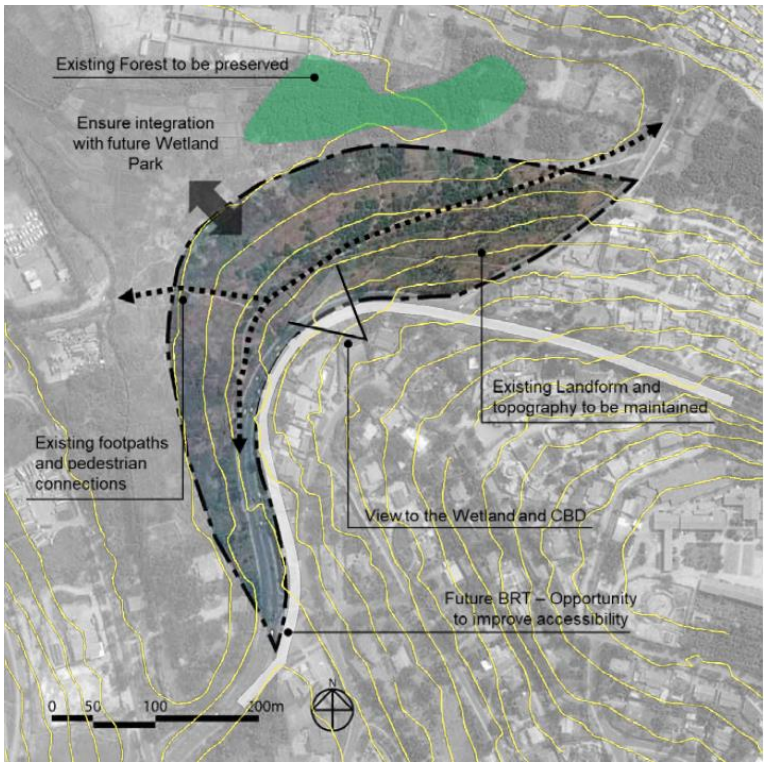


FIGURE 4-5 KIMICANGA GARDEN

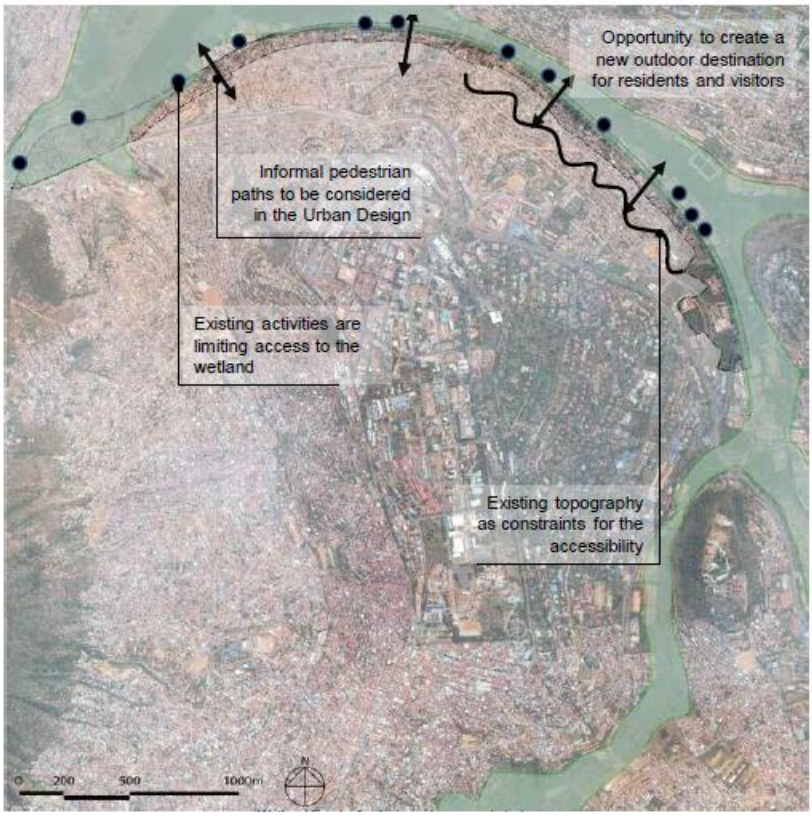


FIGURE 4-6 WETLAND FRONT

4.1.6 Road development in the vicinity of the wetlands

A meeting with the Rwanda Transport Development Authority (RTDA) has enabled to identified roads that will be rehabilitated in the short time close to the wetland system.

- Rwampara wetland:
  - A road named Rwampara-Cyumbati-Miduha of 3.2 Km is planned for upgrading works through City of Kigali, under “Kigali Infrastructure Project (KIP)”. The road follows the wetland along a 1.8km stretch. This road will be asphalted.
- Gikondo, Rugenge-Rwintare and Nyabugogo wetlands:
  - A road named Nyabugogo-Poids Lourds-Kanogo of 4.9 Km is planned for widening works from 2 lanes to 4 lanes through City of Kigali, under “Kigali Infrastructure Project (KIP)”. The road follows the wetland along a 5km stretch.
- Rugenge-Rwintare wetlands
  - Ongoing road works of widening of USA/Embassy-Kimicanga Road which is crossing the Rugenge-Rwintare wetland on 400 m.
- Kibumba wetland:
  - A road named Kagugu-Vision City-Utexrwa of 2.6 Km is planned for rehabilitation works through City of Kigali, under “Kigali Infrastructure Project (KIP)”. The road follows the Kibumba wetland.

Even though these roads are not encroaching in the wetlands, their rehabilitation will lead to modification of the road drainage and existing culverts and impact the wetlands. Some of these roads are not asphalted and do not have collecting drains, their upgrade will require to design drainage system that will be discharged in the wetlands. This may interfere with the rehabilitation scenarios since new road drainage outlets are foreseen. At time of road rehabilitation, it is key to connect drains to existing drains in areas where buffer constructed wetlands are installed (under this Study). This will ensure that no new point sources of pollution are flowing into the wetlands without any prior filtration.

Acknowledging future upgrading of roads into the design of rehabilitation actions was also highlighted as an important aspect during the high-level consultative meeting of October 20 by the Lord Mayor of CoK.



FIGURE 4-7 ROAD UPGRADE PROJECTS

4.2 RAPID BASELINE ASSESSMENT

At inception, a rapid baseline assessment was undertaken during a 4-day field visit which allowed the team of experts to walk along the entire wetland system.

This baseline has helped to identify main ecological, hydraulic, and socioeconomic issues and stressors in the wetlands. During this field visit, the Consultant has identified local issues and described the potential for restoration of the areas. This was the first step in the process of collecting evidence for the development of the rehabilitation scenario. Collected field information was as follow:

- Past, ongoing, and planned interventions in the wetland system.
- Ecological features of wetlands with a focus on remaining semi-natural habitats, modified habitats and degraded habitats, and the physical integrity of the wetland system (river reprofiling, gullies and erosion).
- Human use of the wetlands such as subsistence agriculture in the wetlands, fish farming, plant vendors, horticulture and recreational use.
- Hydrological features of the rivers that flow in the wetland system (Rugenge River, Rwampara River, Kibumba River, Rwenzagoro River, Nyabugogo River, Mpazi Channel, Rwintare River).
- Flooding hotspots and hydraulic transparency issues (culverts, encroachment, drainage), confluence between Mpazi channel and Nyabugogo River.
- Urban drains which are numerous and drain urban runoffs, stormwater and sometimes wastewater to the wetlands, thus contributing to flooding and pollution.
- Characterization of local conditions to install the additional flow measurement stations for the hydrological modeling.
- Identification of remnant wetland habitats to be characterized during dedicated botanical surveys.

4.2.1 Gikondo

Gikondo has three branches:

A southern branch (Gatenga area) of about 25 ha characterized by important wetness conditions and occupied by agriculture. This area has been developed for agriculture for a long time which is attested by the presence of concrete canals collecting wastewater and stormwater and diverting them to the outlet of the wetland and by brick walls surrounding the wetland. Wetness conditions has led to the development of important webs of earth ditch draining agriculture parcels and many areas are naturally recolonized by wetland plants. The single outlet of this wetland is made of a culvert located at the KN3 road. This area is an enclosed wetland, surrounded by walls, in a depression and subject to intense and highly reactive floods due to stormwater discharges in the wetland.

A northern branch (Kagina area) of about 38 ha characterized by the presence of wasteland, fallow land and agriculture plots. The single outlet of this wetland is a culvert under the KK1 Avenue.

A main branch of about 100 ha characterized by the presence of an old industrial area, now entirely demolished were wasteland, brownfields, ruderal plant species and earth backfill dominate the landscape. This area collects important drainage from the surrounding roads. Rugenge River is flowing through this wetland.



FIGURE 4-8 GIKONDO, SOUTHERN BRANCH



FIGURE 4-9 GIKONDO, NORTHERN BRANCH



FIGURE 4-10 GIKONDO, MAIN BRANCH

Characterization was made during the site visit and sectors were delineated according to their dominant hydraulic and ecological features and their level of disturbance. These sectors are presented in the following figure and form the basis for the development of rehabilitation measures.



FIGURE 4-11 CHARACTERIZATION OF GIKONDO

TABLE 4-1 BASELINE IN GIKONDO

Sectors	Main observations	Photos
Southern branch		
EI_G_001	The stream (Gatenga stream) is recalibrated and channelized in a concrete canal to ensure drainage and disconnection from the wetland. It is also possible that most of the wetlands were naturally characterized by a lack of channeled flow. The characteristics of the concrete canal do not allow the wetland to be fed during light rainfall.	
EI_G_002	This area discharges unbuffered urban runoff flowing directly into the wetland.	
EI_G_003	Presence of a typical wetland natural habitats dominated by phragmites and Typha (cattails). The botanical baseline study undertook a full plant inventory at this location and characterized the habitat (see botanical report in Appendix 2). Dominance of nitrophilous plant species, indicating eutrophication of the wetland. Organic pollution from wastewater is obvious in this area leading to a decrease in plant diversity. Some subsistence agriculture occupies this sector with deep drainage channels: • Limiting the residence time of water in the wetland	

Sectors	Main observations	Photos
	• Decreasing biogeochemical functions of the wetland • Lowering the groundwater	
EI_G_004	A concrete canal surrounds the wetland and collects wastewater from local residents and discharges it downstream the wetland at the only outlet. The characteristics of the concrete canal do not allow the wetland to be fed during light rainfall.	
EI_G_005	A recalibrated stream, the Gatenga stream, flows in the center of the Southern branch, its profile does not allow overflow into the wetland during light rainfall. It is also possible that most of the wetlands were naturally characterized by a lack of channeled flow Evidence on the field has demonstrated that the Gatenga stream was recalibrated: constant depth, absence of meanders, regular slopes, presence of backfill and discussions with local users. The depth of the stream contributes to wetland drainage.	

Sectors	Main observations	Photos
EI_G_006	Subsistence agriculture occupies this sector with superficially drained plots. This area is subject to recurrent floods, as it receives water from an urban stormwater outlet (as shown in the picture).	
EI_G_007	Subsistence agriculture occupies this sector with superficially drained plots : • Limiting the residence time of water in the wetland • Decreasing biogeochemical functions of the wetland • Lowering the groundwater	
EI_G_008 EI_G_009 EI_G_010	Infilled wetland area (backfilled areas) limits the floodplain in periods of heavy rainfall. This area was previously occupied by light industries, commercial buildings and warehouses. These have been relocated but the embankment has remained and left abandoned.	
Northern Branch		

Sectors	Main observations	Photos
EI_G_011	A recalibrated stream, the Kagina stream, flows in the center of the Northern branch. This recalibrated stream does not allow overflow onto the plots during light rainfall and the depth of the river contributes to wetland drainage and lowering of the groundwater. Evidence on the field show that the Kagina stream was recalibrated: constant depth, absence of meanders, regular slopes, presence of backfill and discussions with local users. However, it is also possible that most of the wetlands were naturally characterized by a lack of channeled flow.	
EI_G_012	Subsistence agriculture, fallow land and wasteland occupy this sector. There are superficially drained plots : • Limiting the residence time of water in the wetland • Decreasing biogeochemical functions of the wetland • Lowering the groundwater This area is slightly upland and usually not inundated. Many trees are already in place.	
EI_G_013	Subsistence agriculture occupies this sector with superficially drained plots as well as a football field.	

Sectors	Main observations	Photos
EI_G_014	Subsistence agriculture and wasteland occupy this sector. This area is upland and usually not inundated. Lots of trees are already in place.	
EI_G_015 EI_G_016	Natural area/brownfield partially disturbed by surface drainage. These areas are frequently inundated.	
Main branch		
EI_G_017	The recalibrated Rugenge River flows in this part, it does not allow overflow onto the plots during light rainfall. Evidence on the field has demonstrated that Rugenge River was recalibrated: constant depth, absence of meanders, regular slopes, presence of backfill, previous industrial area, and discussions with local users. The depth of the river contributes to wetland drainage. The depth of outfalls contributing to the lowering of the groundwater.	
EI_G_018	Urban discharges (stormwater and wastewater from roads and residential areas) are discharged directly into the wetland and river. The discharges impact water quality and increase bank/soil erosion. There is an important earth drain flowing parallel to the road collecting wastewater and runoff from the KN3 road.	

Sectors	Main observations	Photos
EI_G_019	Some urban discharges (stormwater and wastewater from roads and residential areas) are directly connected to the wetland and river Discharges impact water quality and increase bank/soil erosion. This area is impacted by important gullies and landslides.	
EI_G_020 EI_G_021 EI_G_022 EI_G_023	The former industrial areas (brownfield) contributed to soil pollution and infilling of the wetland Soils are compacted and degraded (earth mount, backfill, debris). Since the industrial area was removed, some informal agriculture is gaining grounds in the wetlands	

4.2.1 Rwampara

This narrow wetland is crossed by the Rwampara River which is characterized by its deeply incised canyon-like bed, the depth of the canyon is about 10-15 meters in its upstream area and gradually decreases moving downstream. Agriculture occupies most of the wetland. Moving downstream, Rwampara collects urban discharges through concrete canals. In its downstream area, a sport club occupies the wetland and Rwampara River is channelized in a gabion-reinforced earth canal.



FIGURE 4-12 RWAMPARA, CONCRETE CANAL DISCHARGING DIRECTLY IN THE RIVER AND CANYON

Characterization was made during the Site visit and sectors were delineated according to their dominant hydraulic and ecological features and their level of disturbance. These sectors are presented in the following figure and form the basis for the development of rehabilitation measures.



FIGURE 4-13 CHARACTERIZATION OF RWAMPARA

TABLE 4-2 MAIN OBSERVATIONS IN RWAMPARA

Sectors	Main observations	Photos
EI_Rw_001	Subsistence agriculture and wasteland occupy this sector. Some areas show important signs of erosion and landslides most of them are hazardous for people. The wetland is disconnected from the Rwampara River due to the important depth of the watercourse (10-15m from natural ground), which looks like a small canyon. Soil of plots bordering the river is partly degraded during floods. At the upstream end, two important urban discharges (stormwater and wastewater) are discharging into the wetland and Rwampara River. Discharges impact water quality, transport solid waste and increasing bank/soil erosion.	 
EI_Rw_002	A concrete canal crosses the wetland and convey stormwater and probably wastewater from local residents. The characteristics of the concrete canal does not allow the wetland to be fed during light rainfall as the discharge is directly in Rwampara River	

Sectors	Main observations	Photos
EI_Rw_003	Several concrete canals discharge stormwater and probably wastewater in the Rwampara River. Discharges impact water quality and increasing bank/soil erosion.	
EI_Rw_004 EI_Rw_005	Urban discharges (stormwater and wastewater) directly flowing into the wetland and Rwampara river Discharges impact water quality and increase bank/soil erosion	

Sectors	Main observations	Photos
EI_Rw_006	Subsistence agriculture occupies this sector. Rwampara river is recalibrated with gabions (after the KK4 Avenue) and positioned to ensure drainage and disconnection from the wetland. The river's characteristics do not allow the wetland to be fed during light rainfall Superficially drained plots impact the wetland by: • Limiting the residence time of water in the wetland • Decreasing biogeochemical functions of the wetland • Lowering the groundwater Some areas are under intense agricultural activity with sugar cane cultivation and banana. The wetland has low diversity of natural wetland habitats.	

4.2.1 Rugenge-Rwintare

Rugenge-Rwintare wetland is composed of two branches.

A western branch where Rugenge River flows which is occupied by earth backfill where land was reclaimed by removing buildings. A sedge meadow occupies the center of the wetland. Moving downstream, the area is occupied by plant vendors and horticulture.

An eastern branch occupied in its upstream area by agriculture and a downstream area where bamboo plantations dominate the landscape. Rwintare River flows in this area



FIGURE 4-14 RUGENGE-RWINTARE, WESTERN BRANCH



FIGURE 4-15 RUGENGE-RWINTARE, EASTERN BRANCH

Characterization was made during the Site visit and sectors were delineated according to their dominant hydraulic and ecological features and their level of disturbance. These sectors are presented in the following figure and form the basis for the development of rehabilitation measures.

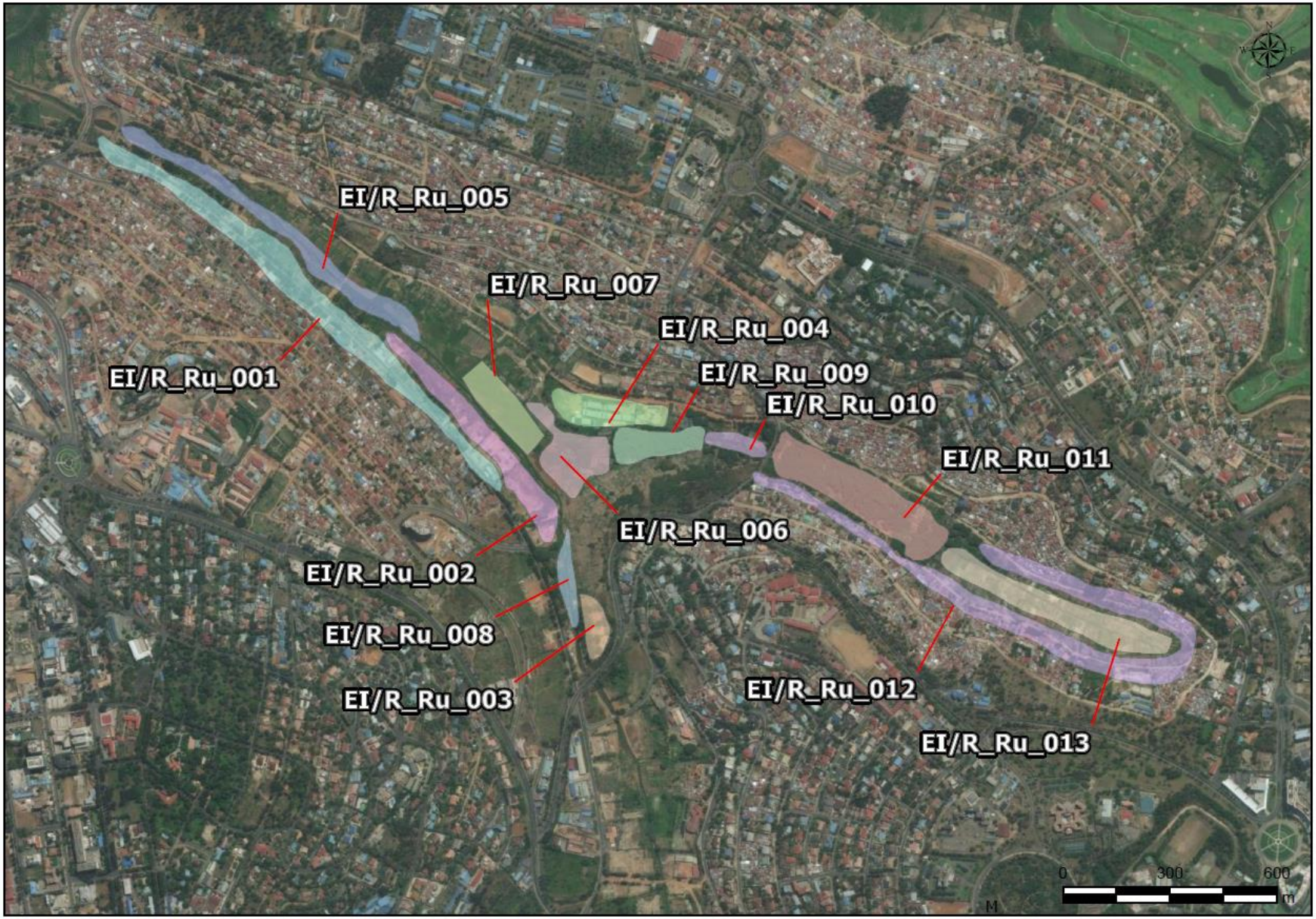


FIGURE 4-16 CHARACTERIZATION OF RUGENGE-RWINTARE

TABLE 4-3 MAIN OBSERVATIONS IN RUGENGE-RWINTARE

Sectors	Main observations	Photos
Western branch		
EI_Ru_001	Urban stormwater and wastewater are discharged directly into the wetland and river. Discharges impact water quality and increase bank/soil erosion. Important occupation by plant vendors and horticulture.	
EI_Ru_002	Former industrial areas (brownfield) that contributed to soil pollution and infilling of the wetland (embankments) leaving compacted and degraded soils Infilled wetland area (backfilled areas) limit floodplain expansion in periods of heavy rainfall Expansion of agriculture in this area. Superficially drained plots are : • Limiting the residence time of water in the wetland • Decreasing biogeochemical functions of the wetland • Lowering the groundwater	
EI_Ru_003	Formerly built-up areas (brownfield) that have contributed to the infilling of the wetland and soil compaction. Infilled wetland area (backfilled areas) limit floodplain expansion in periods of heavy rainfall	
EI_Ru_004	Former industrial areas that contributed to soil pollution and filling of the wetland Compacted and degraded soils requiring significant renaturation Backfilled areas limiting the floodplain in periods of heavy rainfall	

Sectors	Main observations	Photos
EI_Ru_005	Recalibrated Rugenge River does not allow overflow onto the plots during light rainfall. Evidence on the field has demonstrated that Rugenge River was recalibrated: constant depth, absence of meanders, regular slopes, presence of backfill and discussions with local users. Riverbanks are showing signs of erosion and bare soils. Depth of the river contributing to wetland drainage and to the lowering of the groundwater.	
EI_Ru_006	Subsistence agriculture occupies this sector.	
EI_Ru_007	Typical wetland natural habitat (sedge meadow). The botanical baseline study undertook a full plant inventory at this location and characterized the habitat (see botanical report in appendix 2). Organic pollution leading to a decrease in plant diversity	
EI_Ru_008	Recalibrated Rugenge River does not allow overflow onto the plots during light rainfall The depth of the river contributes to wetland drainage and to the lowering of the groundwater	

Sectors	Main observations	Photos
EI_Ru_009	Bamboo plantation crossed by Rwintare River with a deep profile. The riverbed shows significant erosion, and its depth contributes to wetland drainage	
EI_Ru_010	Minor riverbed with significant erosion. River depth contributing to wetland drainage. There is also a Bamboo plantation.	
Eastern branch		
EI_Ru_011	Bamboo plantation occupies this sector and is a significant feature of this area. Recalibrated Rwintare River shows significant erosion and does not allow overflow onto the plots during light rainfall. Evidence on the field has demonstrated that Rwintare River was recalibrated: constant depth, absence of meanders, regular slopes, presence of backfill, signs of erosion, and discussions with local users. The depth of the river contributes to wetland drainage.	

Sectors	Main observations	Photos
EI_Ru_012	Subsistence agriculture occupies this sector. Many small urban drains (stormwater and wastewater) are directly discharging into the wetland and Rwintare river Discharges impact water quality and increase bank/soil erosion	
EI_Ru_013	Subsistence agriculture occupies this sector. Superficially drained plots impact the wetland by: • Limiting the residence time of water in the wetland • Decreasing biogeochemical functions of the wetland • Lowering the groundwater	

4.2.1 Kibumba

Kibumba is composed of three branches:

A central branch, where Kibumba River flow and which is occupied by agriculture, fishponds and earth backfill where land was reclaimed by removing buildings. A textile factory occupies the area as well as other industrial activities. These will be relocated.

A small narrow northern branch of 6.5 ha entirely occupied by agriculture where dense webs of drainage ditches are present.

A southern branch of 20 ha where agriculture was recently abandoned, and wetland habitats have reclaimed the area. This area is also collecting important volume of runoff from the new residential area Vison 2000.



FIGURE 4-17 KIBUMBA, CENTRAL AREA



FIGURE 4-18 KIBUMBA, NORTHERN AREA



FIGURE 4-19 KIBUMBA, SOUTHERN AREA

Characterization was made during the Site visit and sectors were delineated according to their dominant hydraulic and ecological features and their level of disturbance. These sectors are presented in the following figure and form the basis for the development of rehabilitation measures.

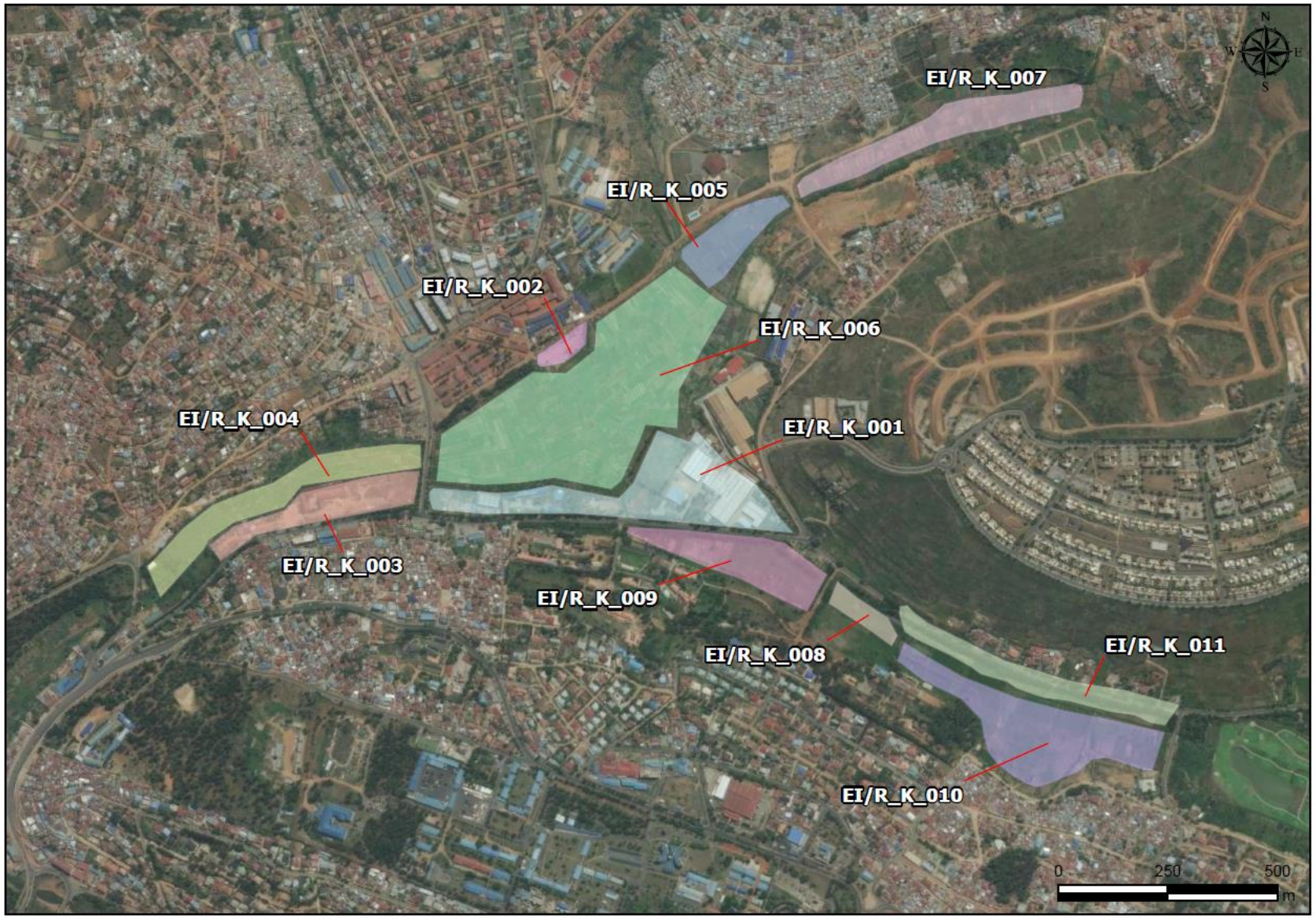


FIGURE 4-20 CHARACTERIZATION OF KIBUMBA

TABLE 4-4 MAIN OBSERVATIONS IN KIBUMBA

Sectors	Main observations	Photos
Central branch		
EI_K_001	A former industrial area (textile factory to be relocated) contributed to soil pollution and filling of the wetland as it was built on an embankment leading to compacted and degraded soils. Infilled wetland area (backfilled areas) limits the floodplain expansion in periods of heavy rainfall	
EI_K_002	A commercial and industrial area with small factories (wood and iron workshops and garages) and a parking place for trucks contributes to soil pollution and infilling of the wetland. It is located at the edge of the wetland. Infilled wetland area (backfilled areas) limits the floodplain expansion in periods of heavy rainfall	
EI_K_003	Warehouses with truck parking contribute to soil pollution and filling of the wetland (some activities are still taking place). It was built on an embankment leading to compacted and degraded soils.	

Sectors	Main observations	Photos
EI_K_004	Subsistence agriculture take place in this area. Superficially drained plots are contributing to: • Limiting the residence time of water in the wetland • Decreasing biogeochemical functions of the wetland • Lowering the groundwater • Intense agricultural activity with sugar cane cultivation Wetland with low diversity of natural wetland habitats	
EI_K_005	Several artificial ponds are used for fish farming.	
EI_K_006	Subsistence agriculture take place in this area. Superficially drained plots are contributing to: • Limiting the residence time of water in the wetland • Decreasing biogeochemical functions of the wetland • Lowering the groundwater Intense agricultural activity with sugar cane and maize cultivation, and some irrigation Wetland with low diversity of natural wetland habitats	
Northern branch		

Sectors	Main observations	Photos
EI_K_007	Subsistence agriculture take place in this area. Superficially drained plots are contributing to: • Limiting the residence time of water in the wetland • Decreasing biogeochemical functions of the wetland • Lowering the groundwater Intense agricultural activity with sugar cane and maize cultivation, and some irrigation Wetland with low diversity of natural wetland habitats.	
Southern branch		
EI_K_008	Typical wetland natural habitats dominated by carex (meadow). The botanical baseline study undertook a full plant inventory at this location and characterized the habitat (see botanical report in appendix 2). Part of the wetland in good conservation status. This area is marked by abandoned agriculture activities and abandoned fishponds.	
EI_K_009	The stream was diverted from the bottom of the thalweg to drain the wetland. There is a lack of connection of the river with the wetland during light rainfall. Degraded natural habitats, especially due to drying out of the wetland.	

Sectors	Main observations	Photos
EI_K_010	The stream was diverted from the bottom of the thalweg to drain the wetland. Evidence on the field has demonstrated this stream was diverted from its original Thalweg to drain the fields and collect road drainage. There is a lack of connection of the river with the wetland during light rainfall. Agricultural activity occupies part of this sector and is in the process to reclaim the entire wetland. Wetland with low diversity of natural wetland habitats.	
EI_K_011	Urban drain from Vision City Estate directly discharges stormwater into the wetland. Discharges impact water quality and increase bank/soil erosion Agricultural activity occupies part of this sector and is in the process to reclaim the wetland	

4.2.1 Nyabugogo Lower

Nyabugogo is intensively occupied by agriculture and an important pond is located in its center. Wet areas are cultivated for rice, the downstream part is occupied by sugar cane plantations and the upstream drier parts are cultivated for maize. The outlet of the wetland is the junction of the Nyabugogo River and the discharge of Mpazi channel. The wetland also receives important volume of urban runoffs.



FIGURE 4-21 NYABUGOGO RIVER AND MAIZE CULTIVATION



FIGURE 4-22 NYABUGOGO, URBAN DRAIN UNDER CONSTRUCTION



FIGURE 4-23 NYABUGOGO, RICE CULTURE IN WET AREAS

Characterization was made during the Site visit and sectors were delineated according to their dominant hydraulic and ecological features and their level of disturbance. These sectors are presented in the following figure and form the basis for the development of rehabilitation measures.

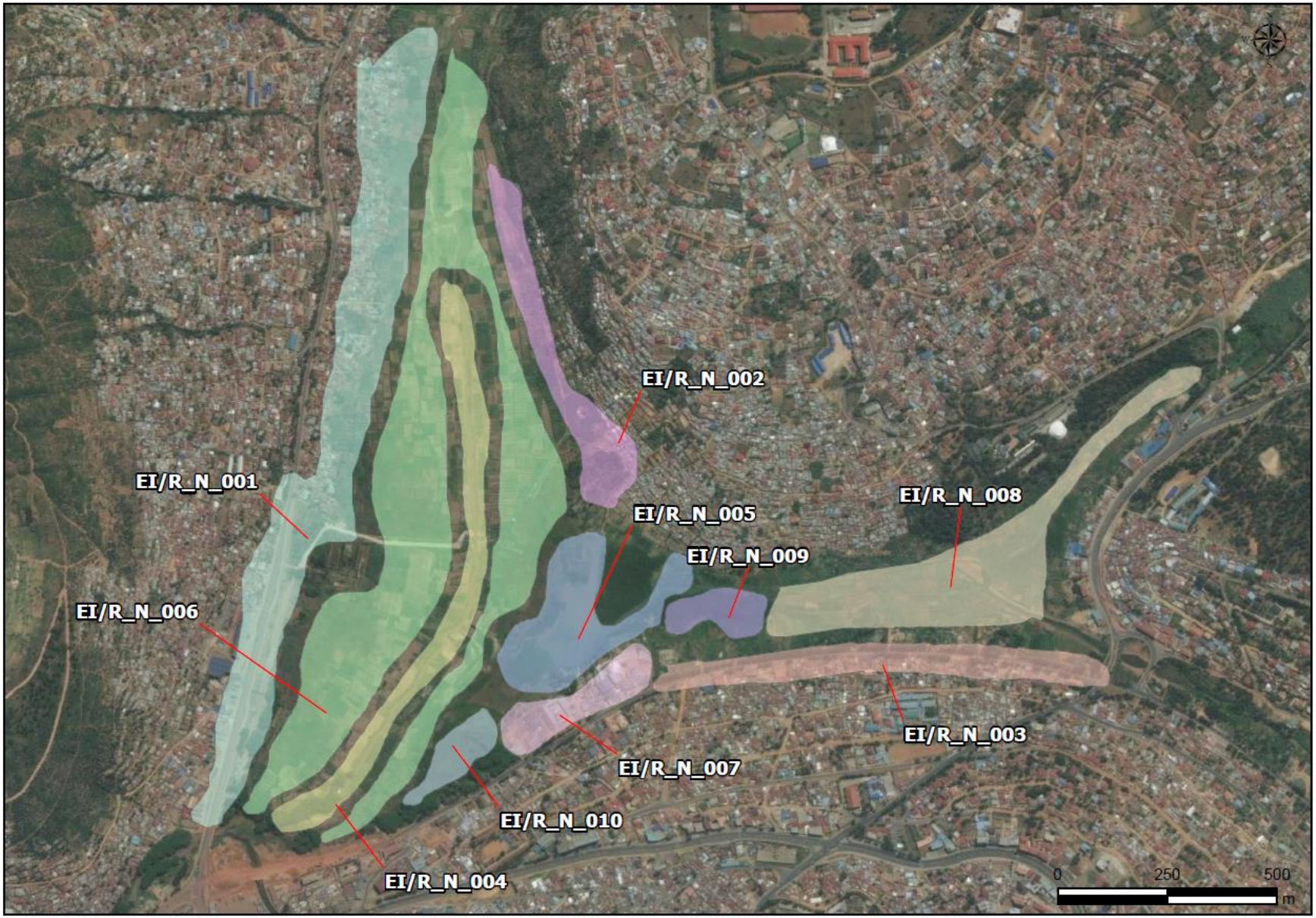


FIGURE 4-24 CHARACTERIZATION OF NYABUGOGO

TABLE 4-5 MAIN OBSERVATIONS IN NYABUGOGO

Sectors	Main observations	Photos
EI_N_001	Subsistence agriculture occupies this sector. Numerous important urban drains are discharging stormwater and wastewater directly into the wetland and Nyabugogo River on its right bank Discharges impact water quality and increase bank/soil erosion	
EI_N_002	One important urban drain is under construction to discharge stormwater (and potentially wastewater) directly into the wetland and river.	
EI_N_003	Numerous urban drains are discharging stormwater and wastewater directly into the wetland and Nyabugogo River on its right bank	

Sectors	Main observations	Photos
EI_N_004	The Nyabugogo River is recalibrated as this stage (in the downstream area) to increase drainage of the watershed for agriculture and reduce overflow during rainy periods. Evidence on the field has demonstrated that Nyabugogo River was recalibrated: constant depth, absence of meanders, regular slopes, presence of backfill, old imagery, and discussions with local users.	
EI_N_005	A large pond is located at the confluence between Nyabugogo River and Rwenzagoro River. It shows signs of important eutrophication and high-water hyacinth cover (invasive species). A small boat regularly ferries people across the pond. Rice is cultivated around the lake (fridges)	
EI_N_006	Subsistence agriculture occupies this sector. Intensive agriculture takes place in this area is well organized with maize in well drained areas and rice in wetter areas Superficially drained plots are impacting the wetland by : • Limiting the residence time of water in the wetland • Decreasing biogeochemical functions of the wetland • Lowering the groundwater The wetland has a low diversity of natural wetland habitats	
EI_N_007	Garages and workshops have contributed to soil pollution and filling of the wetland They have compacted and degraded soils Filled area limits the floodplain expansion in periods of heavy rainfall.	

Sectors	Main observations	Photos
EI_N_008	Subsistence agriculture occupies this sector along with wasteland. This sector is poorly organized as drainage is incomplete Rwenzagoro River is recalibrated to increase drainage of the watershed and reduce overflow during rainy periods Wetland has low diversity of natural wetland habitats	
EI_N_009	Natural habitats typical of wetlands with a presence of Papyrus Natural area to be conserved. The botanical baseline study undertook a full plant inventory at this location and characterized the habitat (see botanical report in appendix 2). Dominance of nitrophilous plant species, indicating eutrophication of the wetland. Organic pollution leading to a decrease in plant diversity.	
EI_N_010	Natural area to be preserved. The botanical baseline study undertook a full plant inventory at this location and characterized the habitat (see botanical report in appendix 2).	

4.3 RAPID INVENTORY OF UTILITY SERVICES

A meeting with WASAC has allowed to identify several water pipelines crossing the wetlands at several locations as shown in the following figure. In addition, there are three water treatment plants inside or close to the wetlands. These are presented in the next figure. In addition, during Detailed design, other utilities will be censused with concerned institutions. It is not expected that major constraints be identified.

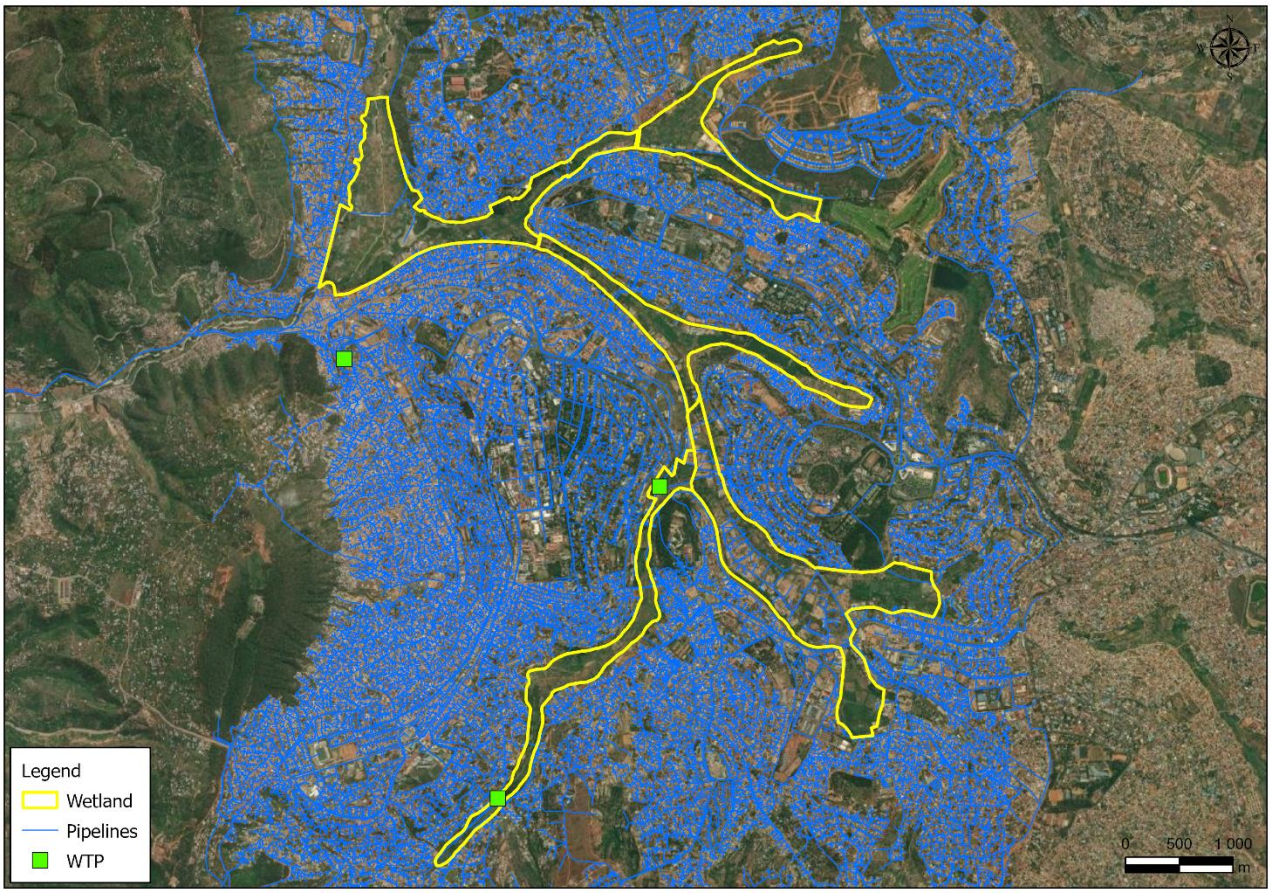


FIGURE 4-25 WATER PIPELINES AND WATER TREATMENT PLANTS

4.4 EXISTING THREATS AND PRESSURE ON THE WETLANDS

Currently, the wetlands are under different sources of stress, these were observed during site-visits, were informed by meetings with stakeholders and were well described in previous studies.

According to the report “Rwanda Wetlands Ecological Integrity Rapid Assessment Report” (ARCOS, 2019), the intensity of and frequency of threats ranks very high due to agricultural wastes dumping, urbanization, free access to wetland resources and exploitation and the overall level of conservation ranks low.

According to Macfarlane report (2020) “Preliminary Baseline Report: Wetlands targeted for rehabilitation under RUDP II, Nyabugogo was rated Largely Modified and Gikondo, Seriously Modified.

The following sections describe the various causes of degradation, some of which can be remediated through the rehabilitation projects and some of which will have to be address in the medium term by the government and urban planners to reduce pressure of the wetlands. The proposed rehabilitation scenarios are designed to acknowledge that not all causes of degradation will be solved in the short-term and that the wetlands will have to sustain in the long-term despite their presence. Proposed interventions are therefore also Nature-Based Solutions (NBS) that will seek to mitigate some causes of degradation.

4.4.1 Agriculture development and wetland resources exploitation

According to the "Economic Valuation of Ecosystem Services of Kigali City Wetlands Complex in Rwanda Final Report" (ARCOS, 2021), recent years have seen an increase in cropland with an increase of 38% from 2012 to 2018, while marshland have reduced to about 50% between 2012 and 2018.

Development of agriculture has led to multiple well documented impacts on wetlands:

- Drainage of the wetland with the construction of drainage furrows. Most of the wetland have in fact been so effectively drained and converted to cropland, the water retention times has significantly been reduced and wetlands no longer support a diverse wetland flora and fauna.
- Dumping of agriculture waste.
- Use of fertilizers, manure and pesticides which represent important nonpoint sources of pollution.
- Soil erosion due to large areas left with bare soils after harvest.

Fish farming is also present in the wetland, as well as bamboo plantation and plant vendors. These activities are also impacting the wetlands. For example, fish farming is impacting water quality and bamboo plantations are hindering the development of native plants.

Lastly, cattle grazing is taking place in some areas, destroying rivers banks at watering points and leading to soil compaction.

The significance of agriculture is further discussed at section 4.13 Livelihood activities in the wetlands.

4.4.2 Presence of industrial facilities

Industrial activities that were located inside the wetland (encroaching in the wetland) were progressively removed, such as the Gikondo industrial park. However, their removal has left the wetlands significantly modified and covered by wasteland and brownfield land with bare soil and ruderal plant species.

According to SMEC water quality survey, Thematic Report: Volume 2B Water Pollution and Water Quality Technical Support for Development of Wetland Master Plan for Kigali City (2019), Gikondo has a high level of pollution mainly from the now demolished Gikondo industrial park valley.

Other industries are still located in the watershed of the 5 wetlands and are some are probably still discharging pollutants in the wetlands.

In addition to industries, some garages, warehouses and workshops are located very close to the wetland are probably also contributing to pollution. For example, there are garages along the KN7 roads impacting Nyabugogo Lower wetland and steel workshops along the KG 695 street impacting Kibumba wetland.

NEMUS (2018) Detailed Management Plans for Gikondo and Nyabugogo Wetlands Systems has identified several pollution hotspots. Since this study, industrial facilities were removed from the wetlands, however some pollution hot spots were still present in 2022 during the consultant site-visit.

The following figures show the pollution hotspots as reported by NEMUS 2018 and adapted by the consultant.

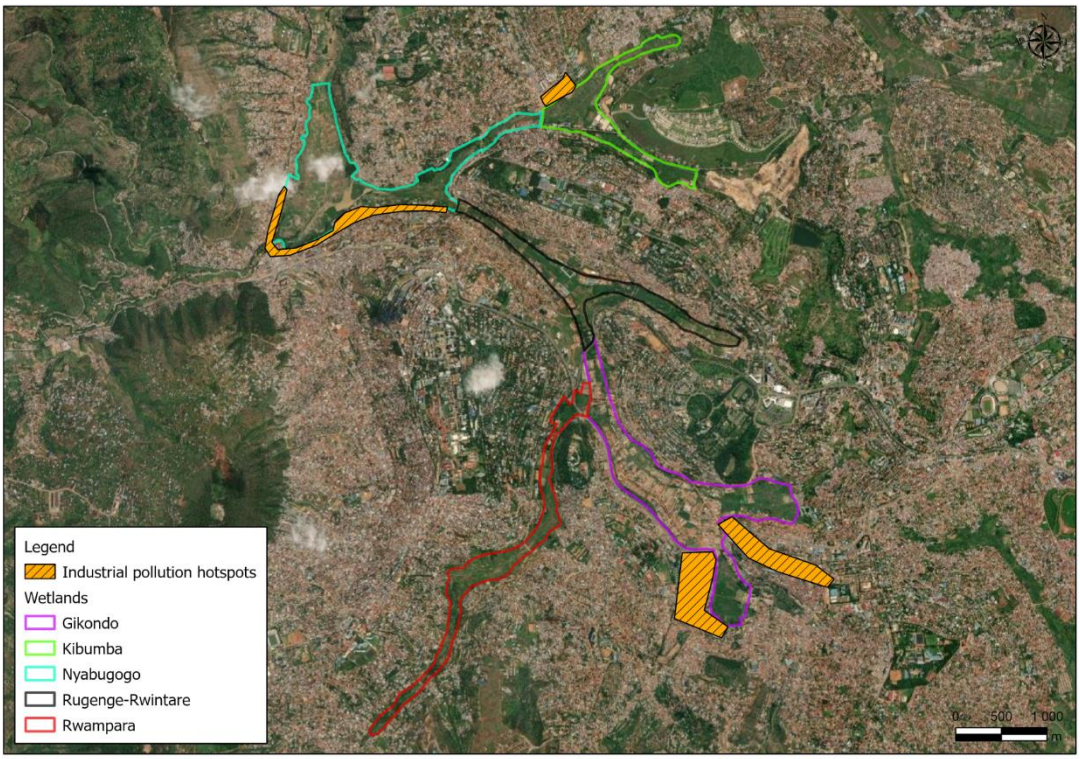


FIGURE 4-26 EXISTING POLLUTION HOTSPOTS

The presence of industrial and commercial facilities has probably left some sites contaminated. It is foreseen that all the old industrial areas contain contaminated soils. Macfarlane, World Bank (2020), suggested that in the Gikondo wetland there is approximately 42ha at high risk of historic soil contamination and a further 25ha of moderate risk. In the Nyabugogo wetland the estimates are for 9.5ha at high risk and 2.5ha of moderate risk. At Nyabugogo Lower there is more potentially contaminated soils from previous commercial and industrial activities in the Southern end of the wetland (where commercial and industrial activities took place).

4.4.3 Urbanization and wetland fragmentation

The City of Kigali has had a dramatic demographic growth between the late 70s and the early 90s. In a period of approximately 13 years the city went from a population of 698 442 inhabitants (1978) to 1 308 568 (1991). An exponential growth that continued up to recent times and that is bound to persist in the next decades. The images below illustrate the evolution of the built-up area of the city in the period of 1975, 1990 and 2015.

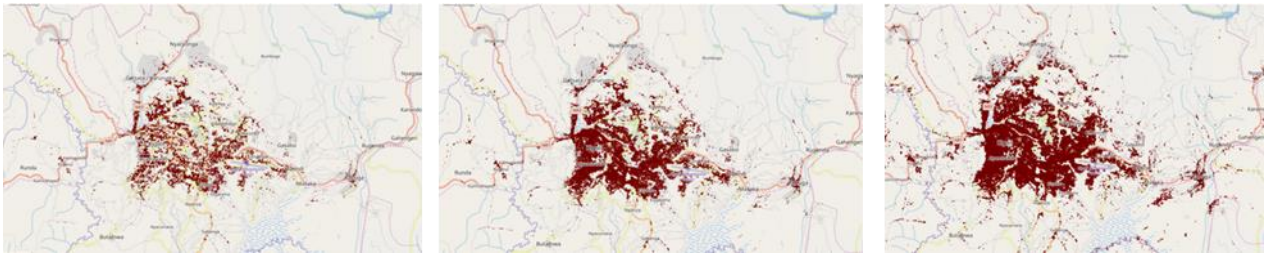


FIGURE 4-27 EVOLUTION OF COK FROM 1975 (LEFT), 1990 (CENTER) TO 2015 (RIGHT)

The exponential scale of population and built-up growth within very short periods of time, as in many other fast-growing cities in developing countries, lead to uncontrolled and concentrated urbanization and to the emergence of impoverished informal settlements. This is particularly true in the case of sensitive zones (natural flow areas, slopes, low zones, wetlands), as they are usually the only affordable and accessible space left to the poor in cities, where competition for land and profits is intense. A quick spatial analysis of the surrounding environment of the five wetland areas target by the project reveals a number of informal settlements located on the immediate borders of the perimeter of study.

The uncontrolled urban evolution combined with low economic capacity and constraining spatial characteristics puts a lot of pressure on the wetlands as they impose a dramatic increase in the demand for natural resources

and contribute to the degradation of the environment (impermeability of the soil increasing flood risk, lack of adequate sanitation that pollute rivers and water streams, elimination of natural green areas for building or agriculture and other forms of production, etc.).

The 5 wetlands are located in depressions surrounded by the city. They are fragmented due to the construction of roads and hydraulic infrastructures that have channelized flows and have reduced transparency and ecological continuity. Some of the hydraulic infrastructures such as concrete culverts are undersized reducing hydraulic transparency. Some buildings have encroached in the wetlands, some were built on earth embankments and surrounded by walls. Today, even if most of them were demolished, earth embankments have remained.

According to the report “Rwanda Wetlands Ecological Integrity Rapid Assessment Report” (ARCOS, 2019), habitats connectivity of the city’s wetlands rank low since natural vegetation has been altered in most areas and the wetlands are highly fragmented.

4.4.4 The wetlands are located in highly reactive watersheds

The wetlands are all located in depressions, downhill and downstream of densely urbanize areas and receive stormwater and surface runoff from highly reactive watersheds that can transport high volumes of water, sediments and solid wastes into the wetlands.

Solid waste disposal was reported in Nyabugogo where individuals burn tires within the wetland, causing pollution to the soil and water.

4.4.5 Discharges into the wetlands

The wetlands are receiving large amount of polluted water from urban discharges from road and urban drains discharging surface runoff, stormwater and untreated wastewater from both domestic and industrial sources. Lack of separation between stormwater and wastewater is another issue affecting the wetlands as highlighted in the Kigali Master Plan.

4.4.6 Past interventions in the wetlands

All riverbeds in the wetland system were channelized and reprofiled to convey flood water faster, and to drain land for agriculture. Important channels were dug to connect urban drains with reprofiled rivers. Most parts of the rivers that flows in the wetlands are no longer natural in shape and do no longer have natural floodplains. The large pond at the southern part of Nyabugogo is the results of a diversion channel, diverting water from the Nyabugogo River that was dug to drain the frequently left bank side of Nyabugogo floodplain.



FIGURE 4-28 ORIGIN OF THE POND IN NYABUGOGO

4.4.7 Other threats

Other threats are worth noting:

- Invasive and exotic plant species. in Nyabugogo Lower, the water hyacinth (Eichhornia crassipes) has invaded the pond.
- Unsustainable use of surface water. According to NEMUS, Detailed Management Plans for the Gikondo and Nyabugogo Wetlands Systems (2018), surface water in the Gikondo and Nyabugogo is mainly used for agricultural purposes, drinking for grazing animals and bathing/recreational use. Surface water is also used for washing vehicles, bicycles and motorcycles, as well as collection of water for construction purposes and washing clothes.
- Erosion of soil and wetlands banks, which is a consequence of several factors mentioned above. Many areas are depleted from vegetation (are in fact wasteland) mainly in Gikondo. This issue is highlighted in the Kigali Master Plan. At several locations in Gikondo, banks are highly erodible, and several gullies can easily be observed. Some houses are also at risk as shown in the following figure.



FIGURE 4-29 IMPORTANT BANK EROSION IN GIKONDO

4.5 LAND USE AND TENURE ANALYSIS AND ZONING REGULATION IN THE WETLANDS

4.5.1 Objectives

This section briefly analyses the land use and tenure and zoning in the wetland.

4.5.2 Method

The characterization of land use and tenure and zoning of the wetlands is based on ground truthing and consultation of the Kigali City Master Plan. The Kigali City Master Plan and its wetland master plan are key reference documents that inform all future proposed interventions, and the outcome of the project shall be in conformity with the zoning regulations proposed by these master plans.

4.5.3 Results

An important feature of the 5 wetlands is that these were extensively occupied by settlements, businesses and industries until recently. In 2019, the Gikondo industrial park was relocated to the SEZ, houses, buildings, schools and shops that were built in the wetlands were also removed. Today, most have been removed while embankments are left unoccupied. The following figure shows an example of the extent of this vast intervention in the wetlands.



FIGURE 4-30 SHOPS AND INDUSTRIES LOCATED IN NYABUGOGO IN 2018



FIGURE 4-31 NYABUGOGO IN 2020



FIGURE 4-32 SCHOOL IN RUGENGE-RWINTARE WETLAND IN 2017



FIGURE 4-33 RUGENGE-RWINTARE IN 2020 WITHOUT THE SCHOOL

According to the report “Rwanda Wetland Biodiversity Status Report. Technical Report” (ARCOS, 2021), the 5 wetlands under study are part of the City of Kigali Wetland Complex, covering 7,838.2 ha distributed in in 4 main classes:

- Agricultural land covering about 2,808.3 ha
- Natural vegetation covering about 2,763.4 ha
- Water body covering about 308.1 ha
- Other land use covering about 1,958.4 ha

The 5 wetlands only cover very small surface of this complex and are proportionally more utilized for agriculture and have less surface of natural vegetation. The following figure shows the position of the 5 wetlands with regard to the CoK Wetland Complex.

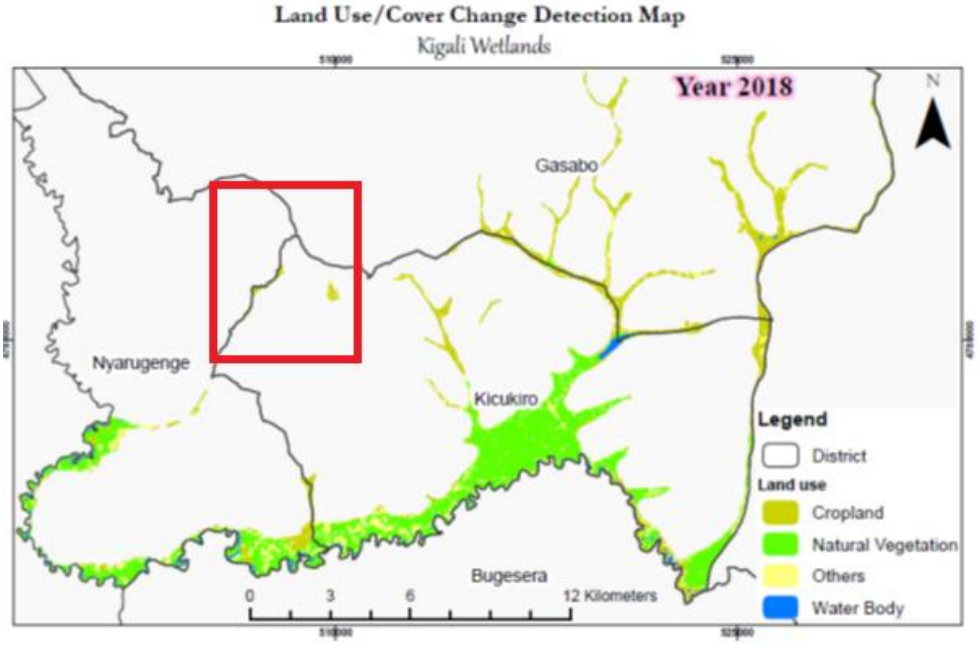


FIGURE 4-34 COK WETLAND COMPLEX

According to the "Economic Valuation of Ecosystem Services of Kigali City Wetlands Complex in Rwanda Final Report" (ARCOS, 2021), recent years have seen an increase in cropland with an increase of 38% from 2012 to 2018, while marshland have reduced to about 50% between 2012 and 2018.

Based on field surveys from the consultant, remnant wetlands still exist, but these cover insignificant portion of the 5 wetlands estimated at about 25 ha (about 5% of the total surface of the 5 wetlands). Large parts of the wetlands are occupied by informal agriculture.

Zoning regulation in the wetlands

The zoning regulation of the Kigali Master Plan 2020 Edition shows that the city's wetlands are classified according to 5 zones.

- W1 - Buffer Zone
- W2 - Rehabilitation Zone
- W3 - Sustainable Exploitation Zone
- W4 - Conservation Zone
- W5 - Recreational Zone

W1 - Buffer Zone

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

Even if Buffer Zone are presented in the zoning regulation, there is no delineation of buffer zones in the interactive map of the Kigali City Master plan. Fringes of wetlands are rather demarcated with a green buffer area classified as Parks and Open Spaces Zone (P1). As per the organic law, all wetlands and natural water bodies need to be provided with 20m buffer which is restrained from development (Kigali Master Plan, 2020).

W2 - Rehabilitation Zone

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

W3 - Sustainable Exploitation Zone

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

W4 - Conservation Zone

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

W5 - Recreational

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

The following figures show the zoning classification for the City's wetland complex and in the study area.

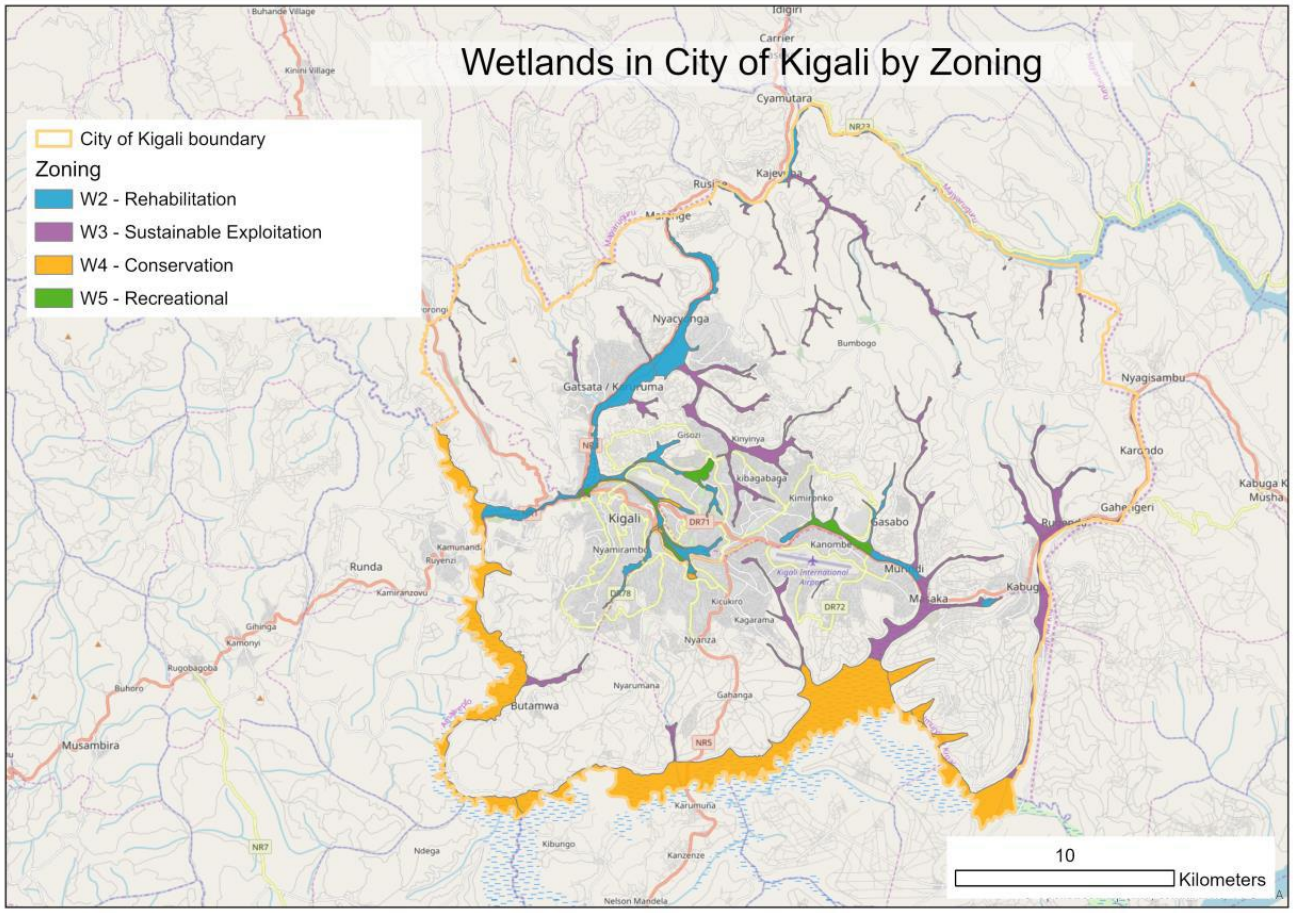


FIGURE 4-35 ZONING IN THE COK WETLAND COMPLEX

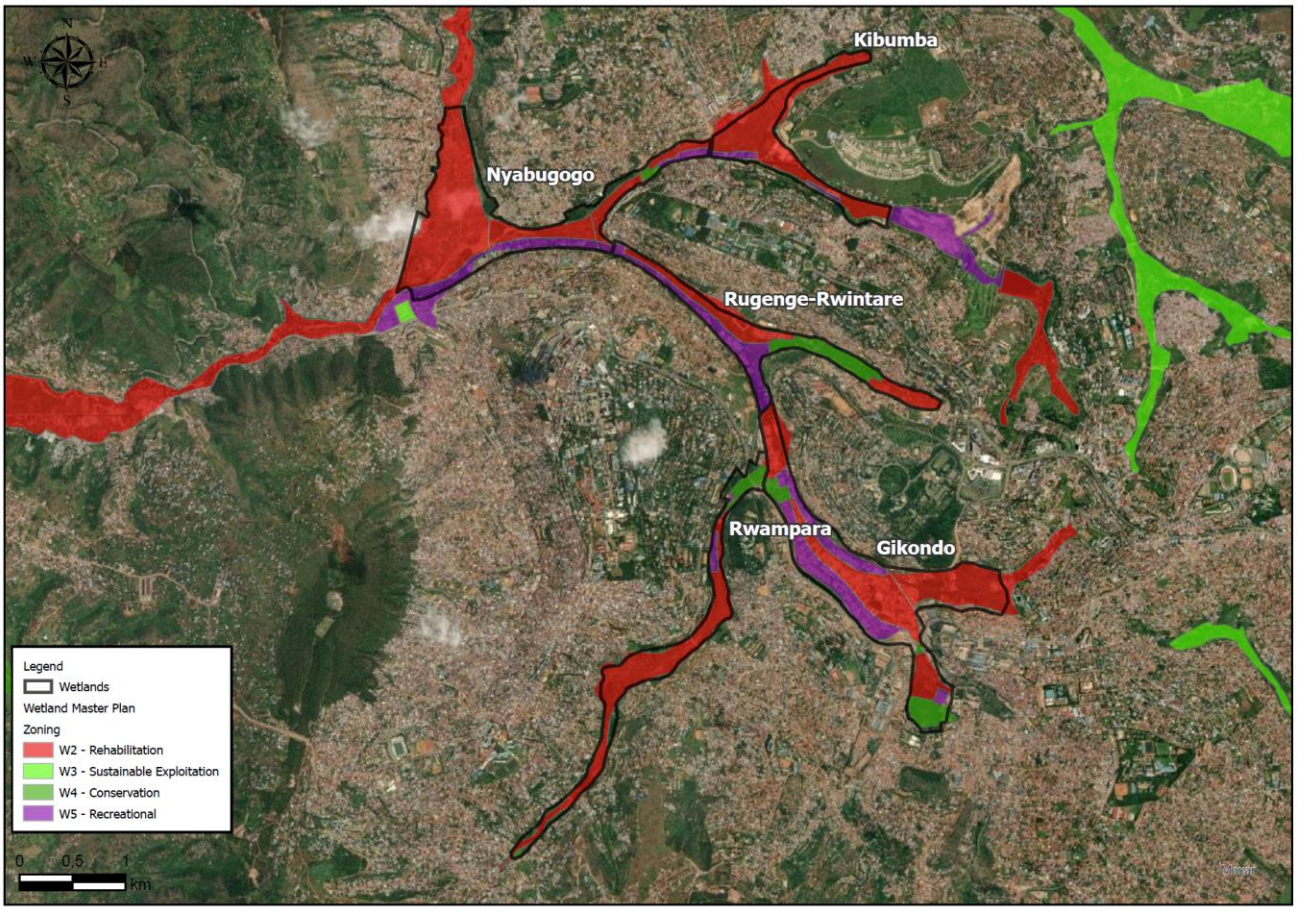


FIGURE 4-36 ZONING IN THE 5 WETLANDS

Activities in each of the zones are regulated and the zoning regulations present authorized and prohibited activities. The complete set of regulations can be consulted in the Zoning regulation. Some regulations are worth noting because of their implication in the development of rehabilitation scenarios:

In the W-2 Rehabilitation Zone:

- Agriculture and clay extraction are to be phased out (however the Zoning-Land-use Matrix mentions that they could continue if an Environmental and Social Impact Assessment (ESIA) is submitted, and a permission granted).
- Stormwater drainage cannot be discharged without creating artificial wetlands.
- There is a prohibition to use pesticides in surrounding agricultural land.
- Drainage channels and ditches must be filled-up to the level of wetland surface.
- Fishponds have to be converted into stormwater retention ponds.

In the W-3 Sustainable Exploitation Zone:

- Agriculture use may continue provided it complies with ESIA provisions.
- Drainage channels and ditches must be filled-up to the level of wetland surface.

In the W-4 Conservation Zone:

- Agriculture is prohibited
- Stormwater drainage cannot be discharged without creating artificial wetlands.
- Stormwater outlets to have an erosion control design so wetland is not impacted.
- There is a prohibition to use pesticides in surrounding agricultural land.
- Drainage channels and ditches must be filled-up to the level of wetland surface.

In the W-5 Recreational Zone:

- Bio-swales are permissible (constructed wetland to allow water to infiltrate in the ground)
- Any non-habitable structure constructed with organic building materials is permissible.

The regulations also refer to the Zoning-Land-use Matrix to determine which land use is allowed with conditions (C) and which one is prohibited (P). Allowed with conditions implies that an Environmental and Social Impact Assessment (ESIA) is submitted before an authority grants permission. Agriculture in the wetland is mainly informal covering very small parcels. These activities, outside of wetlands, are normally not subject to Environmental and Social Impact Assessment (ESIA) and farmers using informally wetlands for agriculture do not submit ESIA since such requirement small landowners to continue its activity is a major constraint. The Zoning regulation refers to the Ministerial Order N°004/2008 OF 15/08/2008 that mentions that "*agricultural and breeding activities which use chemical fertilizers and pesticides in wetlands and large scale monoculture agricultural practices such as tea, coffee, flowers and pyrethrum, etc*" are subject to an ESIA study.

Traditional livelihood activities are concerned by this matrix as show in the following extract.

Table 6.27: Land-use permitted within wetland zones (C = Conditional; P = Prohibited)

PREDOMINANT LAND-USE	W1 BUFFER ZONE	W2 REHABILITATION ZONE	W3 SUSTAINABLE EXPLOITATION ZONE	W4 CONSERVATION ZONE	W5 RECREATIONAL
Farming or horticulture	C	C	C	P	C
Fish farming	C	P	C	P	P
Grazing	C	P	C	P	P
Livestock farming	C	P	C	P	P
Plantation or nursery	C	C	C	C	C

FIGURE 4-37 EXTRACT OF THE ZONING-LAND-USE MATRIX

Accordingly, for agriculture activities to continue in the wetlands, farmers would have to switch to organic farming, avoid digging drains, and would have to form large cooperatives with sufficient means to submit an ESIA.

4.5.3.1 Gikondo

Gikondo is located in both the Kicukiro and Gasabo districts.

In Gikondo, agriculture is marginal, covering about 14%, mainly in the southern branch of the wetland as shown in the following table.

TABLE 4-6 PERCENTAGE OF AGRICULTURE IN GIKONDO

	Total area	**Agriculture (including bamboo plantation, horticulture and aquaculture)**		**Wasteland and brownfield land (including infrastructure and building) and remnant wetlands**	
		Total surface	Percentage of the wetland	Total surface	Percentage of the wetland
Gikondo	162 ha	22.5 ha	14 %	139.5 ha	86 %
Total for the 5 wetlands	**489 ha**	**210.5 ha**	**43 %**	**278.5 ha**	**57 %**

According to the consultant's baseline assessment of agriculture activities (see report in appendix 3), most of the land in the Gatenga tributary arm (southern branch) is within the property of the Gatenga Youth Center (Catholic Church) and that land is leased to private businesses for agriculture production. Most agriculture is the southern branch (at the Gatenga tributary arm), there are individual farmers as well as some small agribusiness.

According to the Kigali City Master Plan 2020:

- W-2 Rehabilitation Zones: cover 55% of the wetland, all current agricultural activities take place in this zone.
- W-3 Sustainable Exploitation Zones: there is no W-3 zone in Gikondo.
- W-4 Conservation Zones: cover 11% of the wetland.
- W-5 Recreational Zones: cover 34% of the wetland.

The following figure shows the zoning of Gikondo wetland according to the Kigali City Master Plan 2020.

Rehabilitation actions were superimposed with the zoning regulation of the city to confirm the compliance of these actions with the City Master Plan (see chapter 5.8).

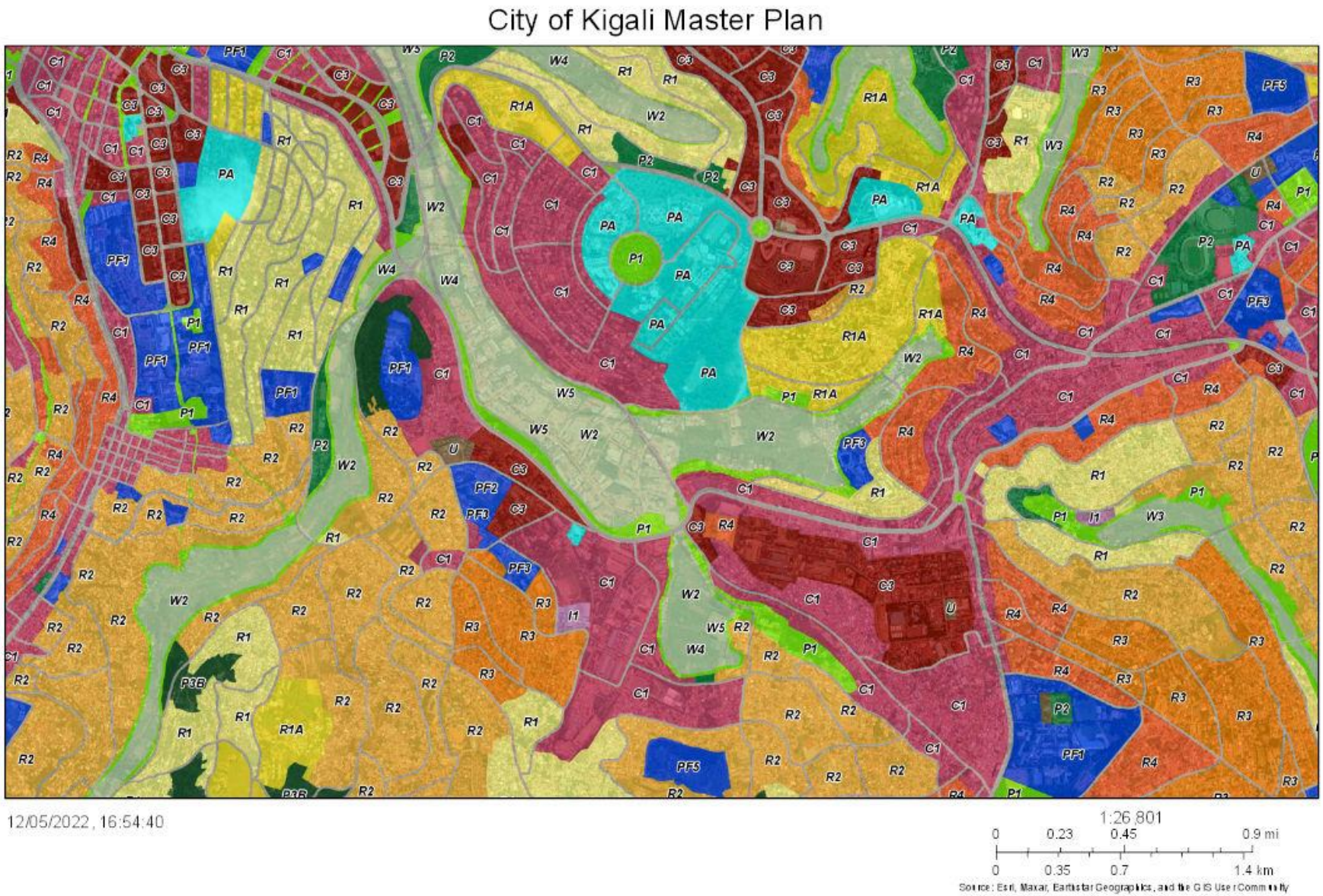


FIGURE 4-38 ZONING OF GIKONDO

Kigali City Master Plan has detailed the city's objectives for Gikondo Wetland and has established that the wetland's surroundings will be mainly occupied by recreational, residential, and commercial uses.

4.5.3.2 Rwampara

Rwampara wetland is located in both Nyarugenge and Kicuriko districts.

TABLE 4-7 PERCENTAGE OF AGRICULTURE IN RWAMPARA

	Total area	**Agriculture (including bamboo plantation, horticulture and aquaculture)**		**Wasteland and brownfield land (including infrastructure and building) and remnant wetlands**	
		Total surface	Percentage of the wetland	Total surface	Percentage of the wetland
Rwampara	65 ha	33 ha	51 %	30 ha	48 %
Total for the 5 wetlands	**489 ha**	**210.5 ha**	**43 %**	**278.5 ha**	**57 %**

According to the consultant's baseline assessment of agriculture activities (see report in appendix 3), Rwampara wetland started to be exploited for agriculture production in 1998. There are four cooperatives cultivating 10,8 ha in the wetlands, the rest is occupied by individual farmers. These four cooperatives of farmers have no concession agreement and pay no tax to the state. They use the wetland by the approval of local authorities, and the City of Kigali. Other individual users continue to cultivate their land left after undergoing resettlement in 2019 for the protection of the wetlands.

According to the Kigali City Master Plan 2020:

- W-2 Rehabilitation Zones: cover 91% of the wetland, all current agricultural activities take place in this zone.
- W-3 Sustainable Exploitation Zone: there is no W-3 zone
- W-4 Conservation Zones: cover 4% of the wetland
- W-5 Recreational Zones: cover 5 % of the wetland (these are existing football fields).

The following figure shows the zoning of Rwampara wetland according to the Kigali City Master Plan 2020.

Rehabilitation actions were superimposed with the zoning regulation of the city to confirm the compliance of these actions with the City Master Plan (see chapter 5.8).



FIGURE 4-39 ZONING OF RWAMPARA

4.5.3.3 Rugenge-Rwintare

Rugenge-Rwintare is located in both the Nyarugenge and Gasabo districts.

TABLE 4-8 PERCENTAGE OF AGRICULTURE IN RUGENGE-RWINTARE

	Total area	**Agriculture (including bamboo plantation, horticulture and aquaculture)**		**Wasteland and brownfield land (including infrastructure and building) and remnant wetlands**	
		Total surface	Percentage of the wetland	Total surface	Percentage of the wetland
Rugenge-Rwintare	65 ha	33 ha Including 13.2 ha of bamboo plantation	57 %	32 ha	43 %
Total for the 5 wetlands	**489 ha**	**210.5 ha**	**43 %**	**278.5 ha**	**57 %**

According to the consultant's baseline assessment of agriculture activities (see report in appendix 3), there are 8 agricultural cooperatives in Rugenge-Rwintare wetland occupying about 26 ha and there are also individual farmers involved in subsistence agriculture. Many cooperatives are plant nurseries. There is also one bamboo cooperative. Peat extraction is practiced in the wetlands and some farmers are involved in fodder production.

Individual citizens had land titles in Rugenge-Rwintare wetlands, and anyone who wanted to use the land mostly for trees and ornamental plants was supposed to pay rental fees to landowners. After relocation of houses and business done by the city of Kigali in 2019, people started to group themselves under cooperatives and request the working authorization from sectors free of rental fee.

According to the Kigali City Master Plan 2020:

- W-2 Rehabilitation Zones: cover 47% of the wetland. All agricultural activities take place in this zone.
- W-3 Sustainable Exploitation Zone: there is no W-3 zone
- W-4 Conservation Zones: cover 23% of the wetland. All bamboo plantations are located in this zone
- W-5 Recreational Zones: cover 29% of the wetland (these are existing football fields.

The following figure shows the zoning of Rugenge-Rwintare wetland according to the Kigali City Master Plan 2020.

Rehabilitation actions were superimposed with the zoning regulation of the city to confirm the compliance of these actions with the City Master Plan (see chapter 5.8).

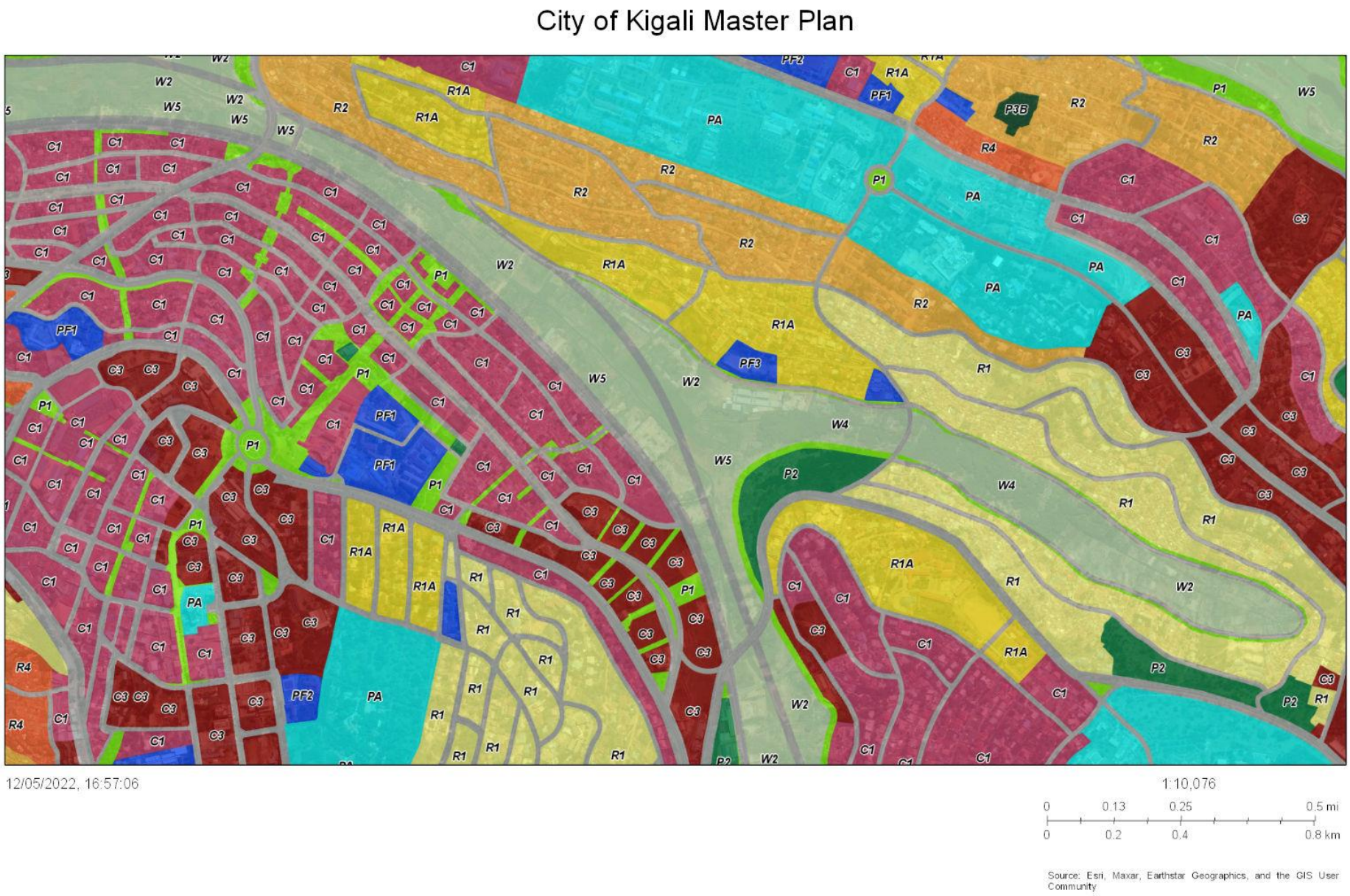


FIGURE 4-40 ZONING OF RUGENGE-RWINTARE

4.5.3.4 Kibumba

Kibumba wetland is located in Gasabo district.

TABLE 4-9 PERCENTAGE OF AGRICULTURE IN KIBUMBA

	Total area	**Agriculture (including bamboo plantation, horticulture and aquaculture)**		**Wasteland and brownfield land (including infrastructure and building) and remnant wetlands**	
		Total surface	Percentage of the wetland	Total surface	Percentage of the wetland
Kibumba	68 ha	34 ha	50 %	34 ha	50 %
Total for the 5 wetlands	**489 ha**	**210.5 ha**	**43 %**	**278.5 ha**	**57 %**

According to the consultant's baseline assessment of agriculture activities (see report in appendix 3), the Kibumba wetland was exploited by smallholder farmers, who gradually organized themselves into farmers' groups until they joined the large KOABIGA Cooperative in 2017.

According to the Kigali City Master Plan 2020:

- W-2 Rehabilitation Zones: cover 89% of the wetland. All agricultural activities take place in this zone.
- W-3 Sustainable Exploitation Zone: there is no W-3 zone
- W-4 Conservation Zones: cover 2% of the wetland
- W-5 Recreational Zones: cover 9% of the wetland

The following figure shows the zoning of Rugenge-Rwintare wetland according to the Kigali City Master Plan 2020.

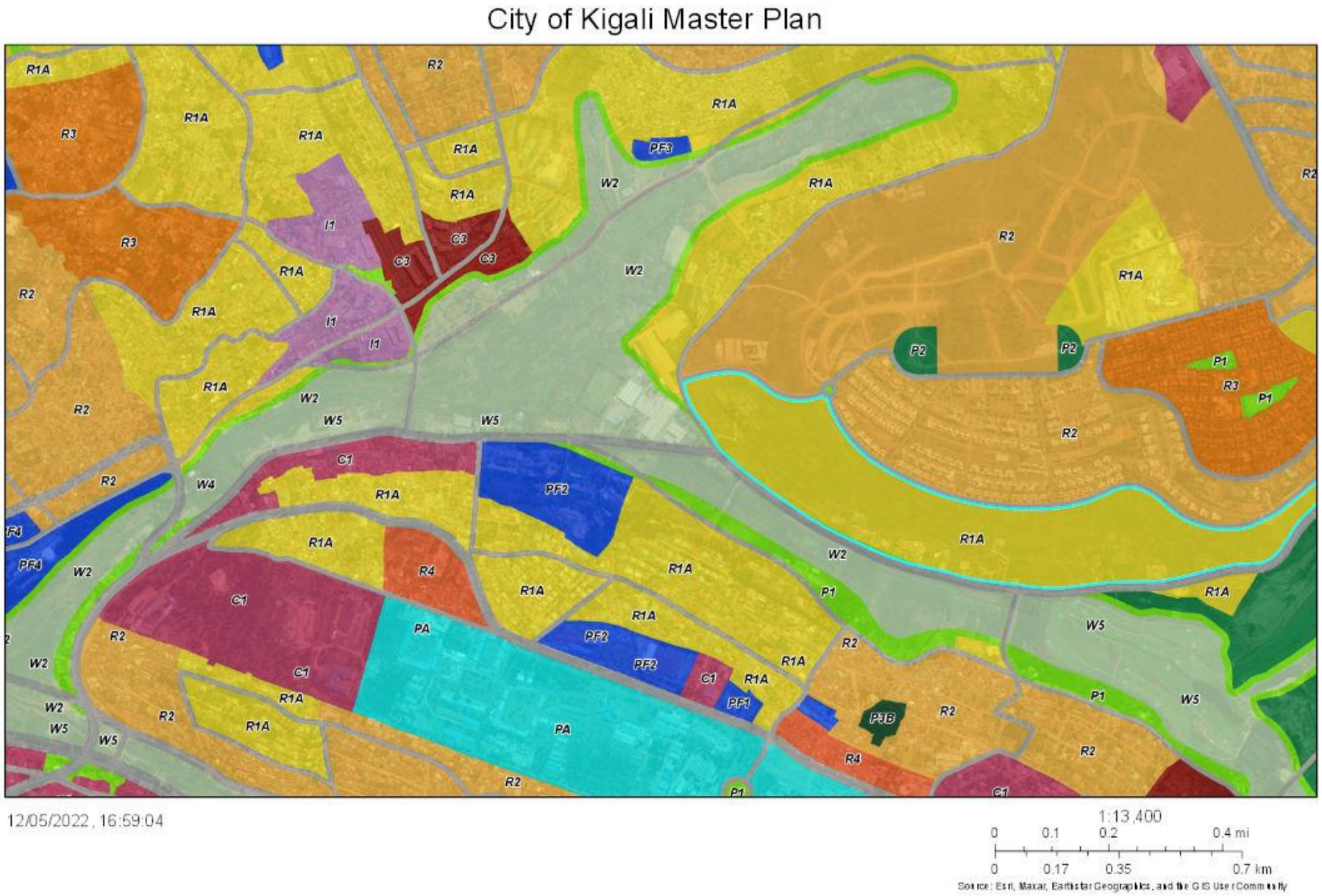


FIGURE 4-41 ZONING IN KIBUMBA

4.5.3.5 Nyabugogo lower

Nyabugogo Lower wetland is located in both the Nyarugenge and Gasabo districts.

TABLE 4-10 PERCENTAGE OF AGRICULTURE IN NYABUGOGO

	Total area	**Agriculture (including bamboo plantation, horticulture and aquaculture)**		**Wasteland and brownfield land (including infrastructure and building) and remnant wetlands**	
		Total surface	Percentage of the wetland	Total surface	Percentage of the wetland
Nyabugogo	131 ha	84 ha	64 %	47 ha	36 %
Total for the 5 wetlands	**489 ha**	**210.5 ha**	**43 %**	**278.5 ha**	**57 %**

According to the consultant's baseline assessment of agriculture activities (see report in appendix 3), rice cultivation was introduced in the main Nyabugogo wetland (Kabuye) in 1962, under the responsibility of the Ministry of Agriculture. The scheme was later transferred to a public entity Soproriz until 2003 and then to cooperatives. CORIKA is the rice producers' cooperative in the main Nyabugogo wetland, whereas farmers in the lower Nyabugogo are organized into the KOPRORIKI Cooperative for the production of maize and vegetables. Other cooperatives include ornamental plant growers and nurseries.

In addition to growing rice, individual farmers in Nyabugogo wetland are cultivating sugar cane, especially in zones not suitable to rice due to flooding or lack of adequate irrigation system. Some parts of the wetland are also used to grow seasonal crops (maize) and vegetables.

Nyabugogo Wetland was covered by papyrus in the past, and people from neighborhood committed to turn bushes of papyrus into an agricultural land for tomatoes, fruits and vegetables, rice and sugar canes. In 2013, the Rwanda Cooperative Agency sensitized wetland users to work under cooperatives and they submitted documents for a permit, and they now have a temporally working permit. Still cooperatives are using the land free of land rental fees.

According to the Kigali City Master Plan 2020:

- W-2 Rehabilitation Zones: covers 83% of the wetland. All agricultural activities take place in this zone.
- W-3 Sustainable Exploitation Zones: there is no W-3 zone
- W-4 Conservation Zone: there is no W-4 zone
- W-5 Recreational Zones: covers 17% of the wetland

The following figure shows the zoning of Nyabugogo wetland according to the Kigali City Master Plan 2020.

Rehabilitation actions were superimposed with the zoning regulation of the city to confirm the compliance of these actions with the City Master Plan (see chapter 5.8).

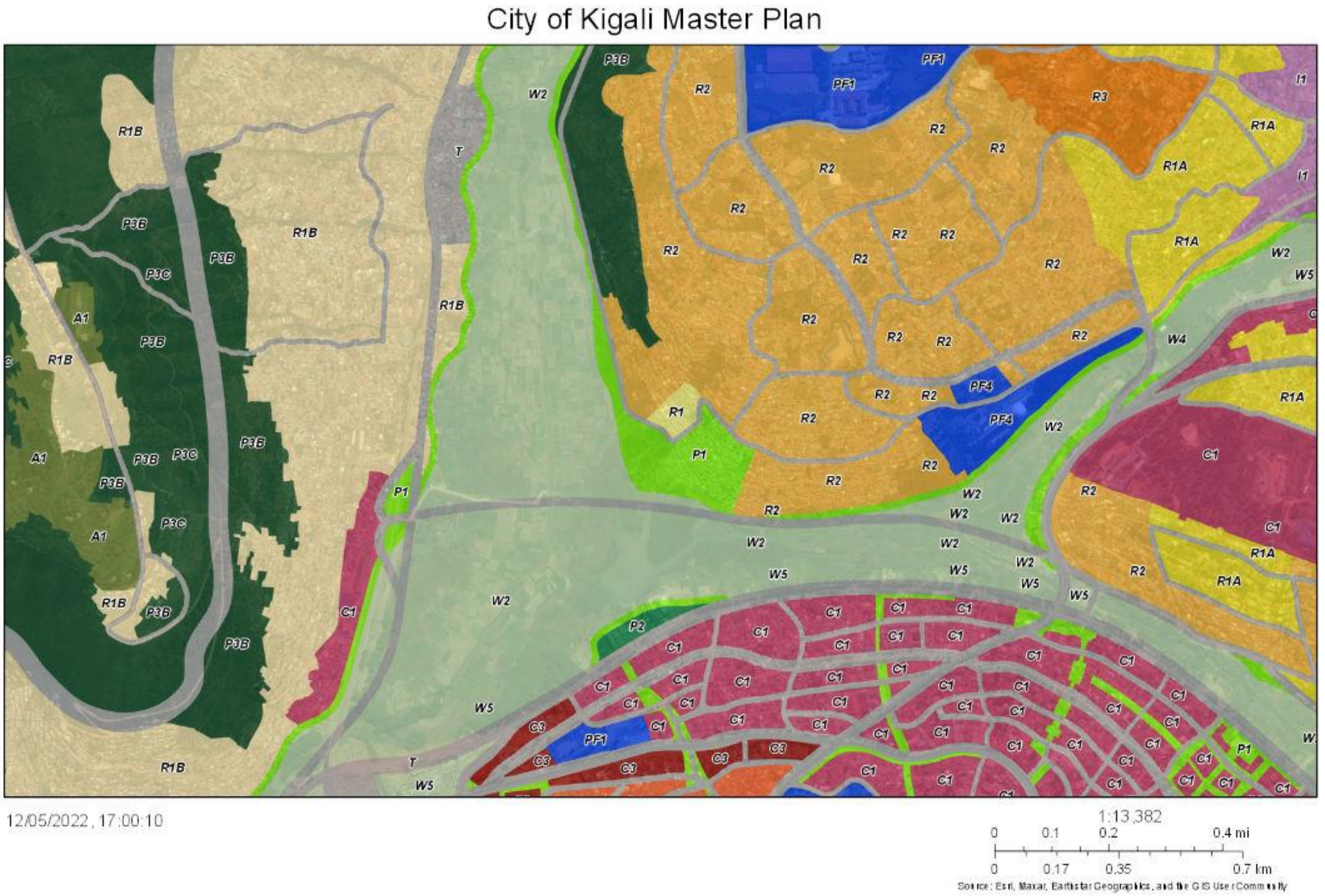


FIGURE 4-42 ZONING IN NYABUGOGO

Kigali City Master Plan has detailed the city's objectives for Nyabugogo Wetland which is to replace livelihood activities by nature and recreational areas according to The Kigali City Master Plan. In addition, the City Master Plan has also proposed the Nyarugenge Urban Design, which is a wetland front that will concern the southern part of Nyabugogo wetland.

4.5.4 Conclusion

Zoning regulation and the City's Master Plan have defined zoning in the wetlands according to 5 categories (W1 to 5). However, land occupation is different, as there are still many livelihood activities taking place in the wetlands, although these are identified as "non compatible" with the zoning regulation. Most of the encroachment by commercial and industrial infrastructures have been recently addressed, however there are still some warehouses, garages and other activities taking place along the fringes of the wetland. They will probably be resettled soon as well.

The presence of intensive agriculture, some of which is organized in cooperatives (as described in section 4.13) renders the rehabilitation project more complex and was acknowledged in the development of rehabilitation scenarios.

4.6 TOPOGRAPHIC ASSESSMENT

The topographic assessment will rely on:

- Additional geotechnical surveys for each planned feature,
- The LIDAR (Pixel size of 0.5 m x 0.5 m),

Topographical maps will be produced at the detailed design phase for each of the planned feature (after validation of their location by the Client). The 5 wetlands extend are covered by the LIDAR collected from CHARIS. Being defined at an 0.5 m x 0.5 m pixel accuracy, the LIDAR gives a great and precise information on the terrain elevation. Below is an example of elevation information extracted from the LIDAR for a part of Gikondo wetland (at the KK 1 road Ave).

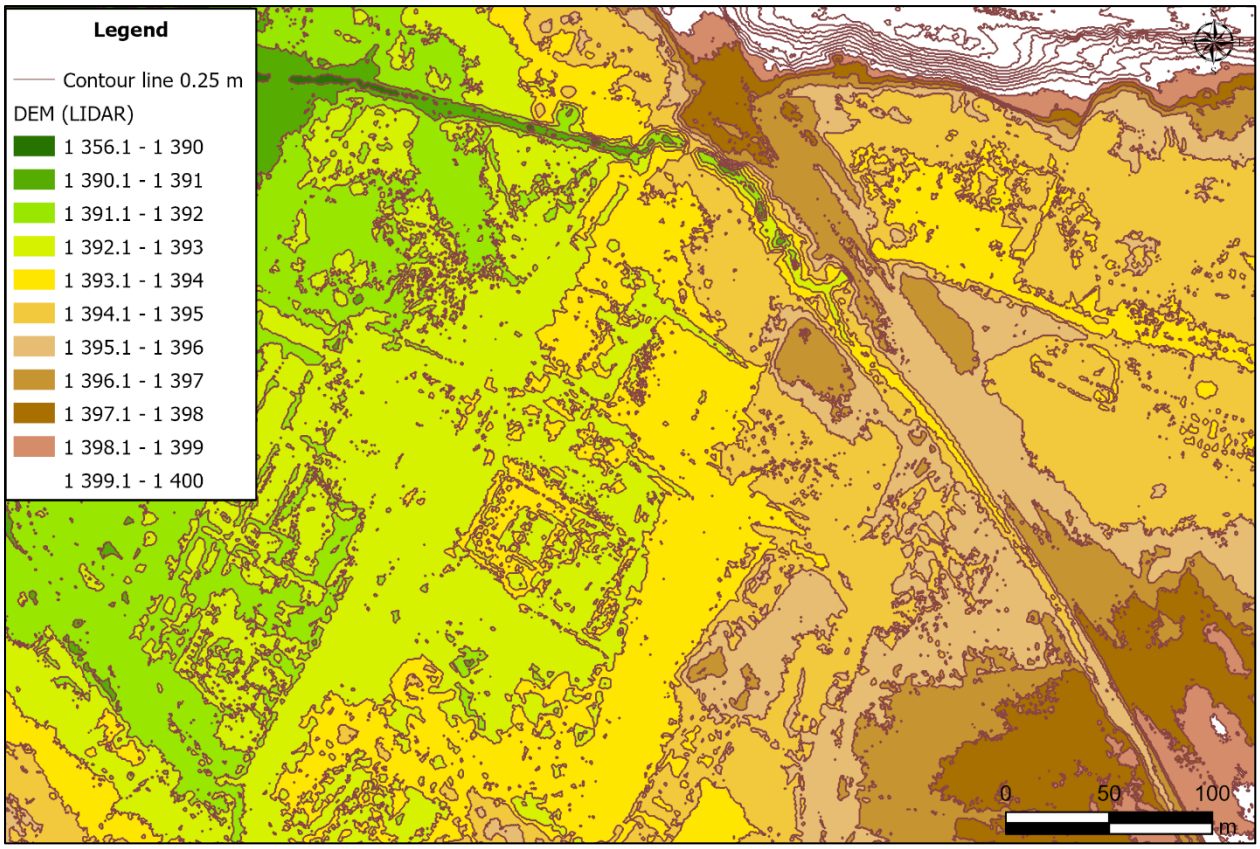


FIGURE 4-43 TERRAIN ELEVATION DATA AT KK 1 ROAD AVE IN GIKONDO

4.7 GROUNDWATER

In the context of wetlands, the interactions between groundwater and surface water flow are important since groundwater is flushed in the wetlands. They, therefore, play a key role in flood management (storage and flow of water) during heavy rainfall events. In order to understand the interactions and to model them as well as possible, there is a need to set up groundwater monitoring measures.

4.7.1 Review of existing data

The only major groundwater study in the country has been developed for the Eastern Province of Rwanda (Ground Water Recharge and Storage Enhancement in Eastern Province – Rwanda IWRM Programme 2019, WE Consult), which does not include our project area.

RWB has implemented 28 groundwater measuring stations over the entire country. Unfortunately, no permanent monitoring station is located into our project domain, the nearest station being downstream Nyabugogo wetland, at the level of the Nemba gauging station (see figure below).

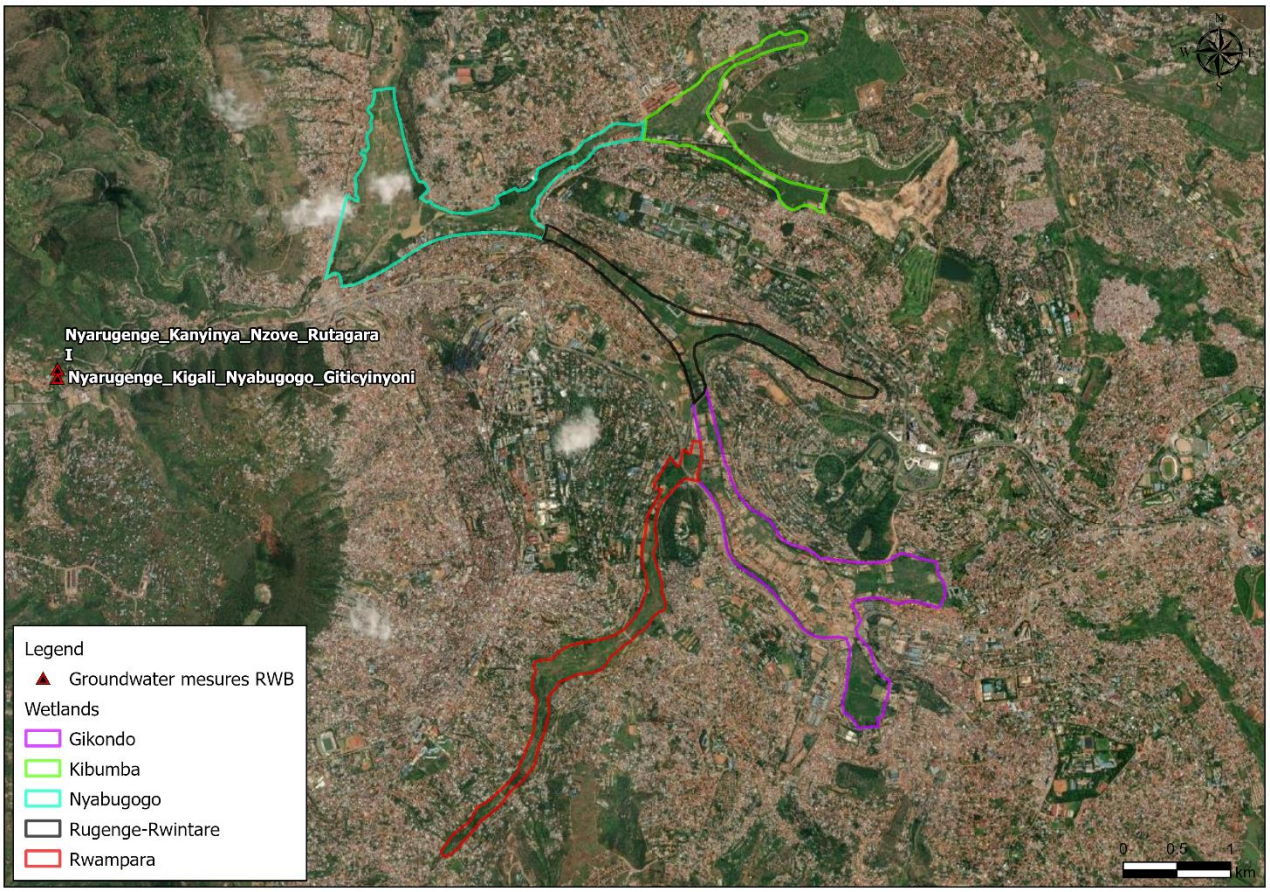


FIGURE 4-44: LOCATION OF THE EXISTING GROUNDWATER MEASUREMENT STATIONS NEAR THE STUDIED AREA

The graph below shows the groundwater level at the Nyarugenge – Nyabugogo – Giticyinyoni station between May 2017 and June 2020.

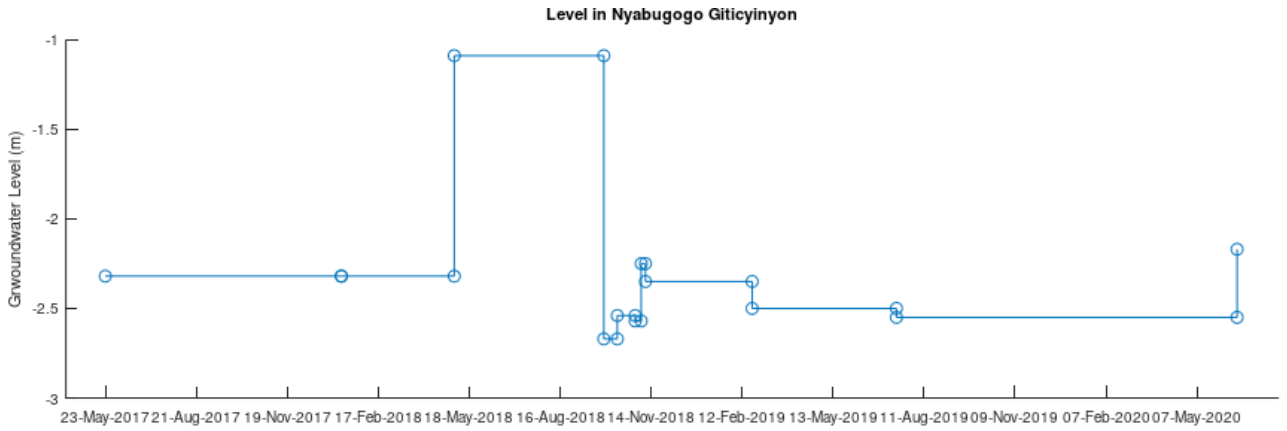


FIGURE 4-45: GROUNDWATER LEVEL AT THE NYARUGENGE – NYABUGOGO – GITICYINYONI STATION

Measures taken are not surveyed on a regular basis, some period being largely covered (e.g between October and November 2018) and some others suffer from large data gaps (e.g between July 2019 and June 2020).

The frequency of the data makes it difficult to assess properly the groundwater behavior on this location. However, from what it has been surveyed, the followings can be highlighted:

- Groundwater recharge seems to take place between May and September 2018, the level raising from -2.32 to -1.09 during this period. The beginning of the groundwater level raise seems to be correlated to the beginning of the rainy season with a delay of several weeks. This would correspond to the necessary time for the water to infiltrate the ground.
- In 2019, no measures have been taken between February and July, the gap could easily hide the potential recharge and ground level raising due to the rainy season
- In 2020, the groundwater level starts to increase in June 2020 but there is not enough data to conclude on the potential groundwater recharge over this period.

This station gives a preliminary trend on what is expected, during a long rainfall event, groundwaters are recharging. This trend will need to be confirmed with the additional groundwater measurements.

4.7.2 Additional groundwater measurements

4.7.2.1 Objectives

Groundwater monitoring will greatly improve the understanding of subsurface flow and groundwater recharge of the 5 wetlands. The measurement campaign will also aim to calibrate the hydrological model.

4.7.2.2 Method

A piezometric borehole has been installed on each wetland (see figures below for exact location and sites photos). Twice a day, a light probe sensor is inserted in the boreholes installed, to measure the groundwater level in each station.

The monitoring stations captured 6 weeks of measurement from the 14th of April till the 26th of May.

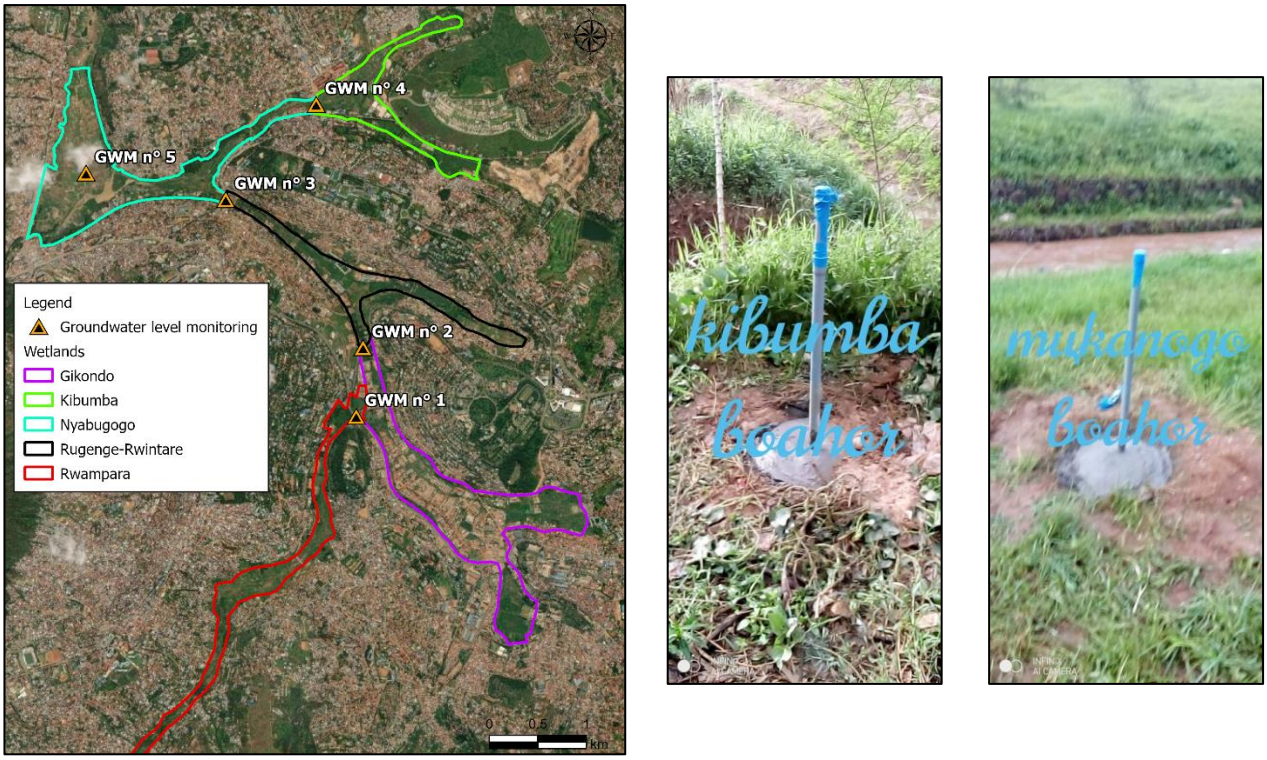


FIGURE 4-46: GROUNDWATER LEVEL STATION MONITORING LOCATION AND SITE PHOTOS

4.7.2.3 Results

The measurement campaign results from the 14th of Avril to the 26th of May are presented below.

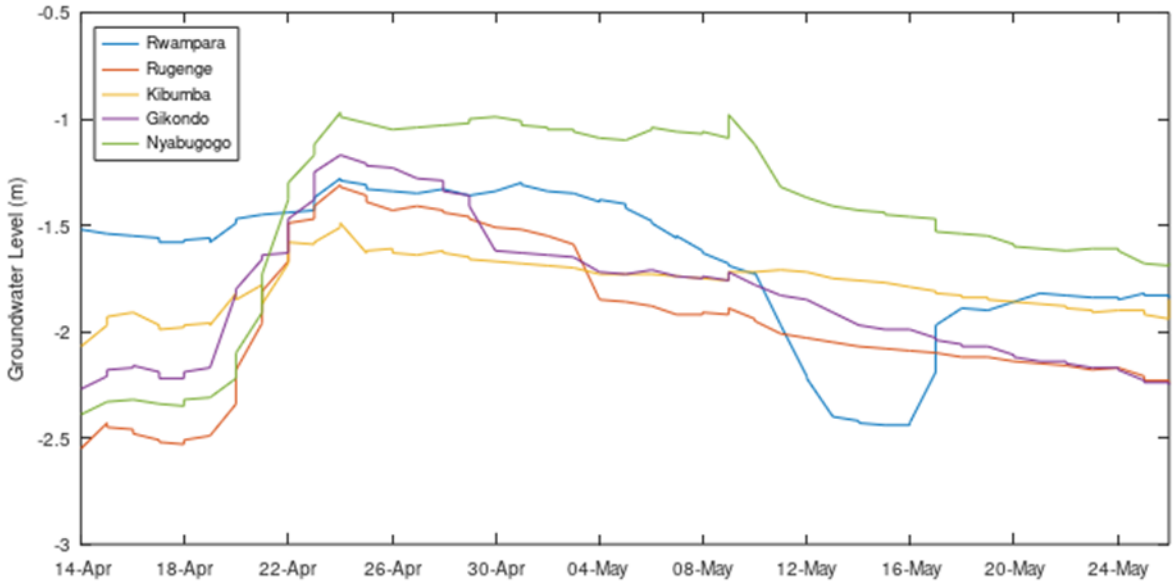


FIGURE 4-47: RESULTS OF THE GROUNDWATER MEASUREMENT CAMPAIGN BETWEEN THE 14TH OF APRIL AND THE 26TH OF MAY

For the 5 surveyed locations, the same trend is observable: The groundwater level is lower during the first two weeks of April than during the afterwards period. In order to assess the groundwater behaviour, the results of the campaign are linked to the rainfall intensity for the same period. The following graphs present the daily rainfall values measured at the Airport Kigali and Gitega meteorological stations (from the 14th of April and the 29th of April).

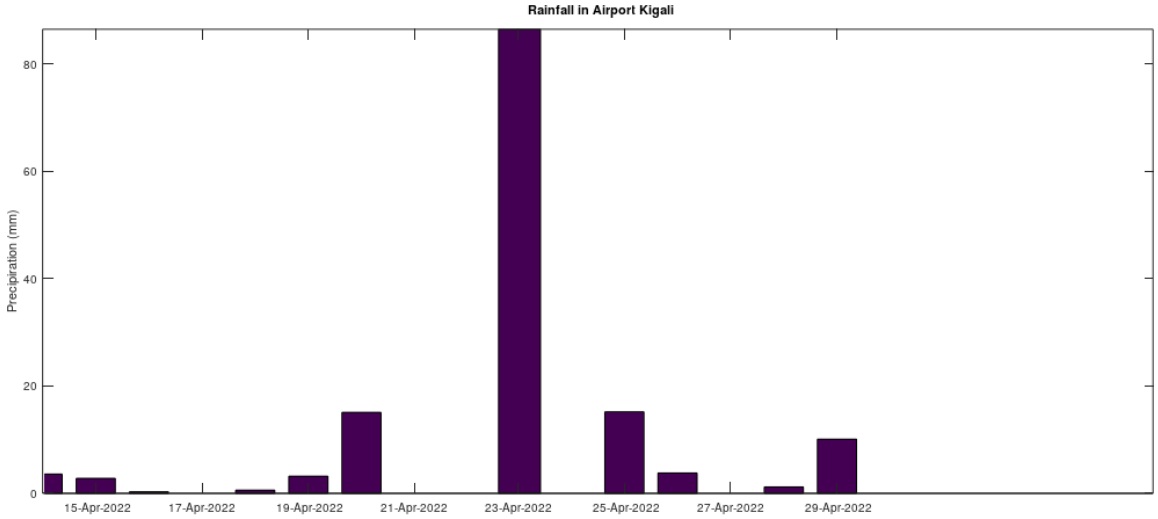


FIGURE 4-48: DAILY RAINFALL MEASUREMENTS AT AIRPORT KIGALI METEOROLOGICAL STATION

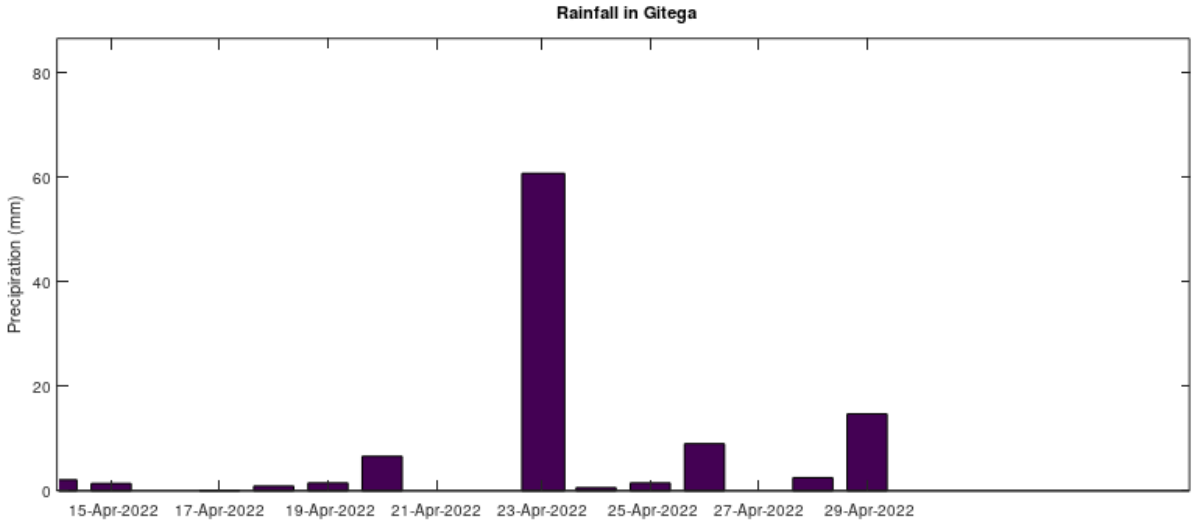


FIGURE 4-49: DAILY RAINFALL MEASUREMENTS AT GITEGA METEOROLOGICAL STATION

4.7.3 Conclusion on baseline in Gikondo

The amplitude between the minimum and maximum groundwater level is 1.10 m. At the beginning of the measurement campaign, the level measured in the borehole is -2.27 m.

The rainfall event of the 20th April (20 mm of precipitation surveyed at Kigali airport) followed by the more significative rainfall event of the 23th April 2022 (86.5 mm in one day surveyed at Kigali airport), implied a rapid groundwater recharge. Rather rapidly, even if some small precipitations have been observed in the following days, the groundwater is emptying to reach -1.73 on the 4th of May. Thus, the groundwater located downstream Gikondo behave reactively to the rainfall precipitations Important and rapid water exchanges between the groundwater and its environment occurs. The groundwater of Gikondo act as a water tank, delaying the water hydrograph.

4.7.4 Conclusion on baseline in Rwampara

The amplitude between the minimum and maximum groundwater level is 0.30 m, the lowest among all the groundwater measurements. At the beginning of the campaign, the level measured in the borehole is -1.58 m, reaching -1.28 m on the 24th of April.

The recharge capacity of the groundwater of Rwampara is small. The infiltrated water does not represent a significative volume and the exchanges between the groundwater and its environment is limited. The soil is compact and steep with low porosity characteristics causing exchanges between the river and the groundwater to be very slow.

4.7.5 Conclusion on baseline in Rugenge-Rwintare

The amplitude between the minimum and maximum groundwater level is 1.24 m. At the beginning of the campaign, the level measured in the borehole is -2.55 m, reaching -1.31 m on the 24th of April.

Happening with approximately one day of delay comparing to the groundwater of Gikondo, the groundwater recharge of Rugenge is also rapid and reactive. This groundwater allows for a large amount of water to be stored. Still comparing to the groundwater flow in Gikondo, Rugenge groundwater is emptying much slower. The exchanges between the groundwater and its environment are gradual.

4.7.6 Conclusion on baseline in Kibumba

The amplitude between the minimum and maximum groundwater level is 0.58 m. At the beginning of the campaign, the level measured in the borehole is -2.07 m, reaching -1.49 m on the 24th of April.

The amplitude between the maximum and the minimum groundwater level being relatively low, the groundwater recharge capacity is not important. The groundwater does not store a large amount of water as it does not release large water volume after the occurrence of the important rainfall event.

4.7.7 Conclusion on baseline in Nyabugogo lower

The amplitude between the minimum and maximum groundwater level is 1.42 m, the largest amplitude between all the groundwater measurements. At the beginning of the measurement campaign, the level measured in the borehole is -2.39 m, reaching -0.97 m on the 24th of April.

Occurring from the 20th of April to the 24th, the groundwater recharge following the rainfall event of the 23th April 2022 is important. The groundwater of Nyabugogo has a great recharge capacity. On the other hand, between the 24th of April and the 05th of May, the groundwater level does not change a lot. The surrounding zone of the measurement point is probably flooded which does not allow the groundwater to discharge in its environment. Thus, the groundwater store ad will delay the hydrograph for several days.

The above highlighted trends for each groundwater is being integrated into the model parameters for a better model calibration.

Except for the groundwater of Rwampara, the four other groundwaters provide a **significative recharge capacity** which is valuable for **water retention during a flood event**. Note that the retention is occurring with a delay comparing to the rainfall event, time for the water to infiltrate and to reach the groundwater. The retention capacity of the groundwater of Rwampara is not reliable for flood attenuation as the soil present low porosity.

4.8 WETLAND HYDROLOGY AND HYDRAULIC

After reviewing the existing model and present the methodology and results of the water level monitoring campaign, an assessment of the hydraulic current state of each of the 5 wetlands will be presented in this section. The assessment is based on the hydraulic model results for ten-year, fifty-year, and hundred-year return period rainfall events. These events will also be modeled with due consideration of climate change and land use change scenarios.

4.8.1 Review of the hydrological (Wflow) and hydraulic (SOBEK) models

4.8.1.1 Objectives

The objective of this chapter is to review and assess the outcomes and limitations of the available hydrological (Wflow) and hydraulic (SOBEK) models and the associated reports: Stormwater and wetland management Model for the delineated flood prone areas in Kigali (inception report, flood model hazard assessment report and final report).

Precision of the model:

- The existing model provided a lot of databases that were completed with additional information

- Additional investigations during the rain period for the 5 wetlands as well as new LIDAR data represent a real added value for our project

- The model can be considered as well calibrated for all the wetlands including Nyabugogo, thanks to additional analysis for the upstream part.

4.8.1.2 Introduction

The first stage of the review consists in comparing the extent of the model with the studied area specified in the ToR. This aims to:

- Verify the consistency of using the same hydrologic parameters,
- Define the potential required extension of the model.

The figure below shows in blue the extent covered by the initial model. The studied area as defined in the ToR (including the 5 wetlands) is covered at 96% by the existing hydraulic model. The Consultant will have in charge the extension of the model for the North-East part of the Kibumba wetland (about 6.3 Ha) and for the southern part of the Rwampara Wetland (about 15 ha). The additional needs for this integration will be discussed later in this section.

As the additional studied zone is relatively small, the hydrological parameters taken in the initial model are relevant and can be used for the model extension.

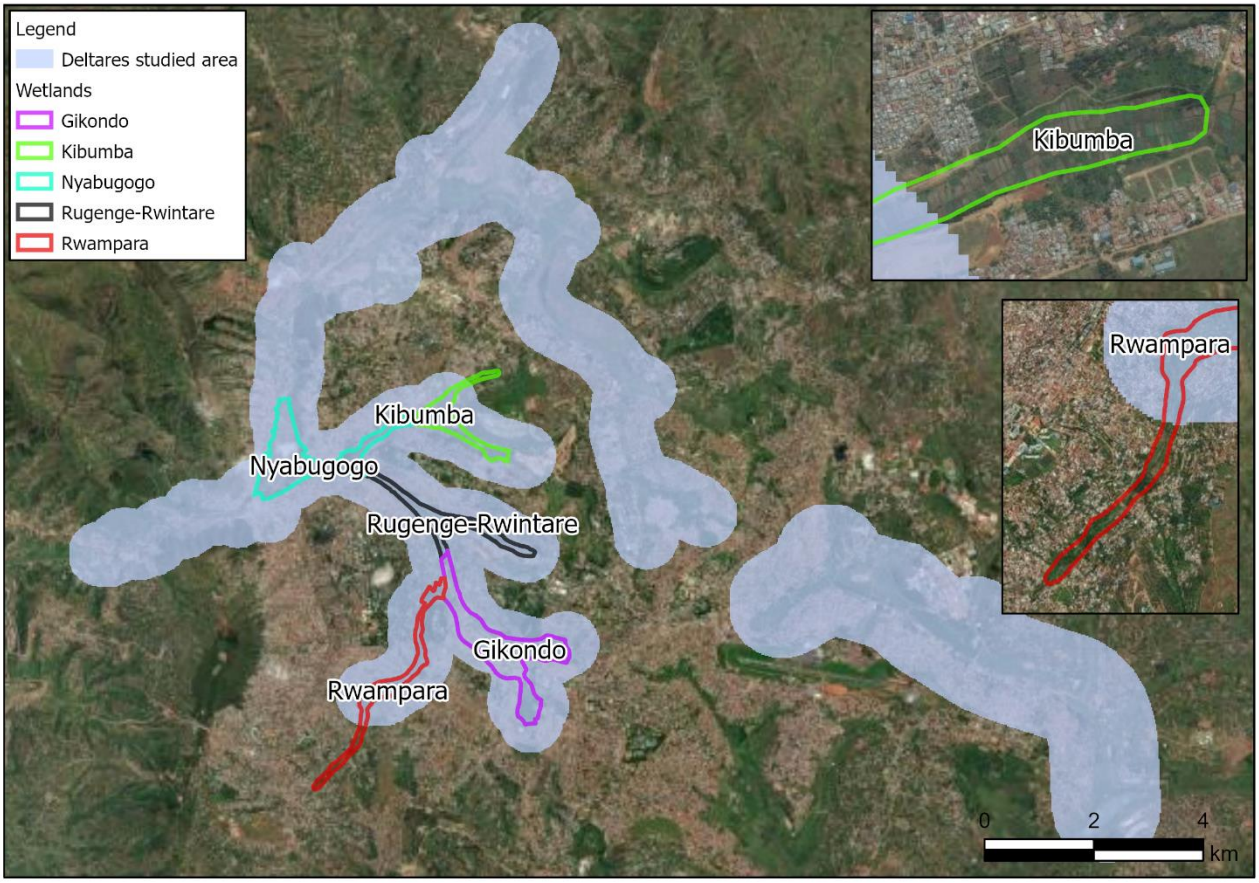


FIGURE 4-50 THE 5 WETLANDS TO BE STUDIED COMPARED TO THE PREVIOUS MODEL STUDY ZONE (BLUE)

4.8.1.3 Rainfall – runoff model review (Wflow)

4.8.1.3.1 Input data accuracy

The first stage of the review consists in a critical accuracy assessment of the input data used for the hydrological model, which can be listed as follow:

Rainfall data

The rainfall data from 12 different meteorological stations have been used as their location and completeness are relevant for the studied area.

The longest period covered by the rainfall data is 40 years which represents a short period to identify a 100-year return period event. Moreover, as specified in the modelling report, the meteorological data have some important time gaps. This lack of data could hide some important extreme events that will not be included in the study. Unfortunately, nothing can be done at this point to gather more historical data except for increasing the quality of the data from the existing or the new stations (ensure the continuous availability of the data).

The meteorological stations recording on a 10-minute basis are only covering a 6-year period. This is a short period to correctly assess the hydrograph form of the different extreme events (10, 50, 100-year return periods). As the model report suggests, we recommend as well, a densification of the 10 min meteorological stations.

Climate change scenario

Two climatic scenarios over the 4 scenarios defined by the IPCC in the 5th assessment report (IPCC-AR5) have been modelled, the RCP4.5 and the RCP8.5 scenario. They represent a moderate and an extremely pessimistic scenario.

According to the 5th assessment report, the RCP4.5 assumes a global temperature rise of 1.1°C in 2040 relative to the pre-industrial period. However, the Global Climate 2020 report - World meteorological organization states that the planet has already reached a global rise of 1.2°C. Then the RCP4.5 can no longer be considered as a

moderate scenario but as an optimistic: from now, a decrease in temperature is assumed to reach 1.1°C in 2040 (i.e. important and numerous climate change measures are taken all around the globe).

As the most pessimistic scenario is the most important to size the infrastructures with a security factor, it is chosen to maintain the mentioned climatic scenarios:

- RCP4.5 for current situation calculation
- RCP8.5 scenario for 2050 situation calculation

Note that the scale used to define the climatic scenarios (temperature and rainfall intensification) is 50 x 50 km which is wide, but suitable regarding the available data and studies that have been collected and led on climate change.

The assumption made of intensity precipitation rise of 7 and 14%/°C respectively for the RCP4.5 and 8.5 scenario has been made according to the Clausius-Clapeyron and the super CC relation, which are relevant hypothesis.

Land use change scenario

Two land use scenarios have been modelled, the current land use and a future land use scenario based on the 2050 City of Kigali Master Plan. They represent how the city of Kigali will be developed in the future. Indeed, the City will be denser and the suburban areas will grow and become more formalized as mentioned in the Deltares flood model and hazard assessment report.

Streamflow data

The hydrological model validation has been developed by Deltares comparing the simulated to the observed discharge in Nemba station.

According to the flood model and hazard assessment report of Deltares, only one hydrological gauging station, Nemba station, was available and has sufficient long and recent records to be used for the model validation. The data are available from 1970 to 2020, representing 50 years. The hydrological study has only used the recent period between 2015 – 2020 as important land use have certainly occurred between those two periods. Considering the data gaps, the validation period represents an actual cover period of 2 years and 10 months, which is small relatively to the rainfall events of 2, 10, 50 and 100 years return period.

Therefore, in addition to the Nemba station, 5 other on-site measurement (one for each wetland, presented in the following chapter) were used for calibration. The results of the calibration are presented in a subsequent chapter dedicated.

Elevation data

The mean vertical offset of the Digital Elevation Model used by Deltares (DEM10) compared to the topographic surveying points is 2.16 m, ranging from -6.8 to +11.3 m. The difference is significantly important. To assess the problem Deltares has affected a +2 m vertical correction over all the elevation value of the DEM10. This assumption is questionable as it will largely under or overestimated the local elevation of some area, which can thus make significant changes in the water runoff behaviour.

The horizontal accuracy of the DEM10 is 10 x 10 m which implies a smoothing of the extreme elevation values. This can have a significant impact on the runoff erasing, for example, storage areas that would low the water flow or great steeps that would speed up the water flow. An example is presented below. Moreover, for time optimization of the running model, the modelling scale has been set up to 20 x 20m. This will smooth ever more the extreme values.

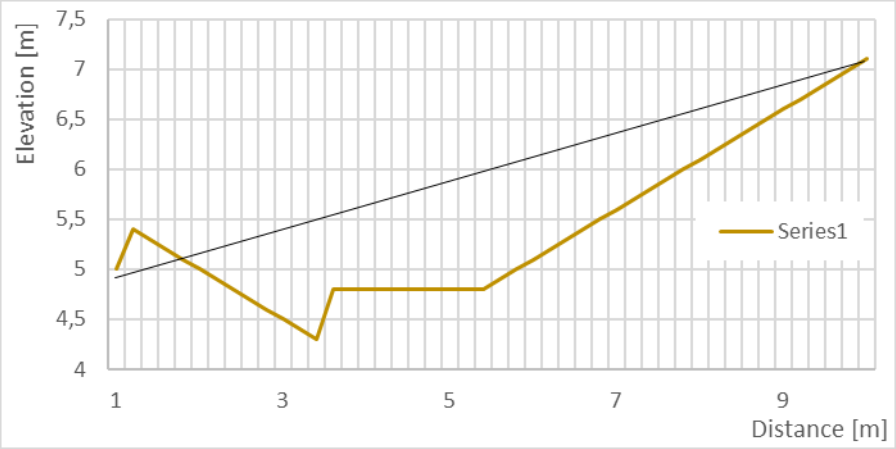


FIGURE 4-51 ELEVATION

With this level of accuracy, the model report points out that looking at relative changes in the flood hazard (depth and area) resulting from the management scenarios is more relevant than looking at absolute values.

To enhance the accuracy of the model, the LIDAR of the city, which is presented in detail in the following chapter, previously not available for the study of Deltares, will be used as the elevation reference. As the DEM obtained from the LIDAR has a great horizontal accuracy (0.5 m), the offset between the topographical survey and the DEM will be greatly reduced.

4.8.1.3.2 Methodological review

The steps leading to runoff definition, detailed in the flood model and hazard assessment report, are assessed in the following chapters:

- Catchment definition
- Define extreme rainfall events (hydrograph)
- Rainfall spread over the studied area
- Hydrological parameters definition
- Model calibration

Catchment definition

The catchment boundaries have been derived by the wflow algorithm, the results are consistent with the DEM (see figure below) and with the definition of a catchment (considering the topography, all the runoff is flowing in direction of a same outlet). The hydrological parameters of each catchment are determined based on the land cover.

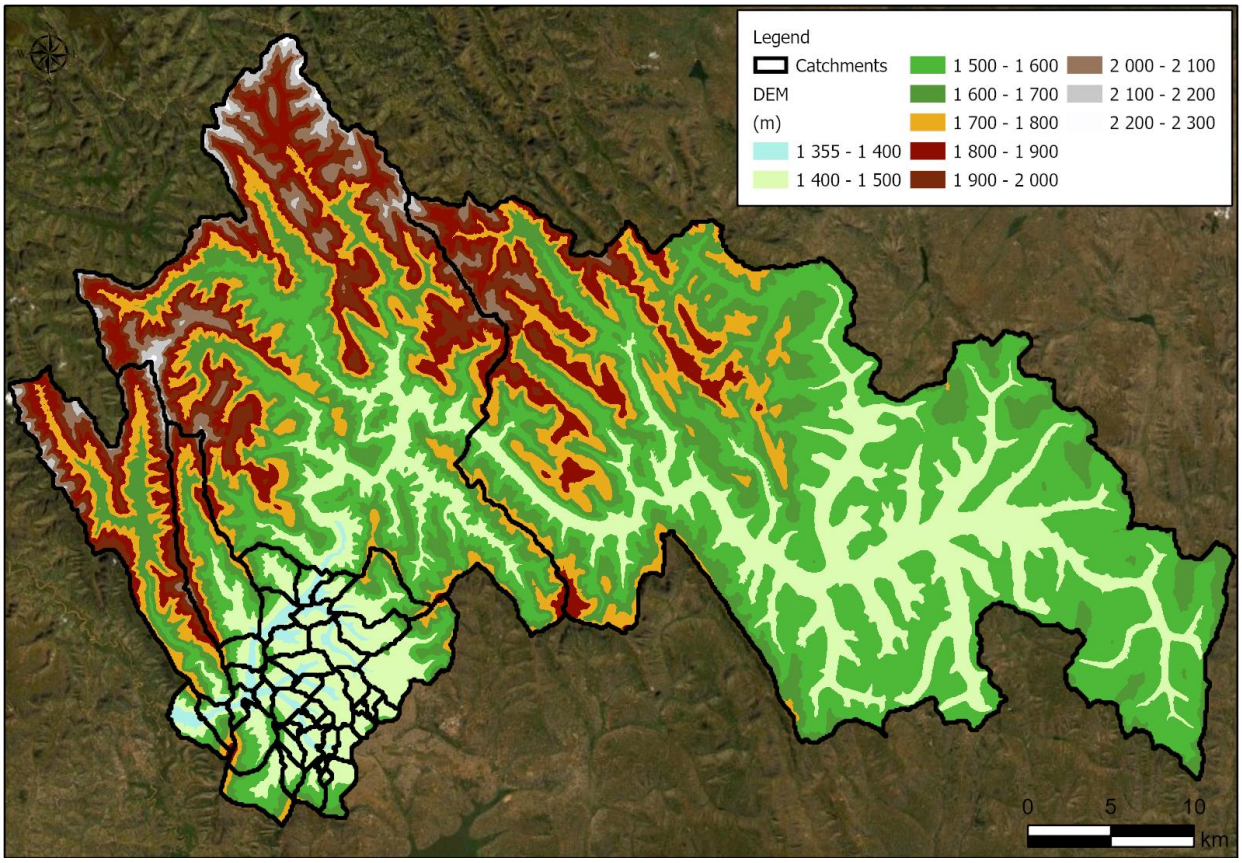


FIGURE 4-52 CATCHMENT DELINEATION BASED ON THE WFLOW ALGORITHM AND DEM

Define extreme rainfall events (hydrograph)

Gumbel method is used for defining the return period of each event. The Consultant went through the methodology applied and does not have any additional comments to make.

Rainfall spread over the studied area

For each meteorological station, hydrographs of extreme events (2, 10, 50,100-year return period) have been calculated. Using a spatial interpolation consisting in applying the inverse square distance weighting, a grid of approximately 4 km x 4 km have been elaborated (see figure below).

Note that the spatial interpolation technic and the large scale used do not consider the impact of the hilly characteristic of the terrain which can easily implies some orographic effect (significant change in meteorological conditions over two sides of one hill).

The maximum distance between one meteorological station and one point on the grid is approximately 12 km. This is a large distance as we see on the map that some local extreme rainfall events can happen around the meteorological station.

The Deltares model report suggests the implementation of new meteorological stations to assess the problem.

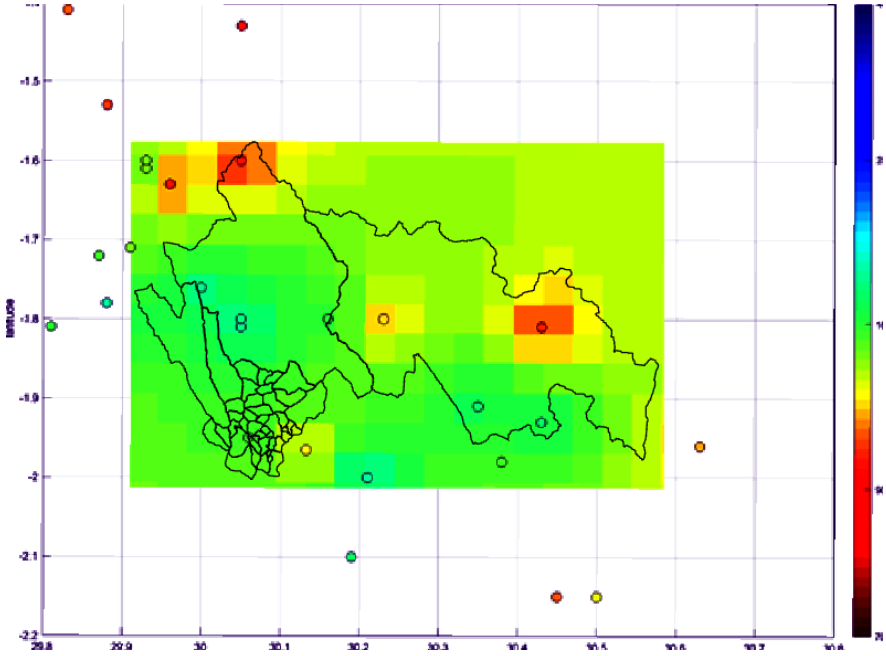


FIGURE 4-53 RESULTING MAP OF 100-YEAR RETURN VALUES OF RAINFALL (MM/DAY), BASED ON SPATIAL INTERPOLATION OF RETURN VALUES FROM STATIONS. STATIONS ARE DEPICTED AS CIRCLES

Source: Deltares flood model and hazard assessment report, 2020

Model calibration

As discuss previously, the hydrological model validation by Deltares was developed comparing the simulated to the observed discharge in Nemba station.

Only one validation point was used to calibrate the model, which is very low to proceed to the model validation as one point provides little insight on how urban catchments generate runoff over the entire studied area.

One other gauging station, Mpazi station, is located in the studied area, but according to the model report, it did not have sufficient accurate data to be used because it has been inundated with sediments.

Moreover, even after the parameter adjustment, the difference between the discharge simulated and observed in Nemba station between 2016 and 2018 is still significant. Note that the simulated discharges tend to underestimate the discharge during the great peak event. This may be an important problem as it underestimates the runoff and the flooding.

As the channels, culverts and bridge have not yet been modelled (will be in the hydraulic model), the model tends to lower the peak (more storage and infiltration).

Setting up some additional measurements and stations are necessary for better hydrologic parameter adjustment and so better accuracy of the model. Therefore, five more point have been used for the calibration. One per wetland, each of this measurement station will be used for the calibration and are presented in detail in the following chapters.

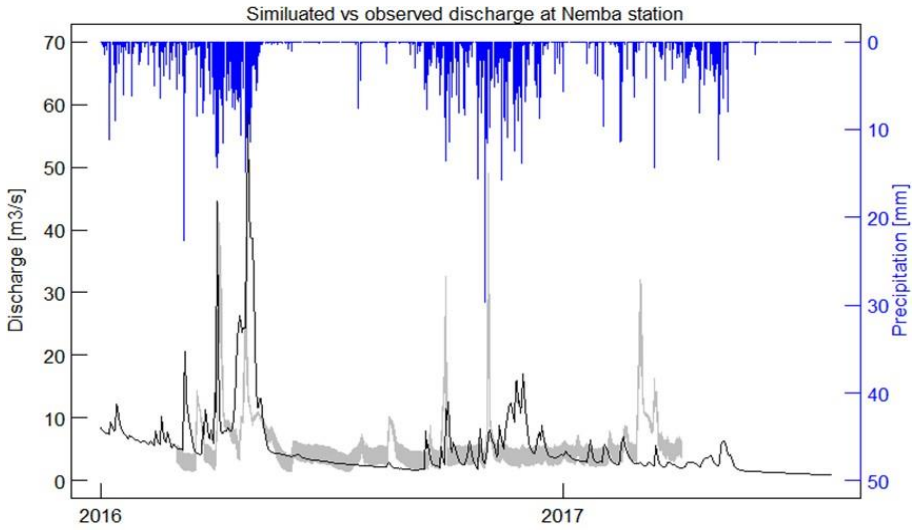


FIGURE 4-54 SIMULATED VS OBSERVED DISCHARGE AT NEMBA STATION

Source: Deltares flood model and hazard assessment report, 2020

4.8.1.3.3 Summary

The following table present the elements that were reviewed as well as some recommendations

TABLE 4-11 SUMMARY OF THE MODELS REVIEW AND RECOMMENDATIONS

Stage Name	Consultant review and assessment	Recommendations
Meteorological data	• Short period covered by the rainfall data • Important gaps in some rainfall data	• Ensure the continuous availability of the meteorological data • Collect additional meteorological data
Climate change scenarii	• RCP4.5 from moderate scenario to optimistic scenario • RCP 8.5 for extreme • Large scale but suitable with the availability data	• No changes recommended
Land use change scenario	• One current and one projected land use in 2050 (2050 City of Kigali Master Plan)	• No changes recommended
Streamflow data	• Short period covered by the Nemba station.	• Setting up some new measurement stations
Terrain	• Mean horizontal offset 2.16 m • Horizontal accuracy 20 x 20 m	• Detailed grid based topographic survey, covered by Lidar
Catchment definition	• Wflow algorithm validated	• No changes recommended
Define extreme rainfall events	• Gumbel method validated	• No changes recommended
Rainfall spread	• Spatial interpolation: grid elaboration 4 km x 4 km • Orographic effect smoothed • Important distance between studied area and some of the meteorological station (12 km max)	• Adding some meteorological stations or collect additional meteorological data
Model calibration	• Only one gauging station for validation • Significant discrepancies between observed and simulated discharge	• Setting up some new measurement stations

4.8.1.4 Hydraulic model review (SOBEK)

4.8.1.4.1 Topography survey

Within the work of the topographic survey, culverts, bridges and some cross sections have been characterized. Approximately one cross section profile every 300 m has been surveyed, which is considered sufficient. Within the present study context, additionally to the Lidar some addition topographic survey has been led in order to characterize the upstream of Kibumba and Rwampara wetlands that was not included in the previous study.

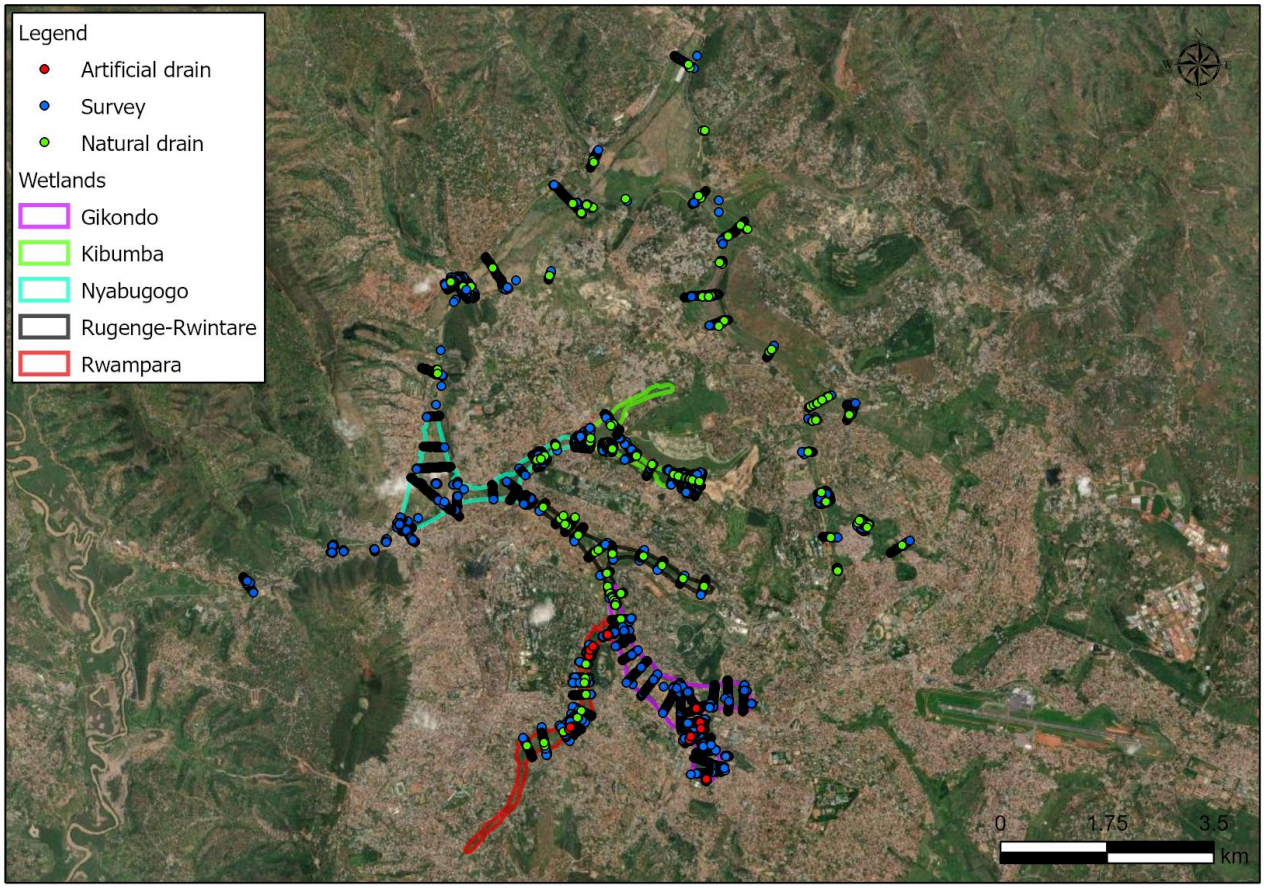


FIGURE 4-55 LOCATION OF THE TOPOGRAPHIC SURVEYED TRANSECTS UNDERTAKEN AS PART OF THE DELTARES STUDY

The location of the new cross sections to be surveyed are proposed in the figure below.





FIGURE 4-56 PROPOSED LOCATION OF THE NEW CROSS SECTIONS TO BE SURVEYED FOR THE RWAMPARA WETLAND ON THE LEFT AND THE KIBUMBA ON THE RIGHT

4.8.1.4.2 Calibration methods and validation processes

To calibrate and validate the model, the simulated and the observed water level of several places implied by the rainfall event of 25th of December 2019 have been compared. Floodmarks have been identified as the maximum water depth occurring during one event. The rainfall event of 12/25/19 can be identified to a 20-year return period event. Then the validation process consists in verifying that the floodmarks are between the water level resulting from the T10 simulation and the water level from the T50.

Most of the floodmarks identified are in the range between T10 and T50, however some errors have been identified and justified in the report as follow:

- The accuracy of the simulation (20 m) compared to the localization of the floodmarks
- Some floodmarks are derived from tide marks (dirt on walls) or trash lines (solid waste of vegetation caught in tree branches), which implies inaccurate values.
- Accuracy of the DEM: as the DEM10 have an error ranging from -6.8 m to +11.3 m, the precision of the landmark is not very accurate. However, comparing the relative water level is the solution used to get rid of this error

To increase the validation process, the additional gauging stations that will be implemented will be used to calibrate other part of the model.

4.8.2 Model baseline data

4.8.2.1 Rainfall data

The water depth over the studied area have been simulated for a 10-yr return period rainfall event. This return period is chosen for the hydraulic assessment of the scenarios. The scenario will be developed to avoid flooding on roads for all the rainfall events occurring once per 10 years or more frequently. For studies uniformity

concerns, the hypothesis taken in the Deltares study concerning the rainfall intensity and spatial distribution have been taken.

4.8.2.2 Terrain

4.8.2.2.1 Terrain data source

The Lidar obtained from CHARIS is composed of elevation values over our studied area for each pixel of size 0.5 m x 0.5 m (see figure below). Some elevation data gaps are observed around the wetlands within the model limits corresponding to protected area where drone flights are not allowed.

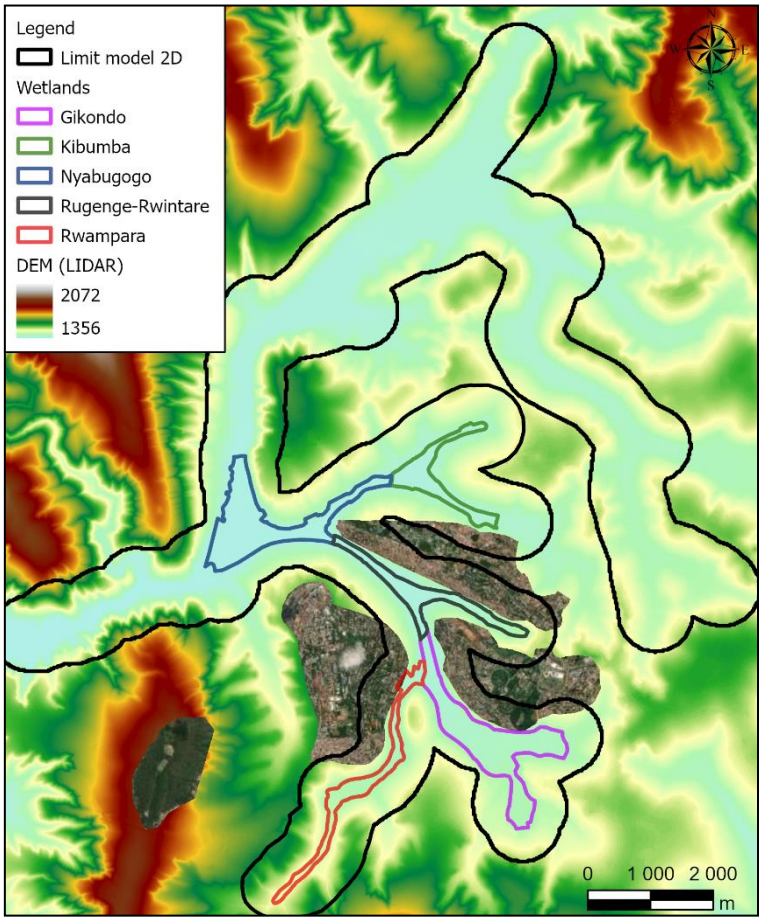


FIGURE 4-57: LIDAR ELEVATION DATA OVER THE STUDIED AREA

The idea is to define the input terrain values of the hydraulic model based on the DEM provided from the LIDAR for the greatest extend of the studied area which would be completed (over highlighted gaps) by the DEM with a pixel accuracy of 20 m x 20 m used by Deltares.

A preliminary analysis between elevation values provided by both data sources is presented below to ensure the consistency to used both sources simultaneously.

Over the 2D model limits, the difference between elevation data from the LIDAR and from the DEM has been assessed. On average, the difference is 0.1 m with a standard deviation of 2.76 m, a minimum of -25.9 m and a maximum of 17.8 m. The difference over the studied area is mapped below and the statistic distribution presented over the following graph.

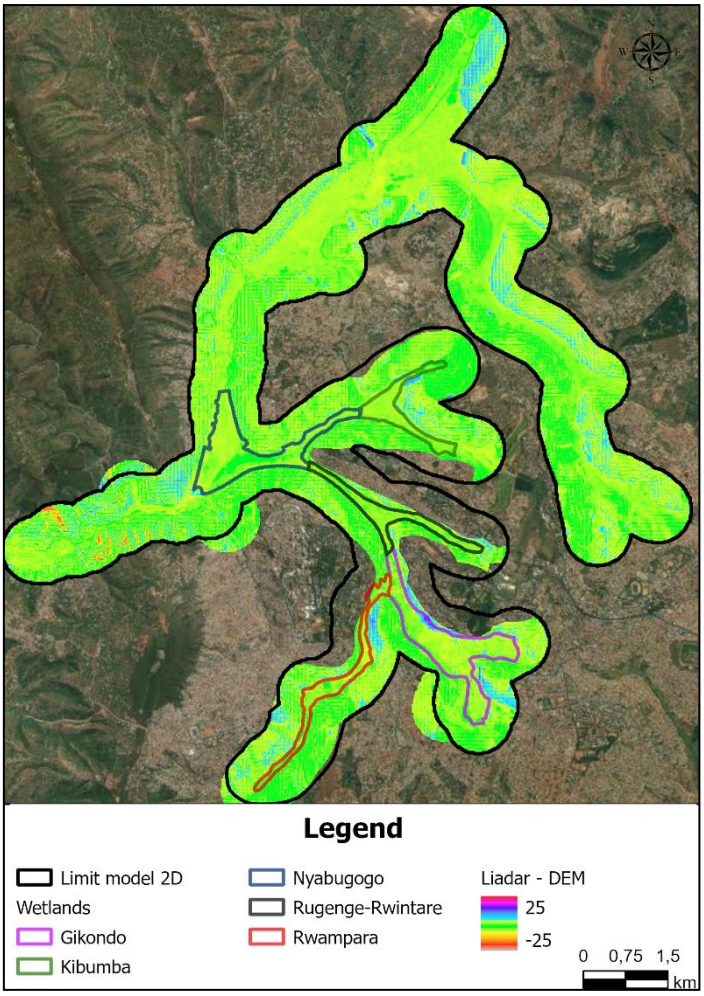


FIGURE 4-58: DIFFERENCE BETWEEN LIDAR ELEVATION DATA AND DEM USED BY DELTARES OVER THE STUDIED AREA

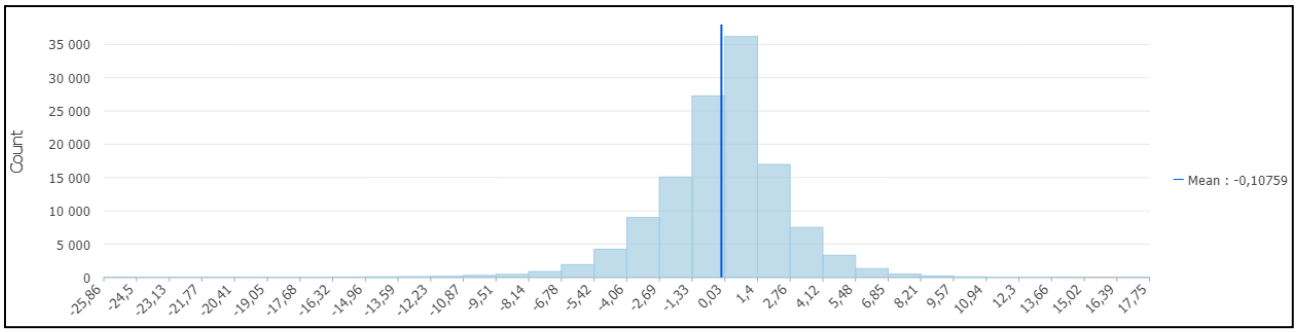


FIGURE 4-59: DIFFERENCE STATISTICS BETWEEN LIDAR ELEVATION DATA AND DEM USED BY DELTARES OVER THE STUDIED AREA

The more sensitive part of the hydraulic 2D model consists in the main water courses situated into the wetland. These elements are integrally covered by the DEM provided by the LIDAR. Additionally, and because the mean difference between both data sources is small, the input terrain of the hydraulic model will be defined as a combination of both DEM (see figure below).

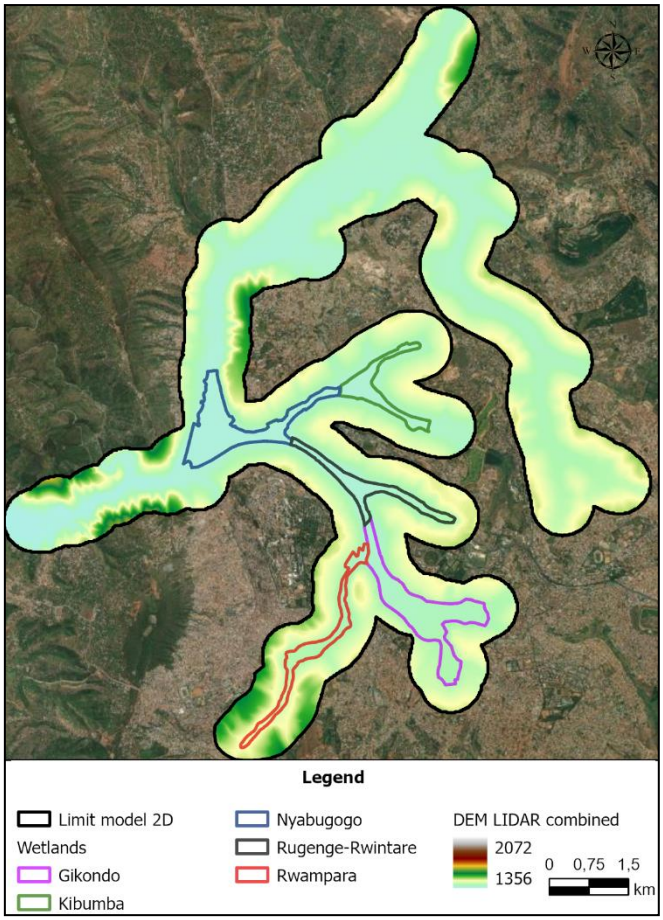
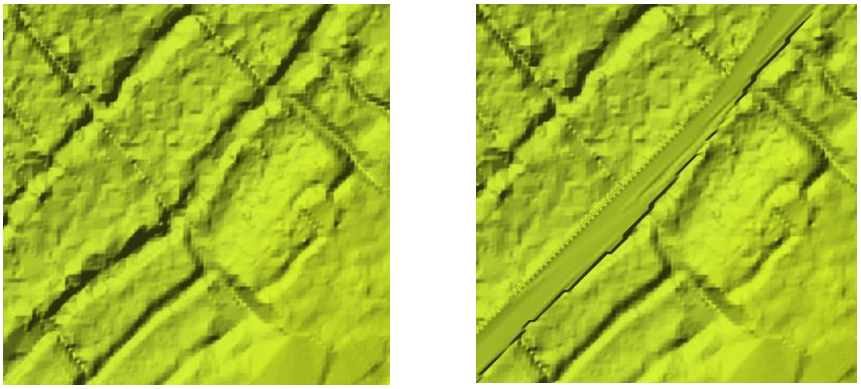


FIGURE 4-60: DEM USED FOR THE HYDRAULIC MODEL (COMBINATION OF THE LIDAR DEM AND THE DEM USED BY DELTARES)

4.8.2.2.2 Terrain treatment

Riverbed levels in the DEM as the rivers (and their conveying capacity) are already represented by the 1D hydraulic model. In order to not doubling the conveyance and storage capacity of the rivers, they do not have to appear in the 2D hydraulic model and need therefore to be filled into the DEM. A correction of the DEM between the embankment lines have been applied. The DEM values between the elevation lines are replaced by the interpolated values of the embankment levels on both sides, see Figure below.



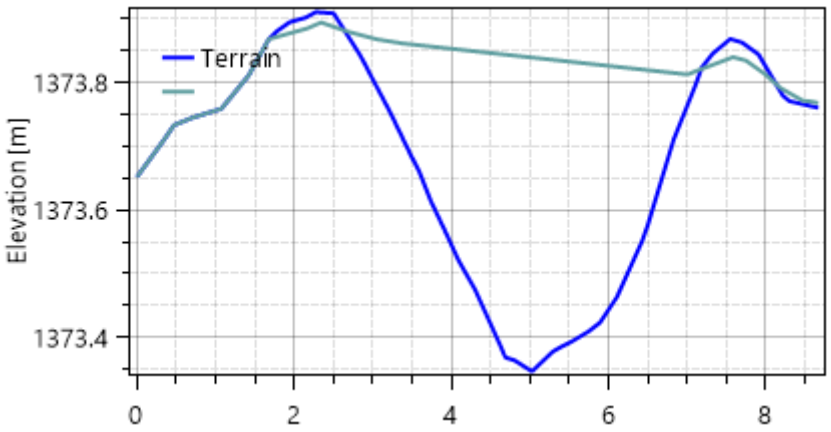


FIGURE 4-61 INTERPOLATION OF EMBANKMENT LEVELS TO REPLACING RIVER DEM LEVELS WITHIN EMBANKMENT LINES. ORIGINAL DEM (UP-LEFT), CORRECTED DEM (UP-RIGHT), PROFILE SHOWING DIFFERENCE BETWEEN ORIGINAL (BLUE LINE) AND CORRECTED (GREEN LINE) PROFILE DEM LEVELS (BOTTOM)

Then the 0.5 m DEM was aggregated to a 10 m DEM in order to keep run-times manageable on a normal laptop computer. Note that a 10 m resolution is sufficient to capture the inundation process. Figure below shows a detail of the 0.5 m accuracy DEM (red line) and the difference with the 10m DEM (blue line).

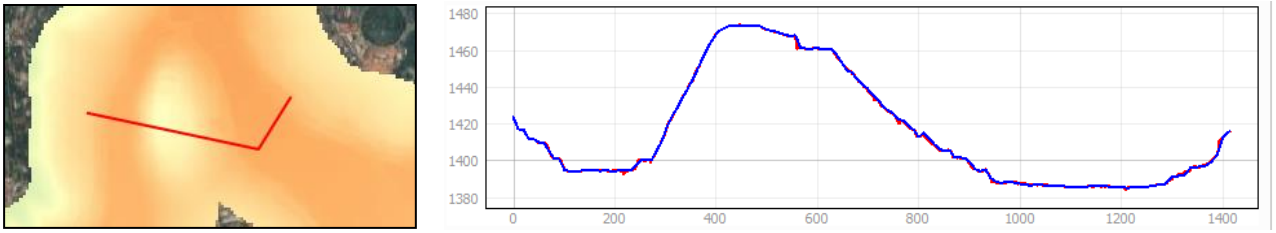


FIGURE 4-62 CROSS SECTION LOCATION (ON THE LEFT) AND PROFILE (ON THE RIGHT) SHOWING THE DIFFERENCE BETWEEN 0.5 M (RED LINE) AND 10 M (BLUE) DEM AT THE LEVEL OF THE RWAMPARA AND GIKONDO OUTLET WETLAND

4.8.2.3 Topography

4.8.2.3.1 Existing topographic data

Through the Deltares study, topographic data of cross sections and hydraulic infrastructure have been collected. The value of this campaign has been cross-checked with the LIDAR elevation data to ensure the consistency of the data.

4.8.2.3.2 Additional topographic data

The missing topographical data include the cross sections located in the extended part of the model (southern part of Rwampara, northern part of Kibumba). These data are extracted from the LIDAR as it has a very high horizontal pixel accuracy (0.5 m) and will be included in the hydraulic model.

Rwampara

The 1D hydraulic model has been extended for nearly 2.4 km in the south part of Rwampara. In the extreme south of the wetland the cross section is defined by a very small hydraulic section (0.5 m width) and high-level banks (3 m high). One bridge has been implemented with its characteristics. The figure below shows the cross section extracted from the LIDAR and integrated into the model.

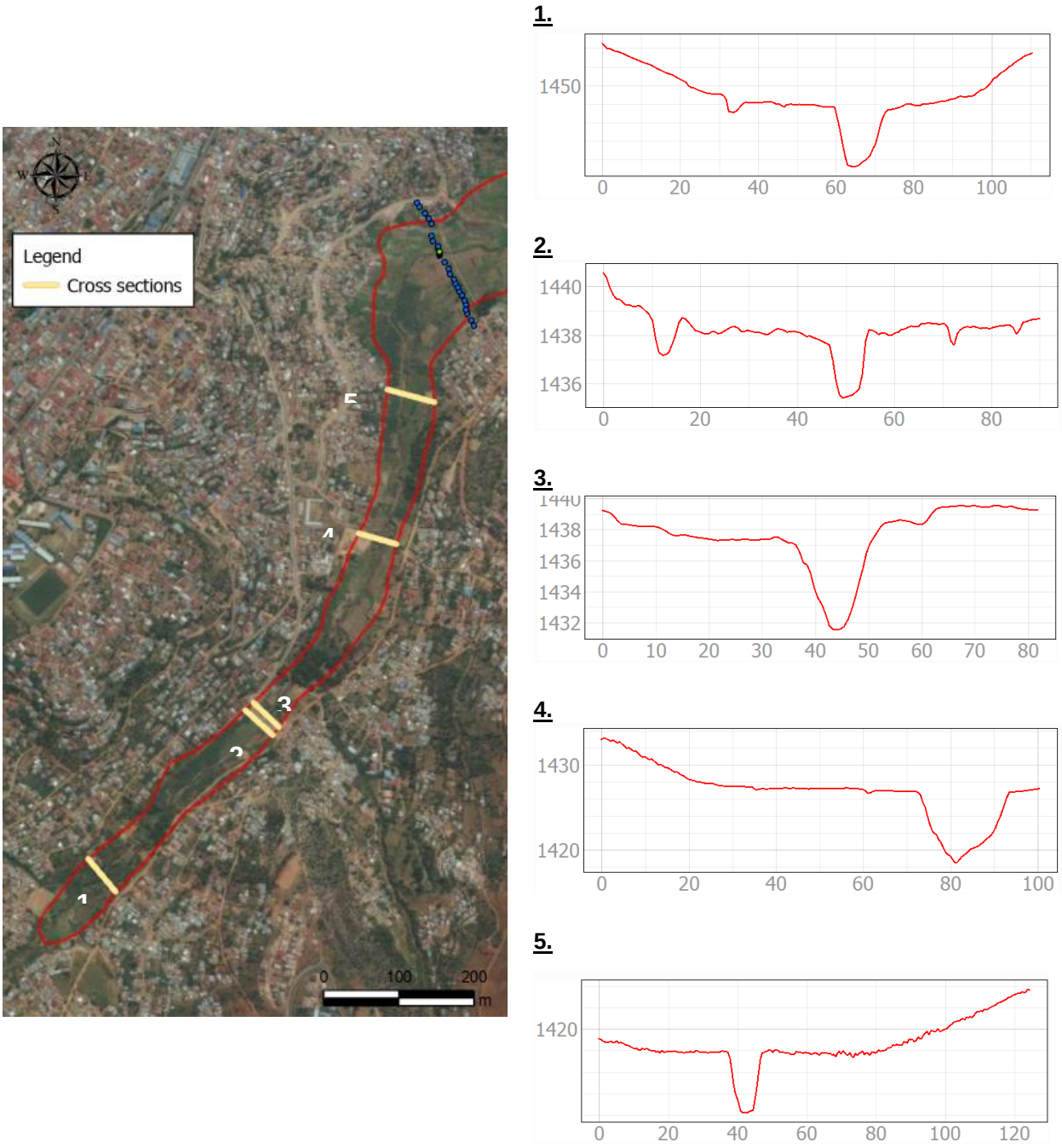


FIGURE 4-63 CROSS SECTION PROFILES EXTRACTED FROM THE LIDAR FOR RWAMPARA WETLAND

Kibumba

The 1D hydraulic model has been extended for approximately 1.2 km in the north part of Kibumba. Upstream of this branch the cross section is 120 characterized by a small width (0.5 to 1.5 m) and small riverbank levees (0.4 – 0.6 m) (see figure below). A bridge is crossing the river on the KG 449 St where water flow underneath through a 0.5 m diameter pipe.

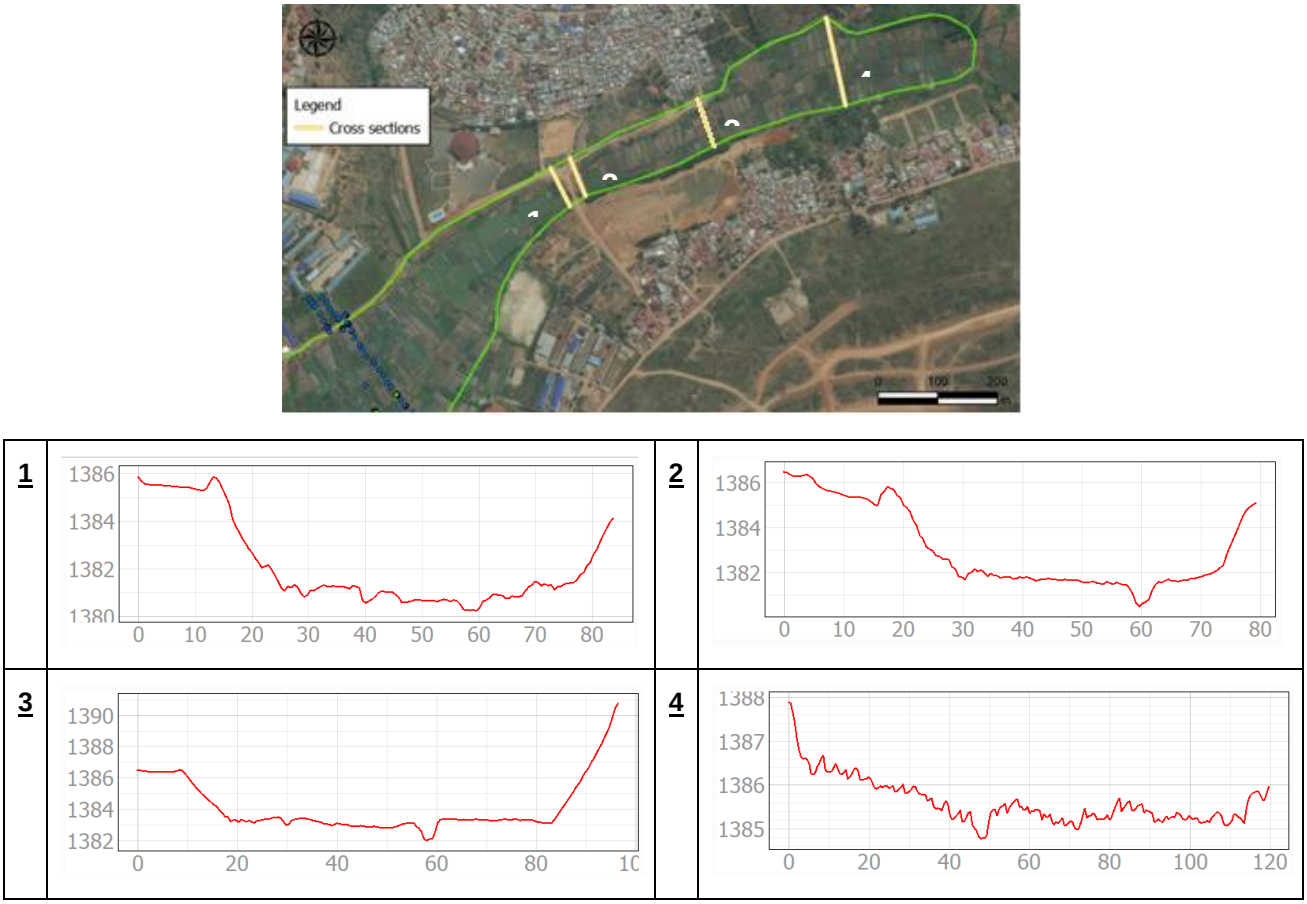


FIGURE 4-64 CROSS SECTION PROFILES EXTRACTED FROM THE LIDAR FOR KIBUMBA WETLAND

4.8.3 Existing model modifications

The existing model developed by Deltares has been extended to the limit of the delineated wetlands as presented in the figure below (and presented at the next figure showing the 5 wetlands to be studied compared to the previous model study zone). The extension is defined by the inclusion of the northern branch of Kibumba wetland and the south part of Rwampara wetland.

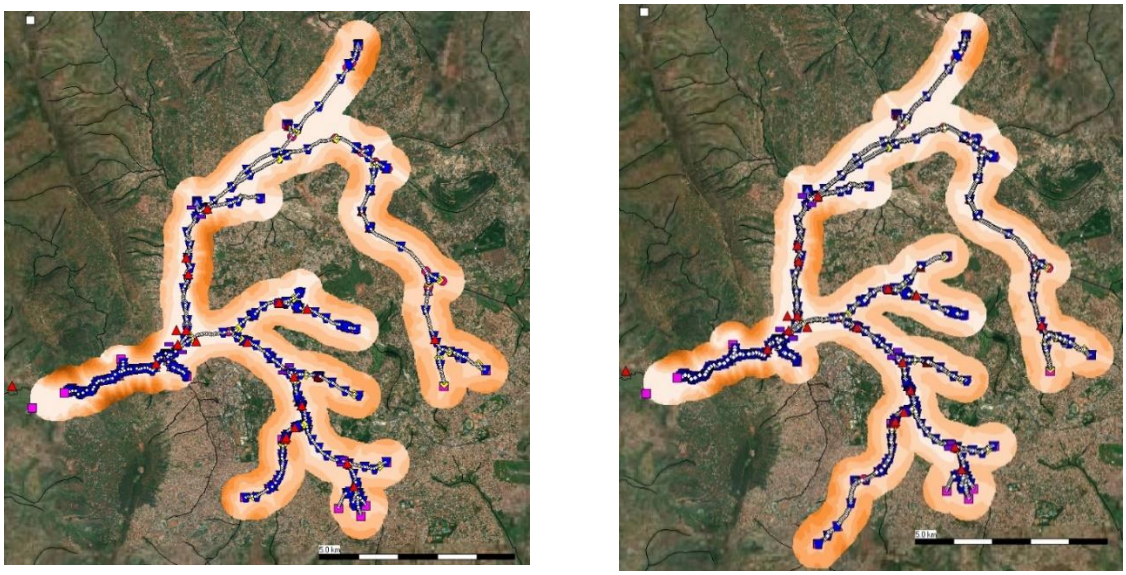


FIGURE 4-65: HYDRAULIC MODEL EXTENT

For the model extension part, new cross sections and bridges have been implemented in the hydraulic model.

4.8.3.1 Rwampara

The 1D hydraulic model has been extended for nearly 2.4 km in the south part of Rwampara. In the extreme south of the wetland the cross section is defined by a very small hydraulic section (0.5 m width) and high-level banks (3 m high). One bridge has been implemented with its characteristics.

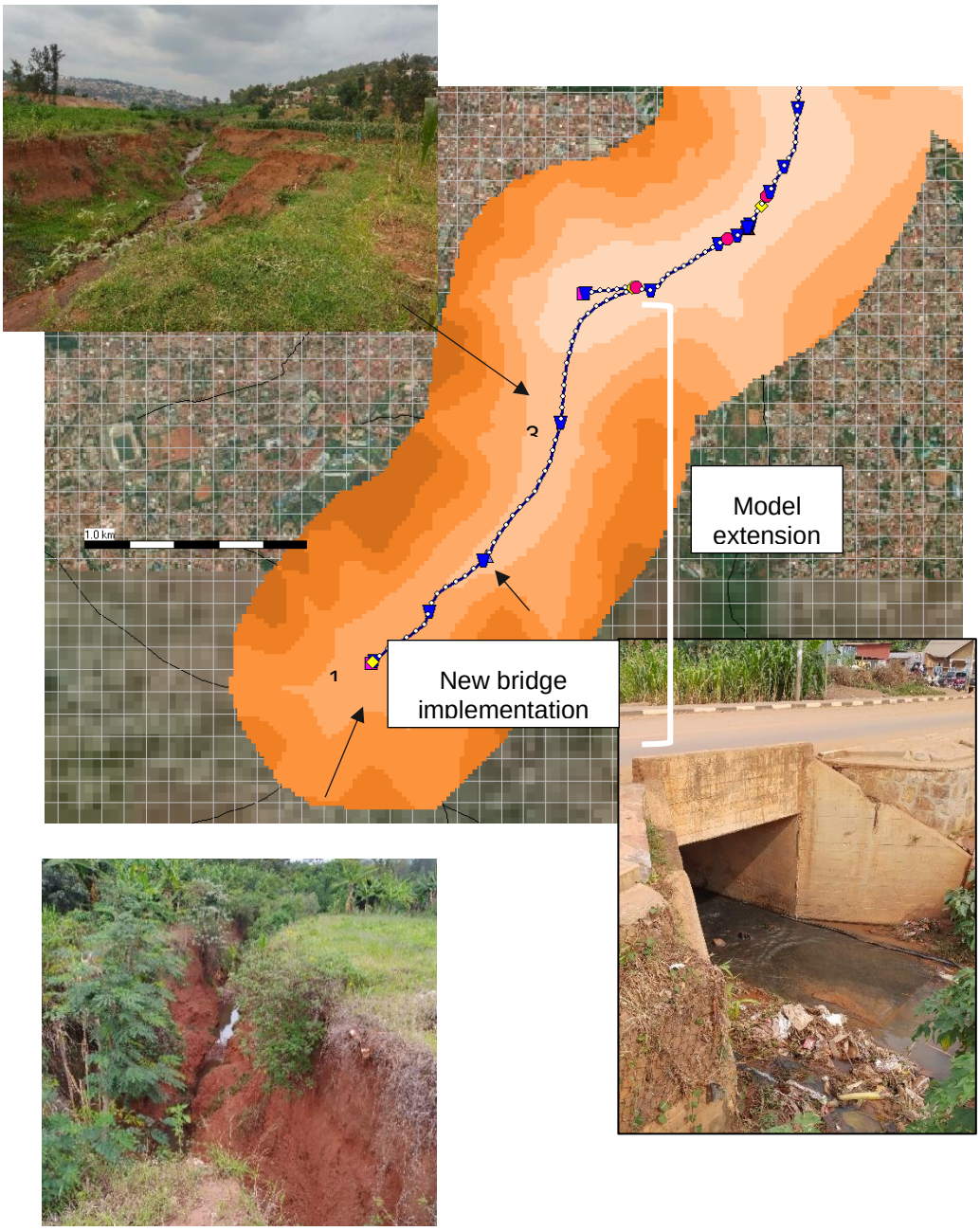


FIGURE 4-66: CROSS SECTIONS IMPLEMENTATION FOR THE MODEL EXTENSION IN THE SOUTH PART OF RWAMPARA

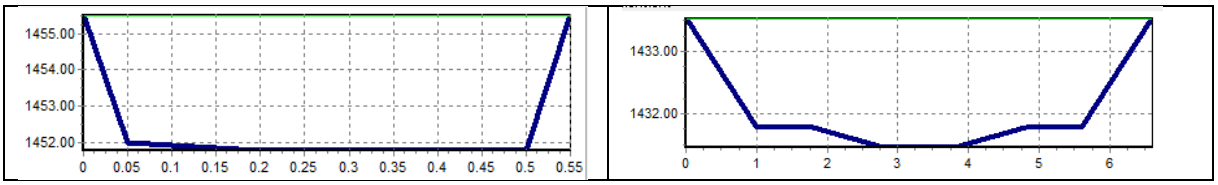


FIGURE 4-67: CROSS SECTIONS IMPLEMENTED IN THE NEW MODEL N°1 (LEFT) AND N°2 (RIGHT)

4.8.3.2 Kibumba

The 1D hydraulic model has been extended for approximately 1.2 km in the north part of Kibumba. Upstream of this branch the cross section is characterized by a small width (0.5 to 1.5 m) and small riverbank levees (0.4 – 0.6 m) (see figure below). A bridge is crossing the river on the KG 449 St where water flow underneath through a 0.5 m diameter pipe.



FIGURE 4-68: CROSS SECTIONS IMPLEMENTATION FOR THE MODEL EXTENSION IN THE NORTH PART OF RWAMPARA

4.8.4 Hydraulic model calibration and validation

The process of calibration and validation of the hydraulic model are established according to the measurement campaign results.

4.8.4.1 Additional hydraulic measurements

4.8.4.1.1 Objectives

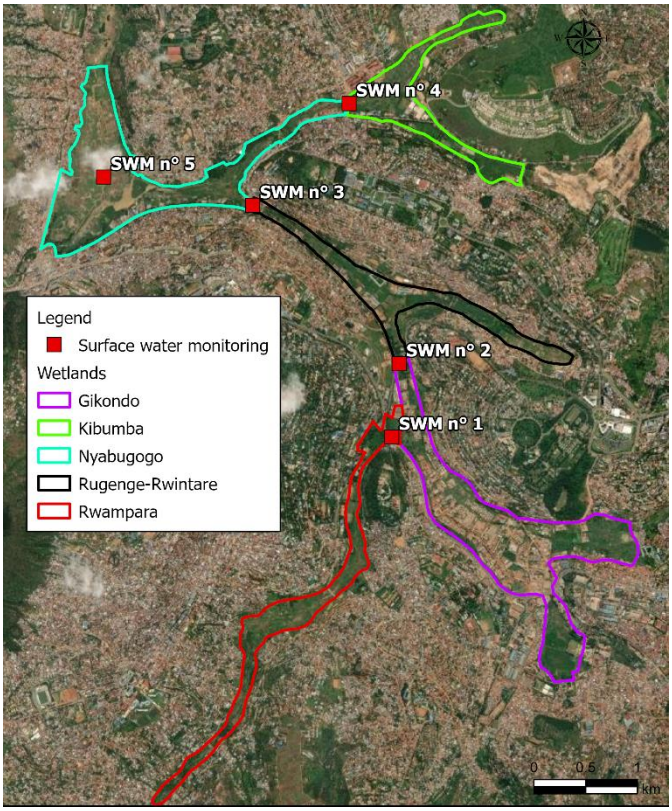
In order to enhance the models' accuracy, implementing some new water level is deemed necessary. These additional measurements aim to provide a better understanding on the water quantity flowing in and out of the wetlands (including flash floods and unsteady flows).

Additional groundwater and surface water monitoring station have been implemented from the 14th of April to the 26 of May 2022. Over this period, the simulated groundwater and water level will be compared to the field observations (obtained during the measurement campaign). The groundwater level will be used to calibrate the hydrological model (wflow) when the water level will be used to calibrate the hydraulic model (SOBEK). In both cases, some parameters will be adjusted for the results of the model to best fit the observed values.

Due to the tight schedule of the study, the measurement campaign last only six weeks covering only one part of the rainy season. The dry season will be partially assessed through the campaign. It is foreseen to implement additional measurement during the detailed design on groundwater level – it will be possible to fine-tune the model calibration, especially the low flow conditions.

4.8.4.1.2 Method

Five measurement stations have been installed (see figure below for the location). For each station, a water level gauge has been installed next to their bridge and the water level is surveyed each 10 minutes. Flow data will be collected from the 14th of April to the 26th of May 2022.



	X	Y	Z0
SWM n°1: Rwampara	508322.605	4783806.35	1372.700
SWM n°2: Gikondo	508338.414	4784475.24	1369.690
SWM n°3: Rugenge	506928.277	4786012.95	1359.685
SWM n°4: Kibumba	507851.525	4786977.98	1362.439
SWM n°5: Nyabugogo	505495.301	4786262.95	1356.623

FIGURE 4-69: SURFACE WATER MONITORING STATION LOCATION

Photos of water level gauge installation in Gikondo, Rugenge and Nyabugogo for examples, are presented below.



FIGURE 4-70: WATER LEVEL GAUGE INSTALLATION IN GIKONDO (LEFT), RUGENGE (MIDDLE) AND NYABUGOGO (RIGHT)

4.8.4.1.3 Results and assessment of the current flood control performance based on the monitoring campaign

The graph below shows the results of the monitoring campaign at each of the 5 locations from the 14th of April to the 26th of May. Results for each wetland is discussed in the next chapters.

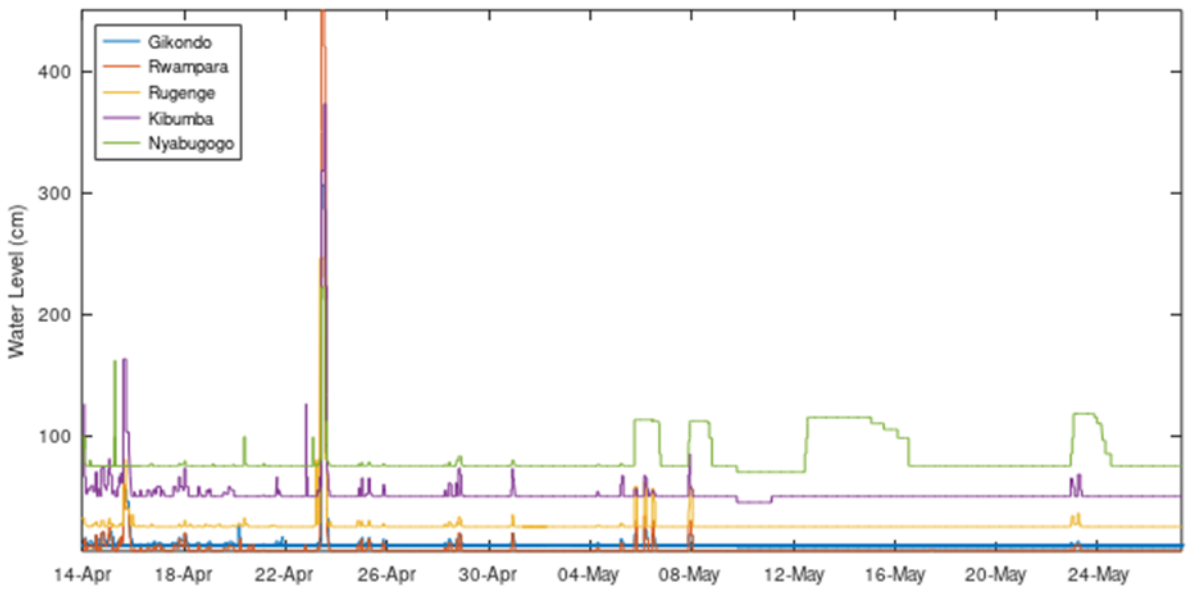


FIGURE 4-71: OBSERVED WATER LEVEL MEASURED AT THE 5 WETLANDS LOCATION FROM THE 14TH OF APRIL AND THE 26TH OF MAY

Gikondo

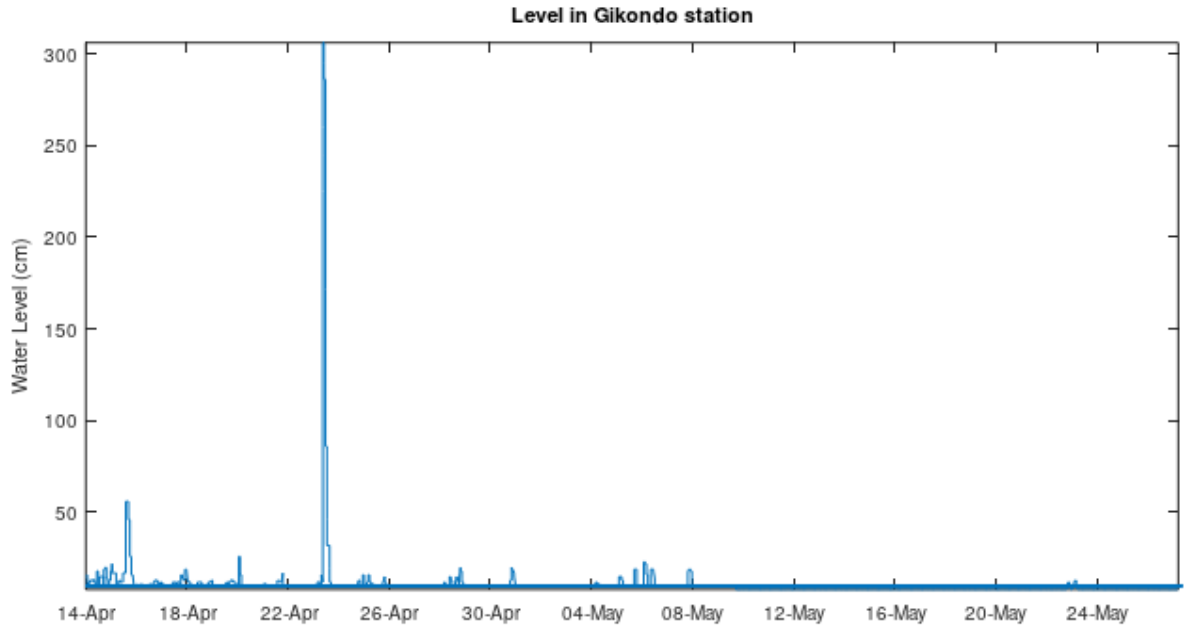


FIGURE 4-72: OBSERVED WATER LEVEL MEASURED AT THE GIKONDO (SWM N°2) WATER LEVEL MONITORING STATION FROM THE 14TH OF APRIL AND THE 26TH OF MAY

The monitoring station is installed at the level of a steel culvert pipe of 4.8 m width and 3 m height (see figure below). After the great rainfall event of the 23th April, the water depth at Gikondo is raised by more than 3 m. Thus, for this rainfall event, the culvert is completely full, implying water to stagnate and potential floods to occur upstream. For other rainy recorded days, the water level at this station is slightly increased (by maximum 50cm) and is not responsible for any flooding.



FIGURE 4-73: CULVERT SIZE IN THE MONITORING STATION OF GIKONDO (SWM N°2)

Rwampara

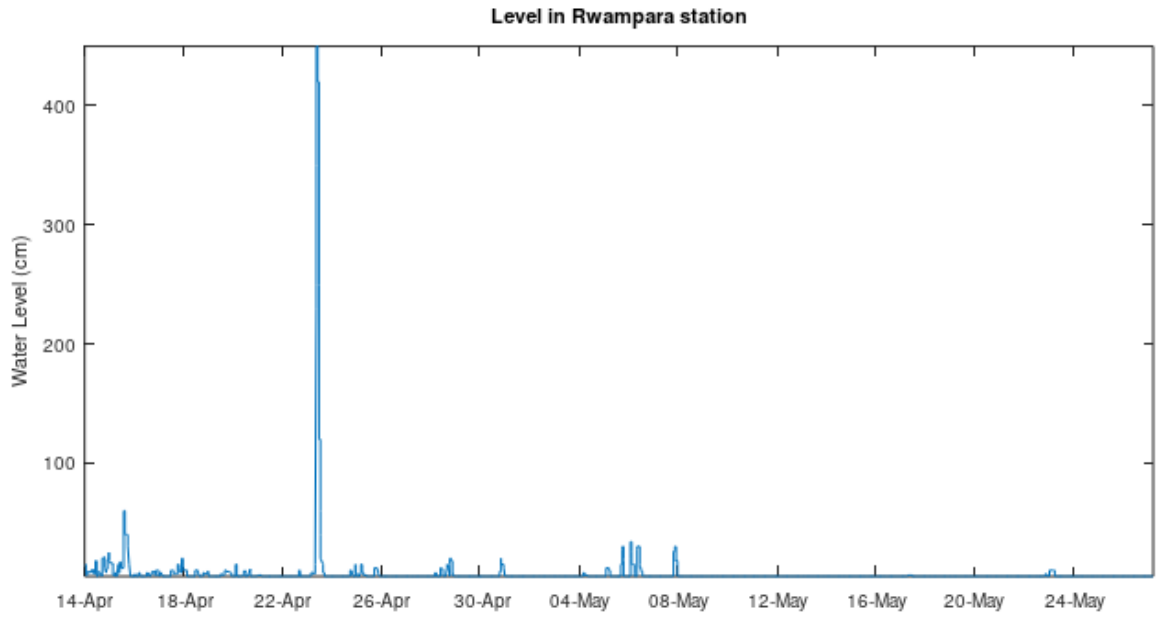


FIGURE 4-74: OBSERVED WATER LEVEL MEASURED AT THE RWAMPARA (SWM N1) WATER LEVEL MONITORING STATION FROM THE 14TH OF APRIL AND THE 26TH OF MAY

The monitoring station is installed upstream the bridge 127haracterized by a 2 steel egg-shaped pipes with a 30.95 m length, a height of 3 m each and a diameter of 3,15 m. After the great rainfall event of the 23th April, the water depth at Rwampara is raised by more than 4 m. Thus, for this rainfall event, both pipes are completely full, implying water to stagnate and potential floods to occur upstream. For other rainy recorded days, the water level at this station is slightly increased (by maximum 50cm) and is not responsible for any flooding.

Rugenge

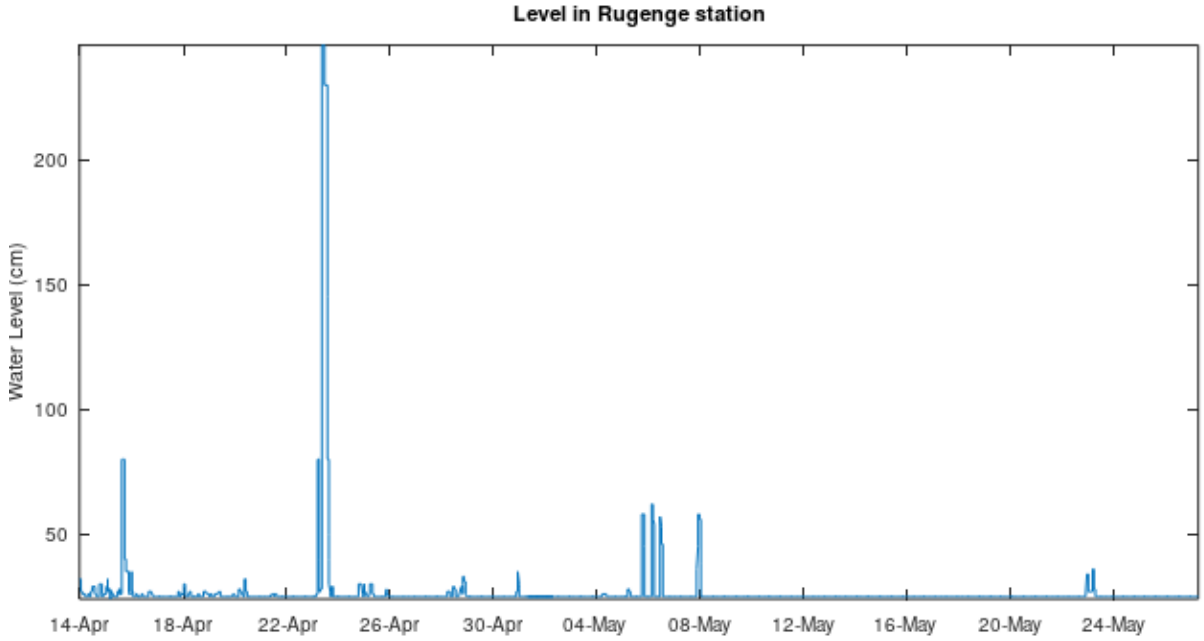


FIGURE 4-75: OBSERVED WATER LEVEL MEASURED AT THE RUGENGE (SWM N°3) WATER LEVEL MONITORING STATION FROM THE 14TH OF APRIL AND THE 18TH OF MAY

The monitoring station is installed upstream the bridge 127haracterized by a 2 steel egg-shaped pipes with a 21.42 m length, a height of 2.9 m each and a diameter of 4,9 m. After the great rainfall event of the 23th April,

the water depth at Nyabugogo is raised by more than 3.5 m. Thus, for this rainfall event, both pipes are completely full, implying water to stagnate and potential floods to occur upstream. It is to be highlighted that the water level at this station is raising very rapidly. For instance, on the 16th of April, the water raised from 26 to 80 cm in several couple of minutes. It is the sign of an upstream very fast flow of water partly caused by the concrete collection network but also by the topography of the city involving an important and fast runoff.

Kibumba

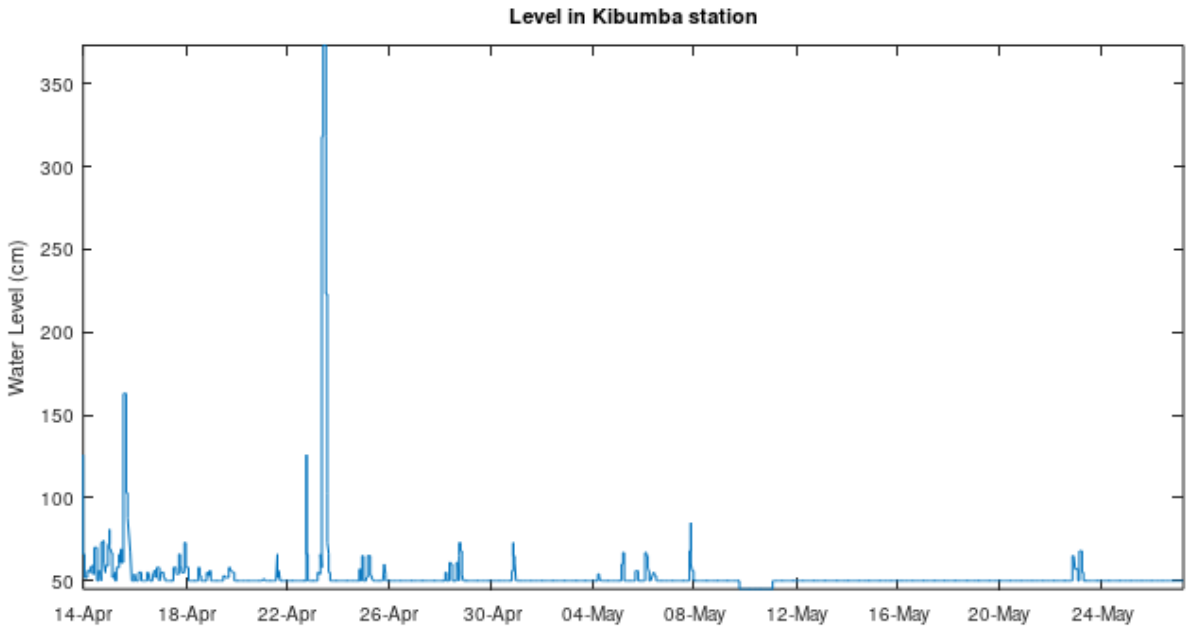


FIGURE 4-76: OBSERVED WATER LEVEL MEASURED AT THE KIBUMBA (SWM N°4) WATER LEVEL MONITORING STATION FROM THE 14TH OF APRIL AND THE 26TH OF MAY

The monitoring station is installed at the level of a 2 concrete pipes of a length of 14m and a diameter of 1 m each. The baseline water level is at a constant level of 50 cm. As it can be seen, for each of the rainy event, the water level is raising rapidly and significatively. The pipes are full when the level is reaching 1m which occurs three times in the surveyed period even with some medium rainfall event (on the 15th of April with 2.8 mm of cumulative daily precipitation). Based on these observations, it is clear that the cross section under this bridge is undersized.

Nyabugogo

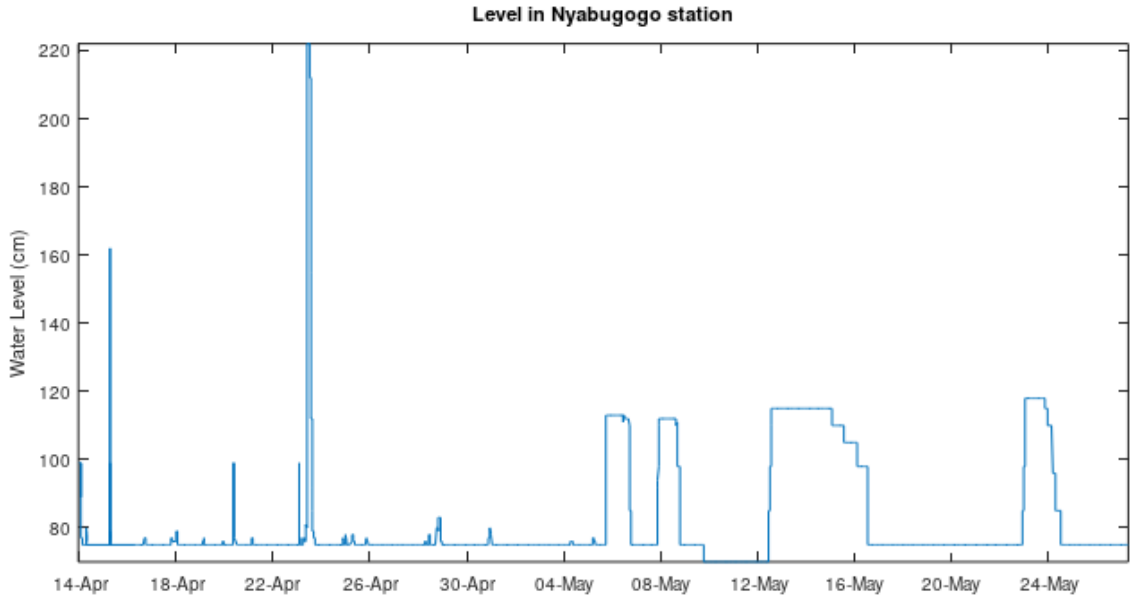


FIGURE 4-77: OBSERVED WATER LEVEL MEASURED AT THE NYABUGOGO (SWM N°5) WATER LEVEL MONITORING STATION FROM THE 14TH OF APRIL AND THE 26TH OF MAY

The monitoring station is installed on the downstream left side of a bridge in Nyabugogo wetland. For the three first rainy events, the water level is raising and decreasing rapidly whereas for the rainfall events of the 6th and the 8th of May the water level stays at 120 m for a longer period. This can be caused by a longer rainfall period event which does not allow the water level to go down.

4.8.4.1.4 Dry season

Due to the tight schedule of the study, the measurement campaign last only six weeks covering only one part of the rainy season. The dry season is partially assessed through the campaign. It should be possible to implement additional measurement for one year long on groundwater level – in order to fine-tune the model calibration, especially the low flow conditions.

Hydraulic simulation in a long period will be provided in the final version of the report, including proposed actions for wetland rehabilitation and proposed infrastructure for hotpots situation improvement.

4.8.4.2 Hydraulic model calibration

The calibration period has been set to 10 days between the 21st of April and the 1st of May represents. The episode includes one extreme event with a 55.8 mm cumulative rainfall happened on the 24th of April.

The hydraulic model was calibrated considering these data for each wetland.

It appears that the model is globally well calibrated and can be used for sizing in the preliminary studies (action sheets presented together with the feasibility report) and, above all, the detailed studies which will begin shortly.

- Gikondo and Rwampara present a very similar trend in the model as the on-site measurement.
- In Kibumba the water level is underestimated which can be explained by an underestimating runoff from Wflow model as well as a bias in the fieldwork conducted
- Rugenge's wetland is calibrated for the water level as both peak (on-site and hydraulic model) corresponds, but the response of the hydraulic model is slower which leads to a slower decrease of the water level for the model compared to the on-situ measurement.
- The calibration for Nyabugogo is more difficult to be assessed since downstream conditions are very difficult to estimate correctly, especially the evacuation capacity of Nyabugogo river downstream of the bridge of Kigali-Gatuma road

According to discussions we had with RWB, adaptation of the IBC-SGI model was implemented for the specific part of Nyabugogo river catchment to improve its accuracy. Only a small part of the Nyabugogo River could be modelled as it is part of our study area, whereas the upstream catchment is very large.

That is why few adjustments were needed to improve the calibration of the model. The main reason of these adjustments was a difference between our measurements on site and the simulation results regarding the water level in the Nyabugogo wetland.

The discrepancy observed earlier can be explained by Wflow results. Indeed, for our design storms and calibration event, the main data comes from the meteorological station of Gitega which is on the south of Kigali. Using the same rain on the north of Kigali that has bigger catchments has a tendency of overestimating the runoff coming from this area.

To correct this, we decided to apply a correction coefficient based on the distance between the point of runoff injection and the meteorological station that was the source of the data, mainly Gitega. This coefficient act like an invert distance weighting coefficient. Therefore, the runoff coming from the northern catchments of the Nyabugogo wetland is reduced compared to the runoff that is coming from the catchments that are closer to the Gitega station.

Once the correction made, the water level has the same magnitude order than the on-site measurements. However, the water level in the hydraulic model takes more time to decrease compared to the reality. A possible explanation for this is the fact that in the model, when the channel overflows, as long as there is water on the 2D grid, it feeds the channel whereas in the reality the overflow water is less connected to the channel.

Based on this calibration the various scenarios have been implemented with uèdated results for Nyabugogo and Rugenge.

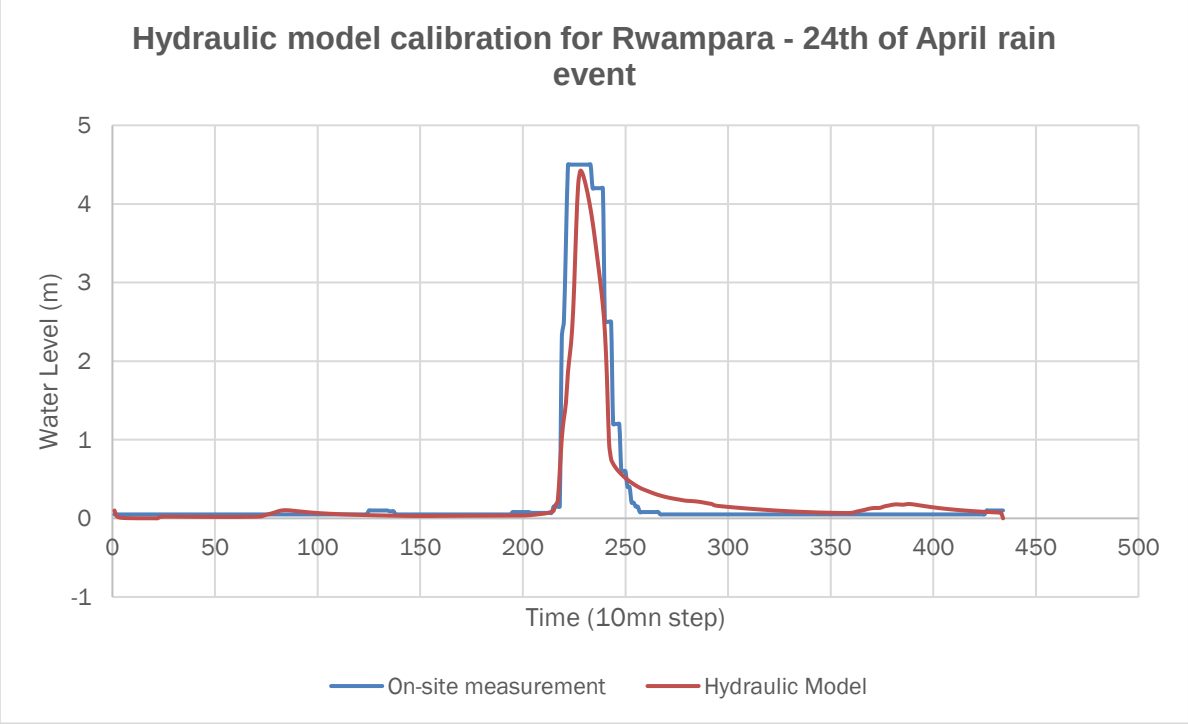


FIGURE 4-78 HYDRAULIC MODEL CALIBRATION FOR RWAMPARA

Rwampara offers a very good Calibration, the intensity and the amplitude of both the on-site measurement and the Hydraulic model perfectly overlap.

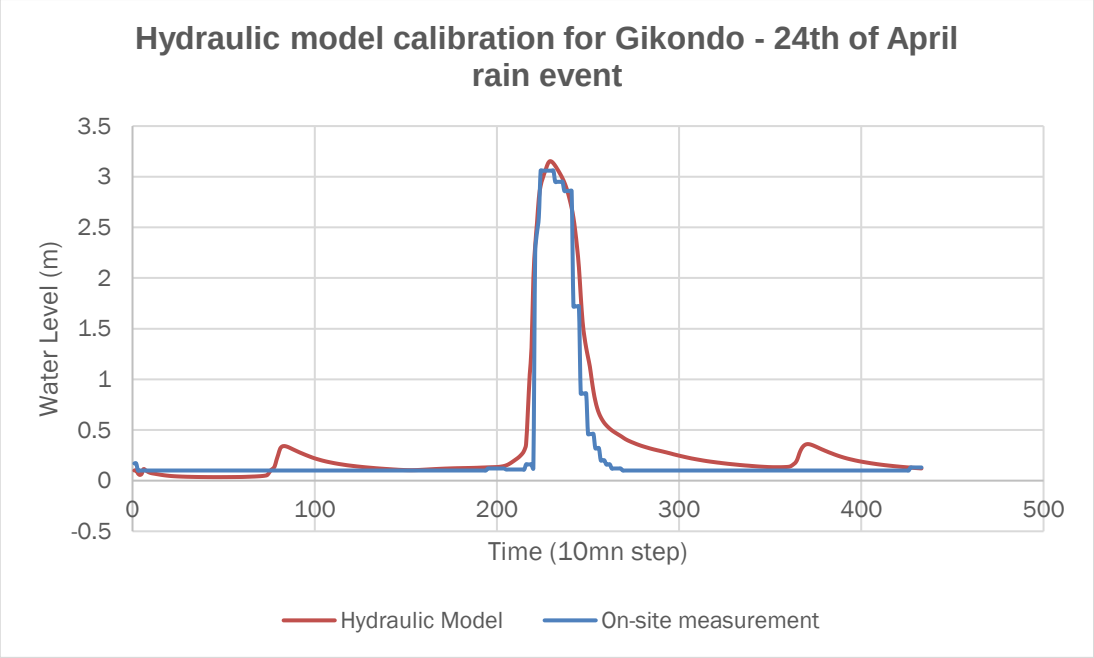


FIGURE 4-79 HYDRAULIC MODEL CALIBRATION FOR GIKONDO

Gikondo offers a very good calibration, the intensity and the amplitude of both the on-site measurement and the Hydraulic model perfectly overlap.

Small increases in level indicated by the model are not observed in the field, these differences are not significant.

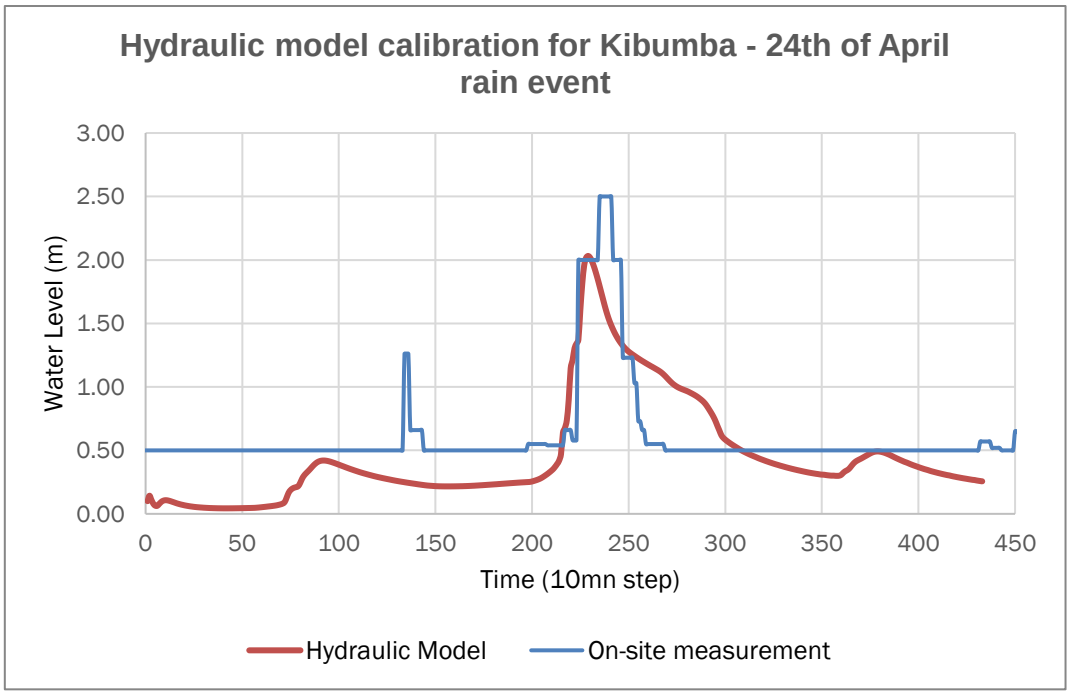


FIGURE 4-80 HYDRAULIC MODEL CALIBRATION FOR KIBUMBA

The model for Kibumba is underestimating the water level observed on the field. This can be explained by:

- a possible underestimation of the built-up area. Indeed, the current land use data (2017) may not be as representative as the situation today for the new built areas
- a possible bias in the measured valued since the reference level may vary for 20/30cm according to the site conditions.

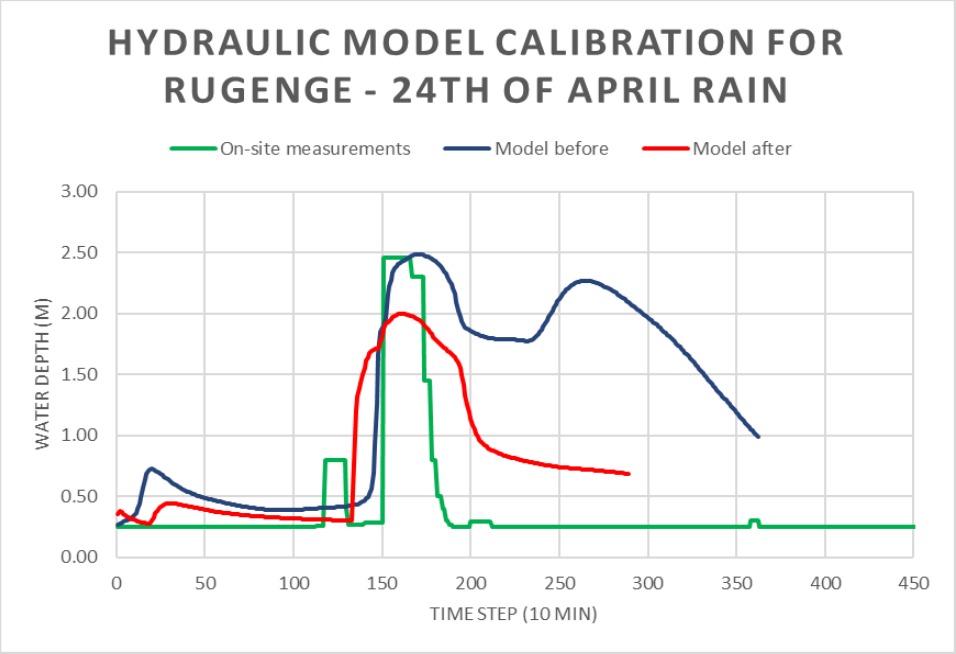


FIGURE 4-81 HYDRAULIC MODEL CALIBRATION FOR RUGENGE

The calibration for Rugenge seems to be better after new calibration:

- the peak between the model and on site-measurement is nearly the same As we are looking at maximum water level to know the maximum inundation depth, this is acceptable.
- The time for water level decrease and return to normal seems to be overestimated is much closer to the observed measurements.

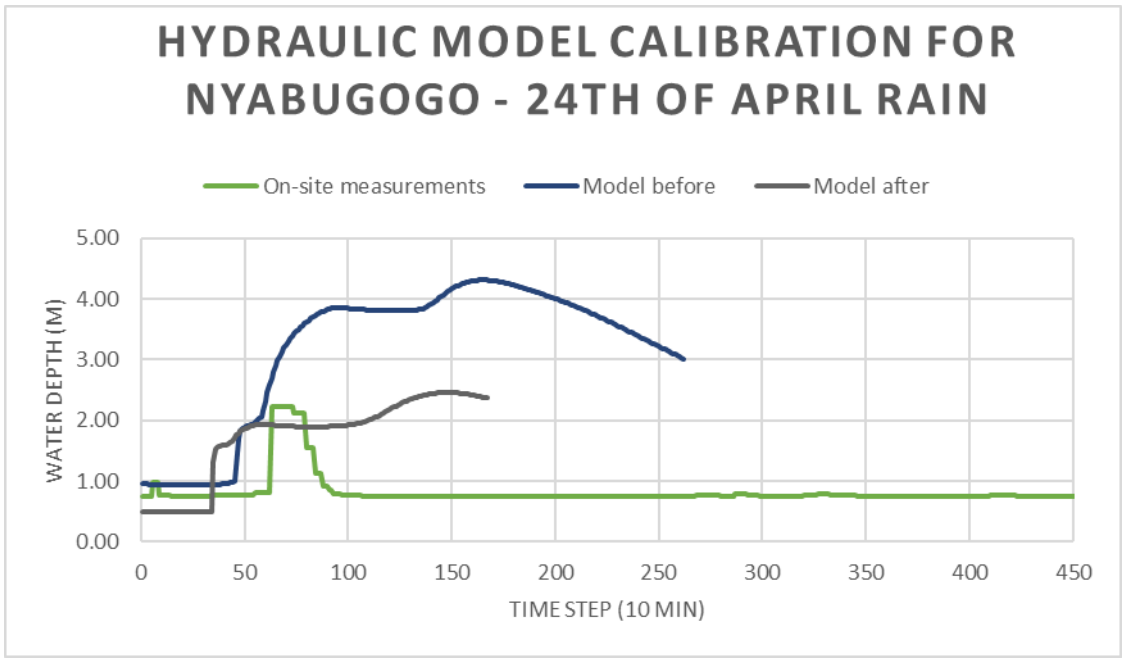


FIGURE 4-82 HYDRAULIC MODEL CALIBRATION FOR NYABUGOGO

The calibration for Nyabugogo is more difficult to be assessed since downstream conditions are very difficult to estimate correctly, however it seems to be better after new calibration.

- Nyabugogo wetland is at the end of a very big watershed. The total area of the watershed is about 166’000 ha. Because of this huge area many parameters even small error in the dataset can lead to a big error. Therefore, it is hard to calibrate perfectly such an enormous area. The hydraulic model is overestimating the water level in Nyabugogo coming from the north.

- We observe that the increase in water is created by a significant increase in level downstream and is not related to a problem of drainage capacity within the wetland itself
- The analysis of the evolution of maximal water level on the longitudinal profile especially the evacuation capacity of Nyabugogo river downstream of the bridge of Kigali-Gatuma Road. This downstream boundary condition is fundamental

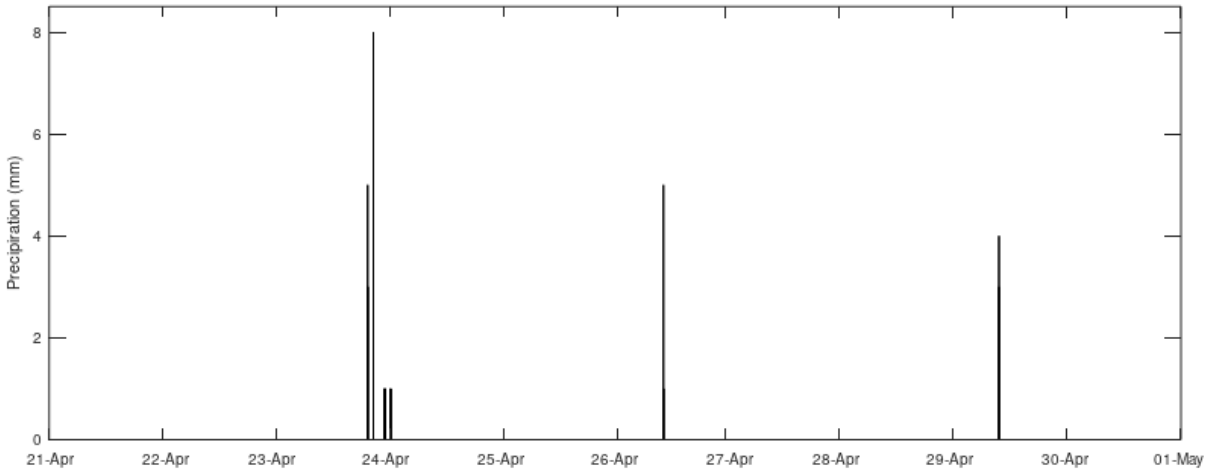


FIGURE 4-83 GITEGA RAINFALL DURING THE RAINFALL CALIBRATION PERIOD

4.8.5 Model in the current landscape

The results of the updated hydraulic model are presented here below. For each wetland the following scenarii were simulated and the results are presented:

TABLE 4-12 SUMMARY OF THE DIFFERENT SCENARII

Land Use	Climate Change	Return period time
2017	Current	10 years
2017	Current	50 years
2017	Current	100 years
2050	Extreme	10 years
2050	Extreme	50 years
2050	Extreme	100 years

For additional parts of the model, lateral flows have been allocated to specific points downstream of the connected catchment in order to consider all the watershed. Below an example is provided with the discharge for the different return period event. Indeed, the sub-catchment considered is in blue and is attributed to the lateral flow number 17 which the latter is a water inlet for the considered wetland (Kibumba).

Details of all hydrographs will be provided in an annex to the final report.

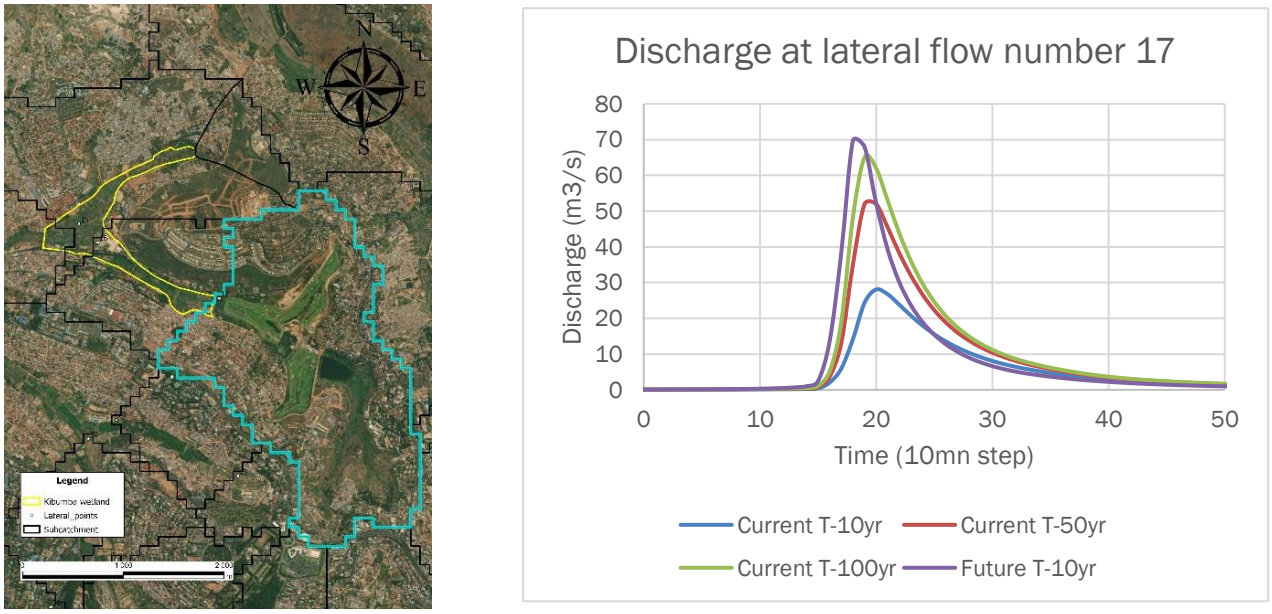


FIGURE 4-84 LOCALISATION AND DISCHARGE FOR ONE OF KIBUMBA INLET

4.8.5.1 Model results - general comments

The model shows an increase of the water level as the return-period event increase.

The scenarios with land use projections in 2050 increase the flooded regions, compared to the current landscape with an event of a return period of 10year, as more impervious areas have been built, which results in increased surface runoff. To avoid future flooding events this will have to be addressed in the planning of rehabilitation scenarios.

Maps are presented here after for each wetland with:

- Results of hydraulic simulations for return period 10, 50 and 100 years
- Elevation maps with accurate elevation data (updated LIDAR)

4.8.5.2 Model results in Gikondo

The observations are the following:

- For all-return period events, the southern arm is greatly flooded with 0.16 to 2 m water depth. The arm is acting as a natural basin, the lowest point at the southeast part of the wetland being at 1404 m whereas the exit point is at 1402 m. The small slope between the inlet and the outlet of the branch, enhanced by the presence of ditches dug for the agriculture force water to stagnate.
- In the east part of the north branch, water is wash out in the existing drains and does not accumulate on the surrounding terrain since the slope is important enough for the water to flow rapidly. In the remaining part of the northern branch, water accumulate slightly for the most part and to a greater extent in the lowest points of the terrain
- In the former industrial zone, the water depth is low (0 – 0.5 m), apart from some zones next to the river.
- Near the outlet of the wetland, after the main river branch is joined by the river flowing from Rwampara, the flooding is important (>0.5 m). A large amount of water is drained by the wetland of Rwampara, issue that will need to be addressed in the rehabilitation scenario planification.

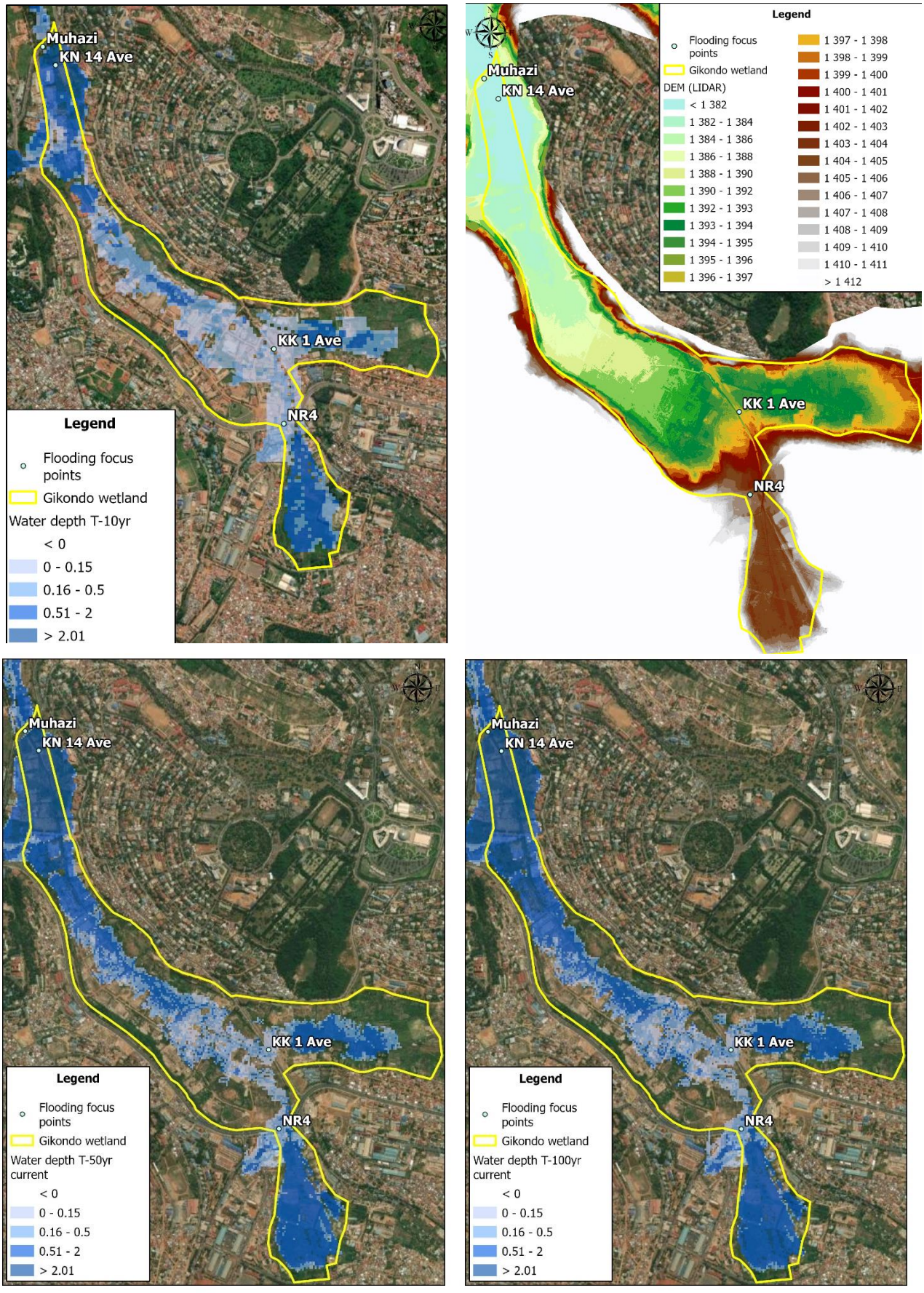


FIGURE 4-85: WATER DEPTH OVER GIKONDO WETLAND FOR DIFFERENT RETURN PERIOD EVENT FOR CURRENT LAND USE AND ELEVATION DATA

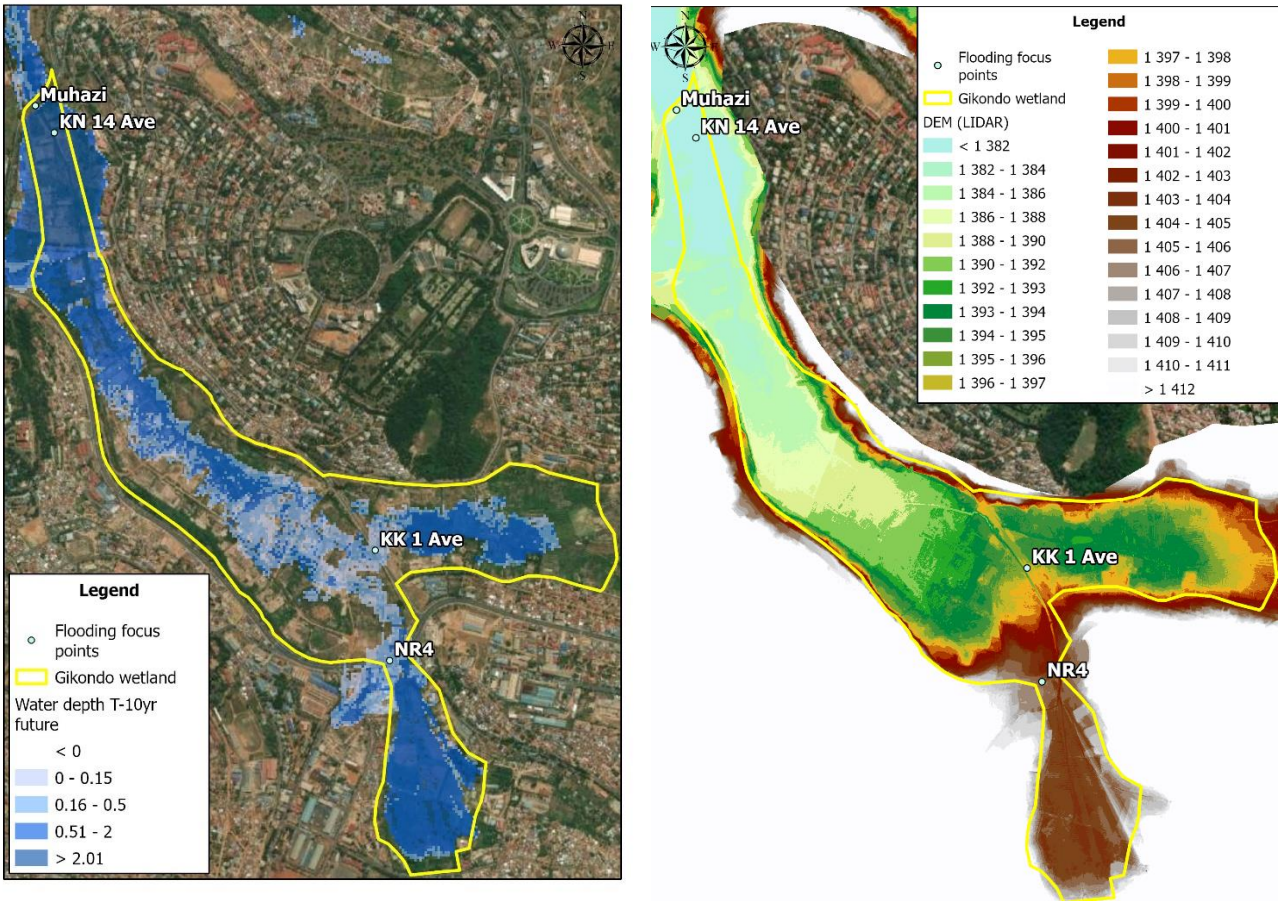


FIGURE 4-86 WATER DEPTH OVER GIKONDO WETLAND FOR A 10-YEAR RETURN PERIOD EVENT FOR FUTURE LAND USE (LEFT) AND ELEVATION DATA (RIGHT)

In Gikondo the inundation area increases, and the water level of the inundation is getting more important with the increase of the return period event.

The future projection also increases the inundation area and the water level of the inundation.

4.8.5.3 Model results in Rwampara

The flood extent maps for different return periods for both the current and the future land use scenario are presented below, as well as the elevation information of the concerned wetland.

The observations are the following:

- The upstream part of Rwampara is very narrow, the water is flowing rapidly, and flooding occurs (information confirmed by inhabitants living in the upstream part of Rwampara). Going a bit downstream, the water level is greater in the river as it is expected and is uniformly distributed in more flat part of the studied area.
- Between the bridge at KK 2 Ave and Avenue des Poids Lourds NR4, the water depth is high (0.5 m and higher). This section corresponds to a concrete channel collection system where the water is speeded, and the infrastructures are much probably under sized causing flooding to occur.
- Once again because of the densification of the urban and suburban zones in the future the wetland faces floods over a larger area with higher water levels.

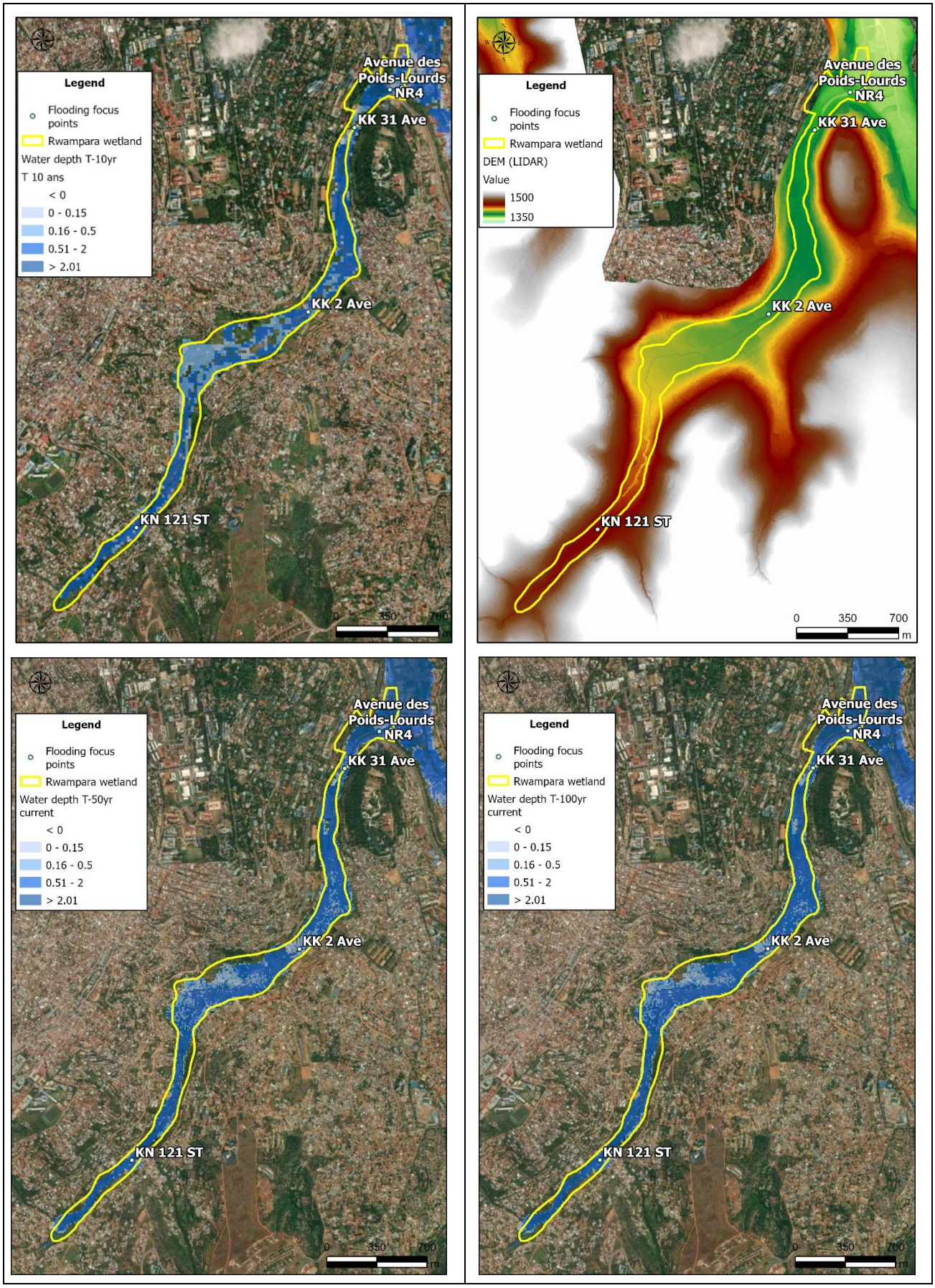


FIGURE 4-87: WATER DEPTH OVER RWAMPARA WETLAND FOR DIFFERENT RETURN PERIOD EVENT FOR CURRENT LAND USE AND ELEVATION DATA

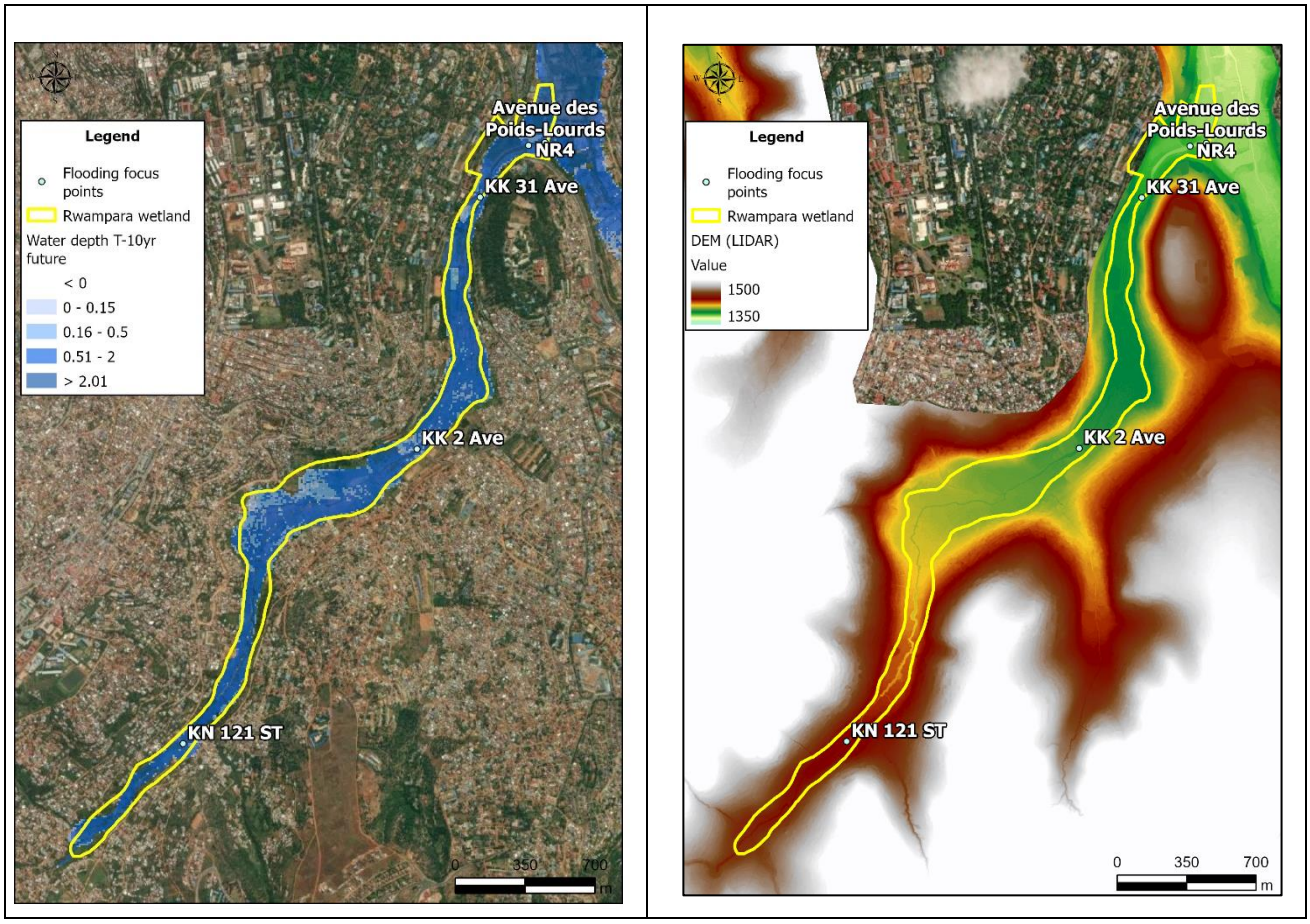


FIGURE 4-88 WATER DEPTH OVER RWAMPARA WETLAND FOR A 10-YEAR RETURN PERIOD EVENT FOR FUTURE LAND USE (LEFT) AND ELEVATION DATA (RIGHT)

In Rwampara the inundation area increases, and the water level of the inundation is getting more important with the increase of the return period event.

The future projection also increases the inundation area and the water level of the inundation.

4.8.5.4 Model results in Rugenge

The flood extent maps for different return periods for both the current and the future land use scenario are presented below, as well as the elevation information of the concerned wetland.

The observations are the following:

- For a all-year return period, the eastern arm of the branch is not flooded at the exception of the upstream part of the bridge KG 3 Ave. For this branch, the slope is important enough for the water to flow correctly and not accumulate.
- The bridge at KG 3 Ave is acting as a small retention tank as the cross section is too small and not sized for a 10-year return period (see figure below). As the DEM shows, the main branch of Rugenge wetland is rather flat and the river level banks are not very accentuated, causing flooding to occur. The dimension of the Rug. and the KN 21 St bridges are undersized.



FIGURE 4-89: CROSS SECTION BELOW THE KG 3 AVE ROAD

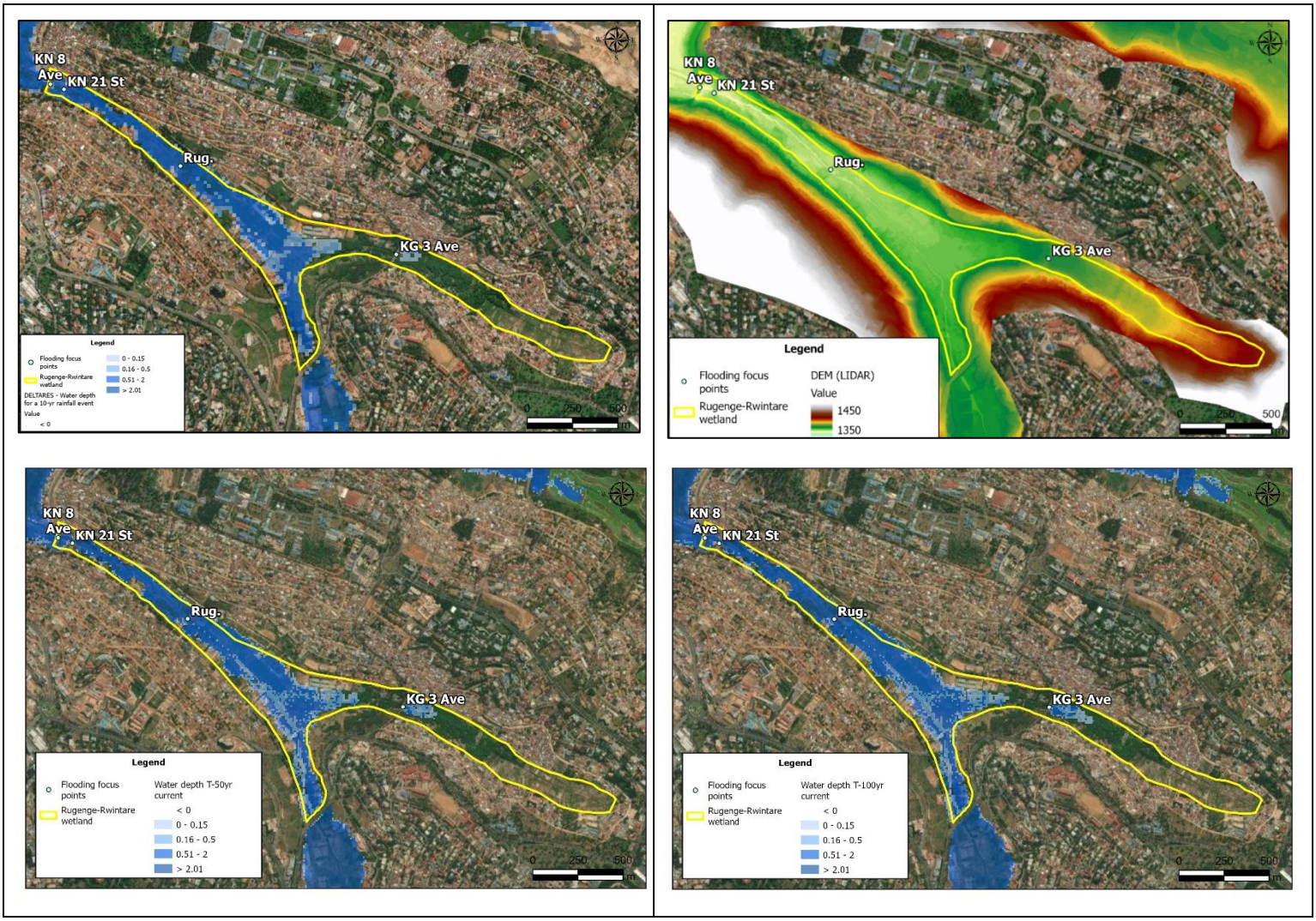


FIGURE 4-91 WATER DEPTH OVER RUGENGE WETLAND FOR DIFFERENT RETURN PERIOD EVENT FOR CURRENT LAND USE AND ELEVATION DATA

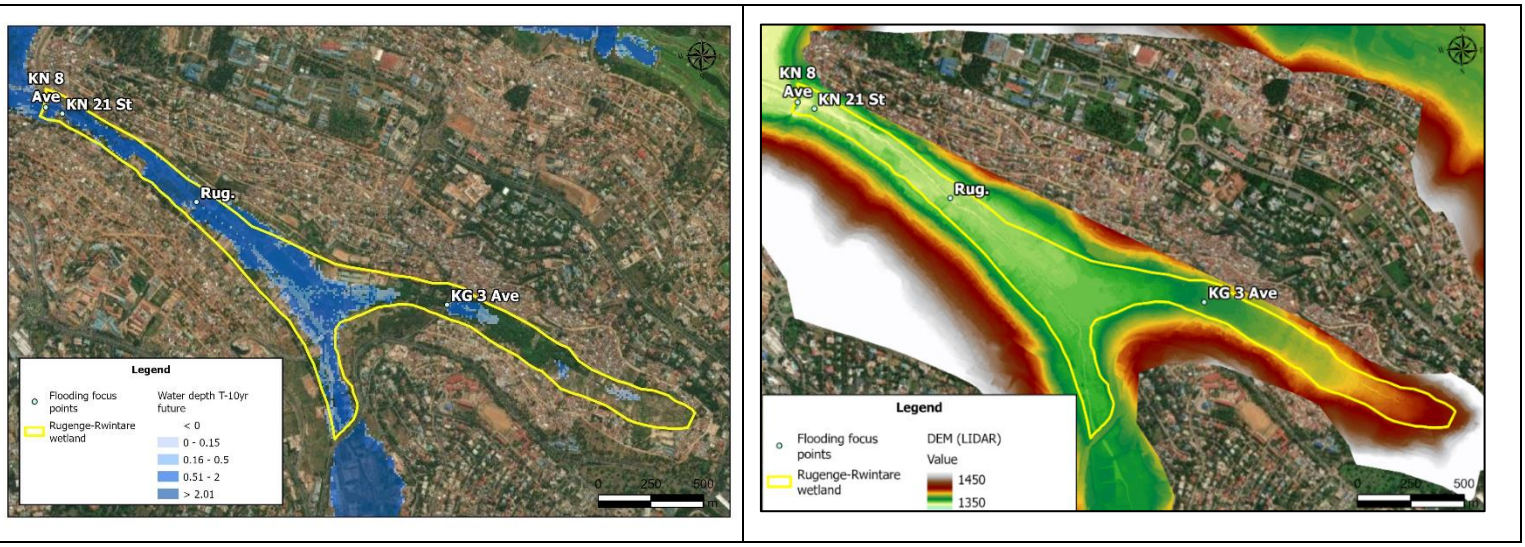


FIGURE 4-90 WATER DEPTH OVER RUGENGE WETLAND FOR A 10-YEAR RETURN PERIOD EVENT FOR FUTURE LAND USE (LEFT)AND ELEVATION DATA (RIGHT)

In Rugenge the inundation area increases, and the water level of the inundation is getting more important with the increase of the return period event.

The future projection also increases the inundation area and the water level of the inundation.

4.8.5.5 Model results in Kibumba

The flood extent maps for different return periods for both the current and the future land use scenario are presented below, as well as the elevation information of the concerned wetland.

The observations are the following:

- Upstream of the southern and the northern branches of Kibumba, there is no clear river delineation, the water is flowing through small ditches dug for agricultural purposes. Therefore, as soon as there is an important rainfall event, the water is overflowing the ditches and spreading over a uniform zone of same elevation.
- Water accumulates in a more significative way in some lower part of the wetland (e.g some water ponds).
- At the level of the KG 33 Ave the water section is narrowed causing flooding to occur around the river with a greater water depth.

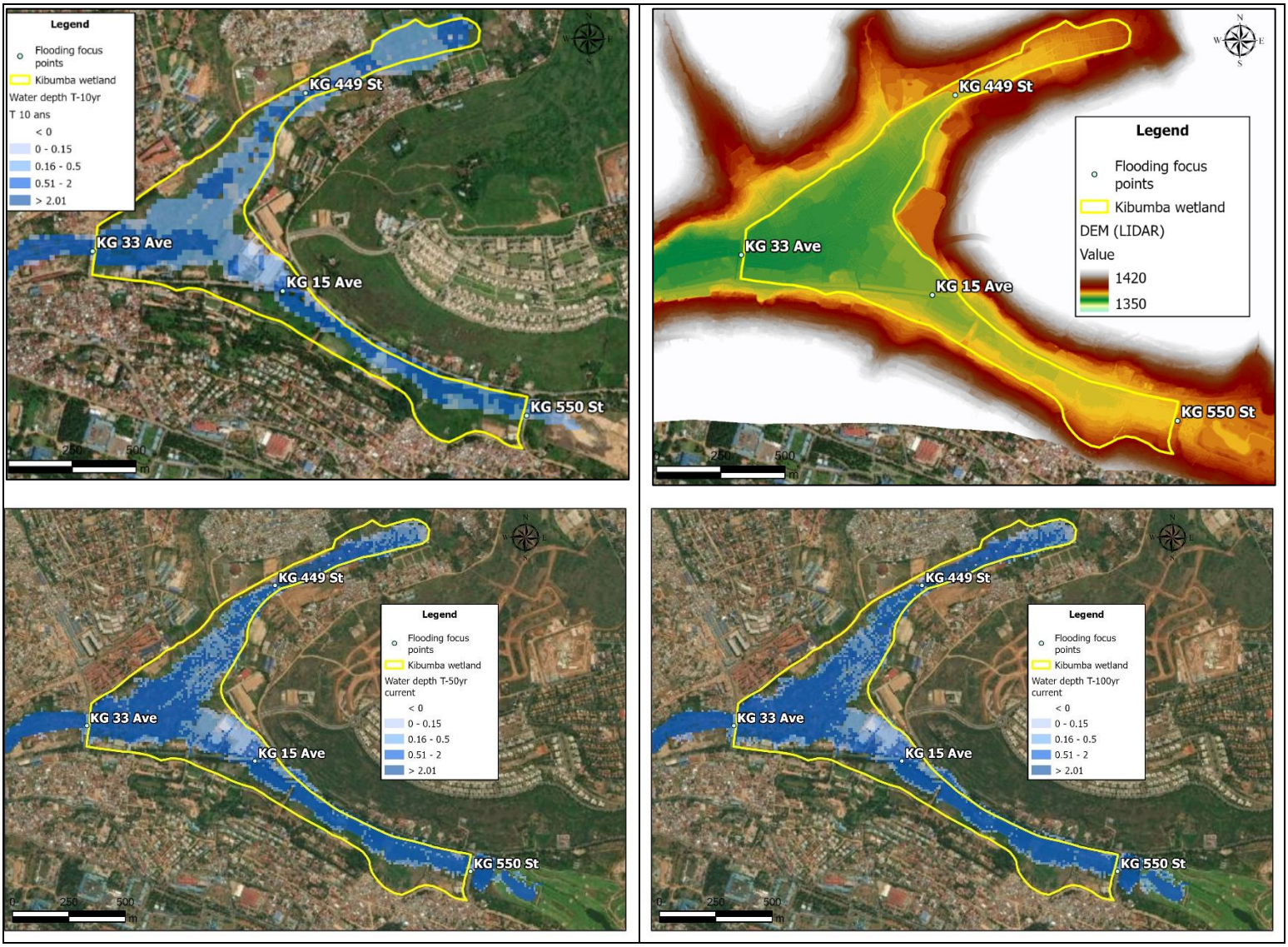


FIGURE 4-92 WATER DEPTH OVER KIBUMBA WETLAND FOR DIFFERENT RETURN PERIOD EVENT FOR CURRENT LAND USE AND ELEVATION DATA

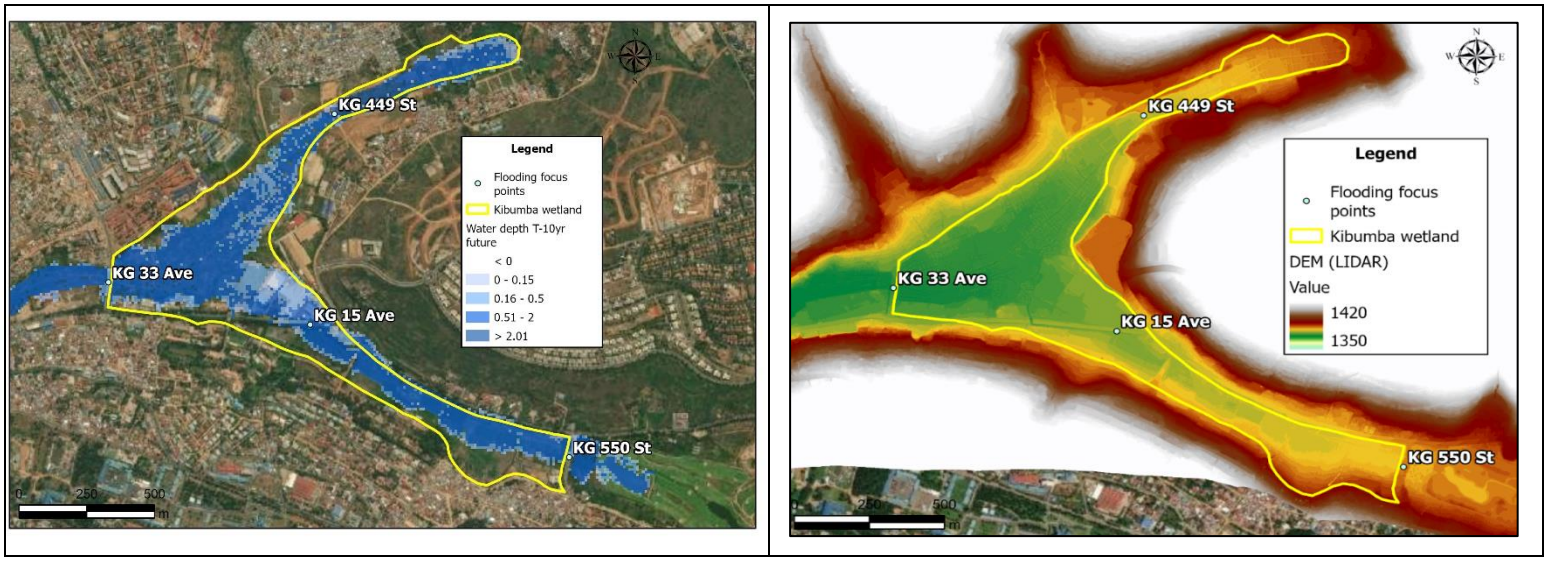


FIGURE 4-93 WATER DEPTH OVER KIBUMBA WETLAND FOR A 10-YEAR RETURN PERIOD EVENT FOR FUTURE LAND USE (LEFT)AND ELEVATION DATA (RIGHT)

In Kibumba the inundation area increases, and the water level of the inundation is getting more important with the increase of the return period event.

The future projection also increases the inundation area and the water level of the inundation.

4.8.5.6 Model results in Nyabugogo

The flood extent maps for different return periods for both the current and the future land use scenario are presented below, as well as the elevation information of the concerned wetland.

The observations are the following :

- The Nyabugogo wetland is a very flat wetland with elevation not varying from more than 10 m of amplitude. This terrain configuration leads to significant and uniform flooding over the entire wetlands.
- Large part of agricultural terrain is flooded regularly in this wetland according to some local farmers which confirm the model results.

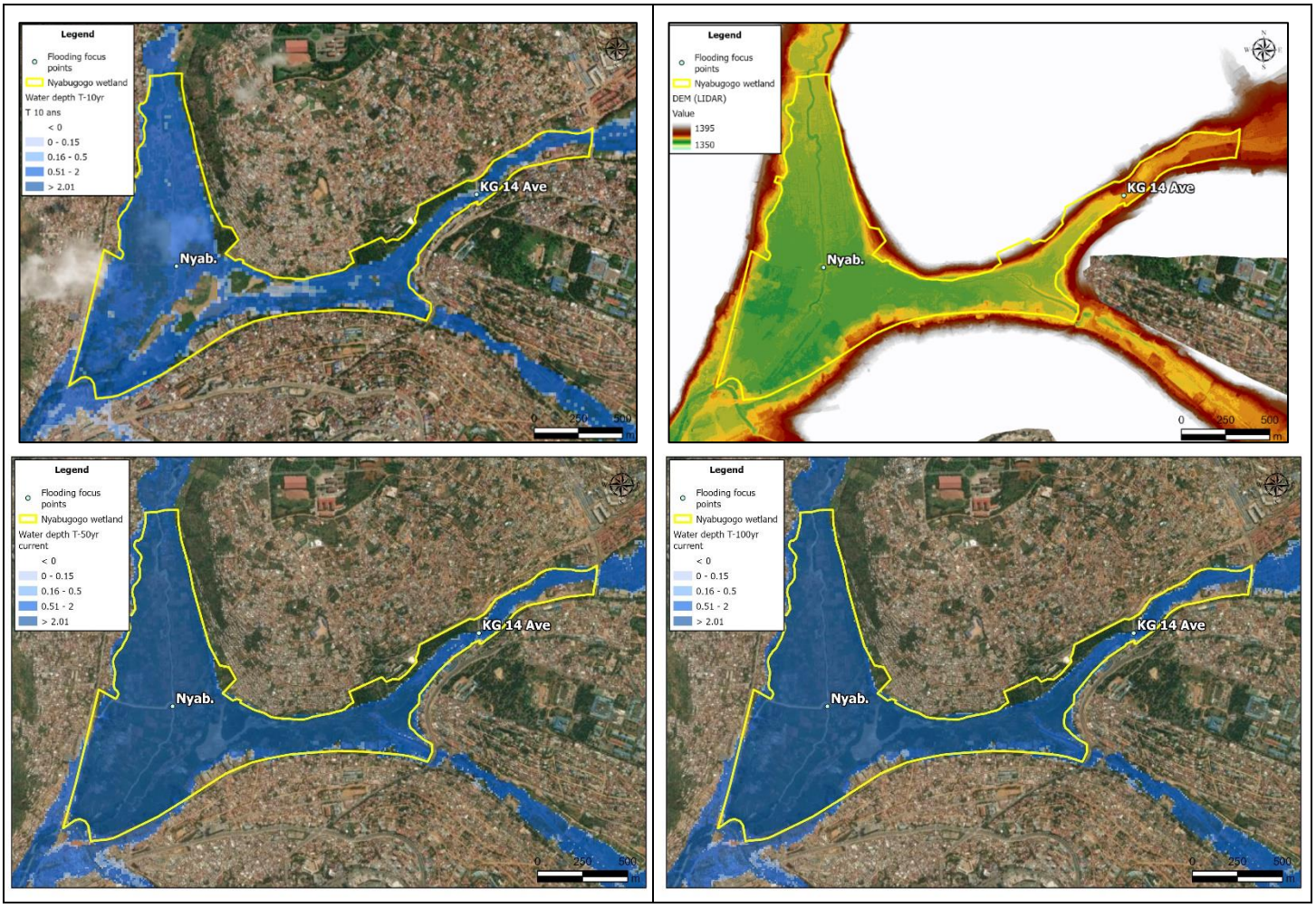


FIGURE 4-94 WATER DEPTH OVER NYABUGOGO WETLAND FOR DIFFERENT RETURN PERIOD EVENT FOR CURRENT LAND USE AND ELEVATION DATA

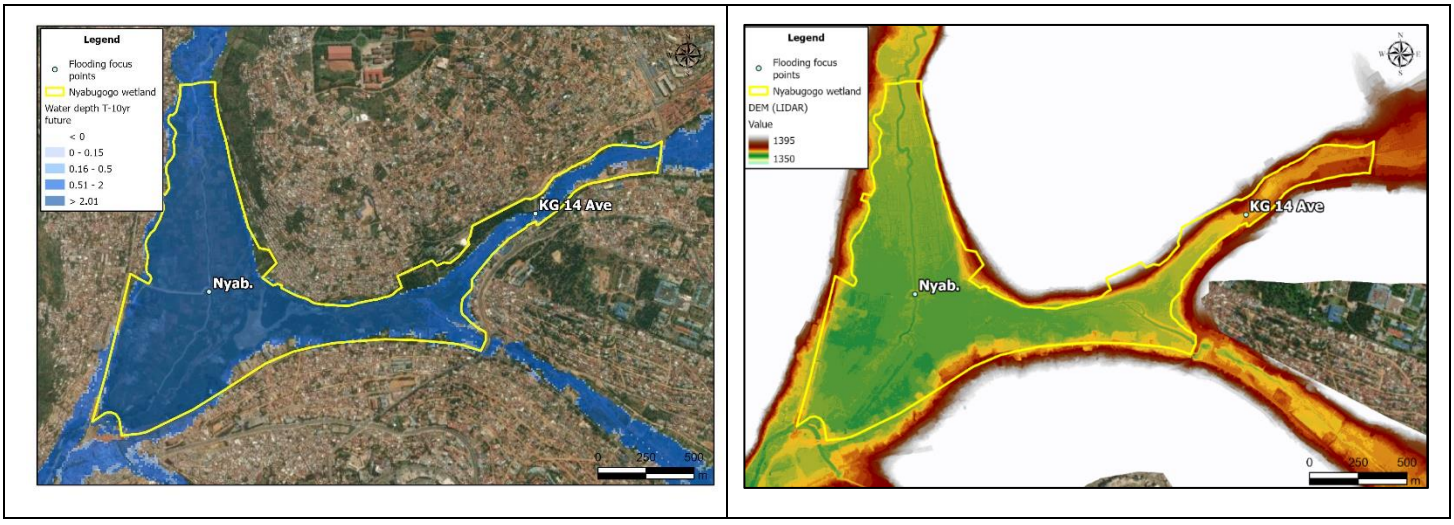


FIGURE 4-95 WATER DEPTH OVER NYABUGOGO WETLAND FOR A 10-YEAR RETURN PERIOD EVENT FOR FUTURE LAND USE (LEFT)AND ELEVATION DATA (RIGHT)

In Nyabugogo the inundation area increases, and the water level of the inundation is getting more important with the increase of the return period event.

The future projection also increases the inundation area and the water level of the inundation.

4.8.5.7 Comparisons between simulation results for the previous and current models (IBC/SGI)

As part of the general assessment of the hydraulic study, the Consultant compared for some specific points the results of hydraulic calculations for previous model (Deltares) and the current calibrated model (IBC-SGI).

The following table is presenting the results for 10, 50 and 100 years return period for current situation. All values are to be considered for current land use and current climate change scenario.

TABLE 4-13 COMPARISONS BETWEEN DELTARES MODEL AND IBC/SGI MODEL / CURRENT SITUATION

Location	Design Event	Water depth Deltares [m]	Water depth IBC/SGI [m]
Gisozi-Mukindo	10	2.1	0.5
	50	2.4	2.0
	100	2.6	2.2
Rugunga	10	2.9	0.8
	50	3.8	1.0
	100	4	1.1
Nyabugogo	10	4	2.8
	50	4.9	3.3
	100	5.2	3.8

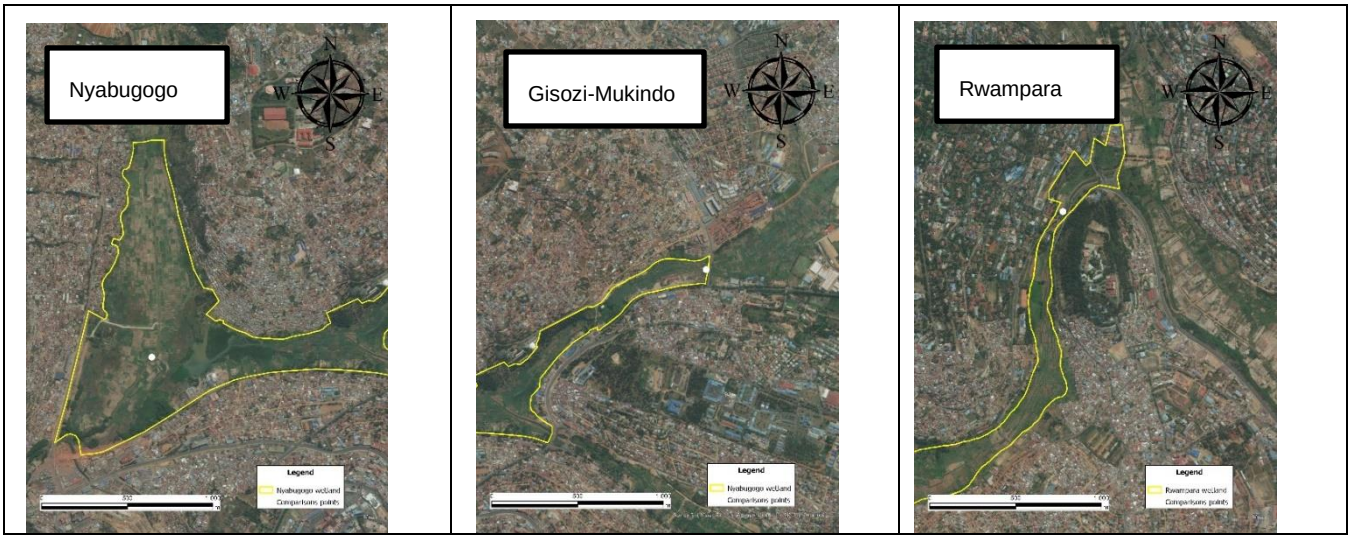


FIGURE 4-96 LOCALISATION OF THE COMPARED POINT BETWEEN DELTARES AND IBC/SGI

The observations are the following :

- The calculated water levels are always higher for Deltares model than for IBC-SGI model. The most likely explanations are that :
  - Deltares model had a DEM less accurate than IBC-SGI one (extracted from very recent LIDAR)
  - Deltares model was only calibrated in 1 point (Nemba) whereas IBC/SGI is calibrated by 5 points.
- Despite the difference in absolute values, the trends and the increases are relatively the sames.

4.8.6 Conclusion on baseline for all five wetlands

The section below presents the results of the current state hydraulic assessment of all wetlands based on the indicators defined in the feasibility study report and on a ten-year return period event.

4.8.6.1 Conclusion on baseline in Gikondo

The table below presents the results of the current state hydraulic assessment of Gikondo based on the indicators defined above. The existing wetland state of development obtain a score of 55 %.

TABLE 4-14 FLOOD MITIGATION AT BASELINE, CRITERIA RANKING MATRIX -GIKONDO

Criterion: Flood mitigation for Gikondo										
Sub-criteria	Ranking system for this criterion									
	No flooding H=0m		**Very low intensity of flood** 0m < H ≤ 0.15m		**Low intensity of floods** 0.15m < H ≤ 0.5m		**Medium intensity of floods** 0.5m < H ≤ 2m		**High intensity of floods** H > 2m	
	10	9	8	7	6	5	4	3	2	1
Sub-Criteria 1: Water depth over road NR4					6 Flooding occurs with some impacts on people or infrastructures. Material damages are expected					
Sub-Criteria 2: Water depth over KK1 Avenue							4 People are at risk but only to a small extent; damage to infrastructure is to be expected			
Sub-Criteria 3: Water depth over KN14 Avenue									2 People are endangered even inside buildings; considerable damage to buildings and infrastructures is to be expected, leading to their destruction	
Sub-Criteria 4: Water depth over Muhazi	10 There is no flooding of infrastructure									

For a 10-yr return period, no flooding occurs on the Muhazi road downstream of Gikondo wetland, but a bit upstream, on the KN 14 Ave flooding is important with a water depth higher than 2 meters which could be responsible for some great damages and traffic perturbations. Smaller water depth values are simulated on the KK 1 Ave and NR4 Ave for the same return period. These issues will need to be addressed in the rehabilitation scenarios to avoid at best flooding on roads. These results do not necessarily demonstrate the state of the wetland to mitigate floods but the overall performance of systems in which the wetland is part.

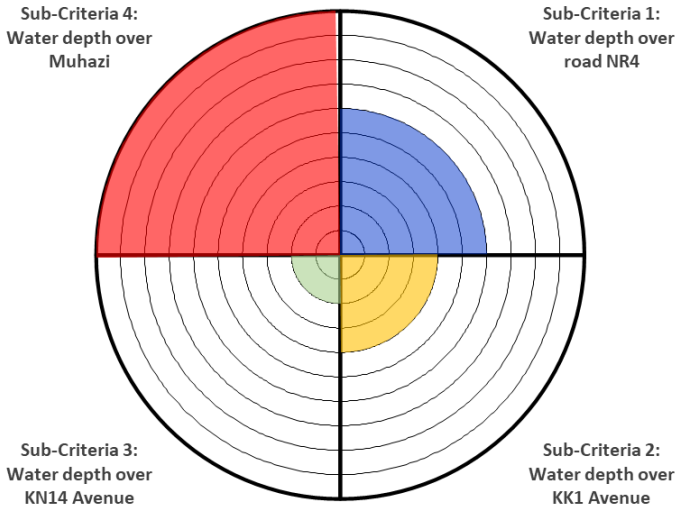


FIGURE 4-97 FLOOD MITIGATION AT BASELINE, CRITERIA RANKING FIGURE -GIKONDO

4.8.6.2 Conclusion on baseline in Rwampara

The table below presents the results of the current state hydraulic assessment of Rwampara based on the indicators defined above. The existing wetland state of development obtain a score of 50 %.

TABLE 4-15 FLOOD MITIGATION AT BASELINE, CRITERIA RANKING MATRIX -RWAMPARA

Criterion: Flood mitigation for Rwampara										
Sub-criteria	Ranking system for this criterion									
	No flooding H=0m		**Very low intensity of flood** 0m < H ≤ 0.15m		**Low intensity of floods** 0.15m < H ≤ 0.5m		**Medium intensity of floods** 0.5m < H ≤ 2m		**High intensity of floods** H > 2m	
	10	9	8	7	6	5	4	3	2	1
Sub-Criteria 1: Water depth over road KN 121							4 People are at risk but only to a small extent; damage to infrastructure is to be expected			
Sub-Criteria 2: Water depth over KK 2 Avenue							4 People are at risk but only to a small extent; damage to infrastructure is to be expected			
Sub-Criteria 3: Water depth over KK 31 Avenue							4 People are at risk but only to a small extent; damage to infrastructure is to be expected			
Sub-Criteria 4: Water depth over Avenue des Poids-Lourds NR4							4 People are at risk but only to a small extent; damage to infrastructure is to be expected			

For a 10-yr return period, flooding occurs on the 4 bridges of the wetland of Rwampara with a water depth simulated between 0.5 and 2 m. These issues will need to be addressed in the rehabilitation scenarios to avoid at best flooding on roads. These results do not necessarily demonstrate the state of the wetland to mitigate floods but the overall performance of systems in which the wetland is part.

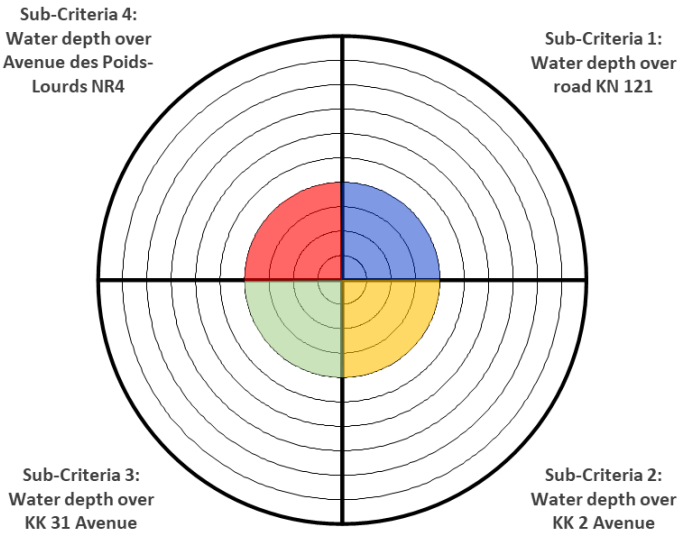


FIGURE 4-98 FLOOD MITIGATION AT BASELINE, CRITERIA RANKING FIGURE -RWAMPARA

4.8.6.3 Conclusion on baseline in Rugenge-Rwintare

The table below presents the results of the current state hydraulic assessment of Rugenge-Rwintare based on the indicators defined above. The existing wetland state of development obtain a score of 70 %.

TABLE 4-16 FLOOD MITIGATION AT BASELINE, CRITERIA RANKING MATRIX -RUGENGE-RWINTARE

Criterion: Flood mitigation for Rugenge-Rwintare										
Sub-criteria	Ranking system for this criterion									
	No flooding H=0m		**Very low intensity of flood** 0m < H ≤ 0.15m		**Low intensity of floods** 0.15m < H ≤ 0.5m		**Medium intensity of floods** 0.5m < H ≤ 2m		**High intensity of floods** H > 2m	
	10	9	8	7	6	5	4	3	2	1
Sub-Criteria 1: Water depth over KG 3 Avenue	10 There is no flooding of infrastructure									
Sub-Criteria 2: Water depth over Rugenge road							4 People are at risk but only to a small extent; damage to infrastructure is to be expected			
Sub-Criteria 3: Water depth over road KN 21							4 People are at risk but only to a small extent; damage to infrastructure is to be expected			
Sub-Criteria 4: Water depth over KN 8 Avenue	10 There is no flooding of infrastructure									

For a 10-yr return period, no flooding occurs on the KG 3 Ave and the KN 8 Ave, whereas on Rug. Road and KN 21 St, the flooding is important (between 0.5 and 2 m of flooding). These issues will need to be addressed in the rehabilitation scenarios to avoid at best flooding on roads. These results do not necessarily demonstrate the state of the wetland to mitigate floods but the overall performance of systems in which the wetland is part.

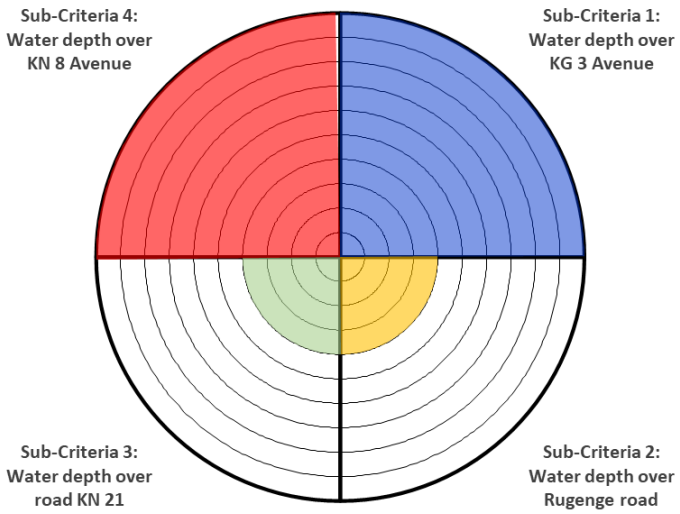


FIGURE 4-99 FLOOD MITIGATION AT BASELINE, CRITERIA RANKING FIGURE -RUGENGE-RWINTARE

4.8.6.4 Conclusion on baseline in Kibumba

The table below presents the results of the current state hydraulic assessment of Kibumba based on the indicators defined above. The existing wetland state of development obtain a score of 40 %.

TABLE 4-17 FLOOD MITIGATION AT BASELINE, CRITERIA RANKING MATRIX -KIBUMBA

Criterion: Flood mitigation for Kibumba										
Sub-criteria	Ranking system for this criterion									
	No flooding H=0m		**Very low intensity of flood** 0m < H ≤ 0.15m		**Low intensity of floods** 0.15m < H ≤ 0.5m		**Medium intensity of floods** 0.5m < H ≤ 2m		**High intensity of floods** H > 2m	
	10	9	8	7	6	5	4	3	2	1
Sub-Criteria 1: Water depth over road KG 550							4 People are at risk but only to a small extent; damage to infrastructure is to be expected			
Sub-Criteria 2: Water depth over KG 15 Avenue							4 People are at risk but only to a small extent; damage to infrastructure is to be expected			
Sub-Criteria 3: Water depth over road KG 449							4 People are at risk but only to a small extent; damage to infrastructure is to be expected			
Sub-Criteria 4: Water depth over KG 33 Avenue							4 People are at risk but only to a small extent; damage to infrastructure is to be expected			

For a 10-yr return period, flooding occurs on the 4 bridges of the wetland of Rwampara with a water depth simulated between 0.5 and 2 m. The four hydraulic infrastructures are undersized. These issues will need to be addressed in the rehabilitation scenarios to avoid at best flooding on roads. These results do not necessarily demonstrate the state of the wetland to mitigate floods but the overall performance of systems in which the wetland is part.

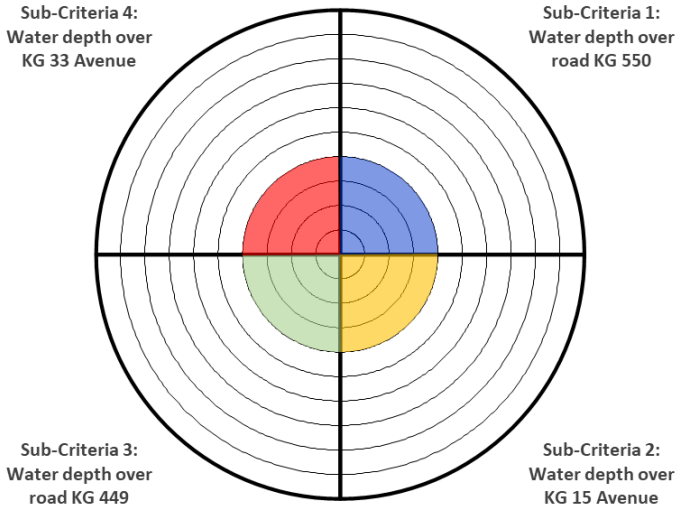


FIGURE 4-100 FLOOD MITIGATION AT BASELINE, CRITERIA RANKING FIGURE -KIBUMBA

4.8.6.5 Conclusion on baseline in Nyabugogo lower

The table below presents the results of the current state hydraulic assessment of Nyabugogo based on the indicators defined above. The existing wetland state of development obtain a score of 40 %.

TABLE 4-18 FLOOD MITIGATION AT BASELINE, CRITERIA RANKING MATRIX -NYABUGOGO

Criterion: Flood mitigation for Nyabugogo Lower										
Sub-criteria	Ranking system for this criterion									
	No flooding H=0m		**Very low intensity of flood** 0m < H ≤ 0.15m		**Low intensity of floods** 0.15m < H ≤ 0.5m		**Medium intensity of floods** 0.5m < H ≤ 2m		**High intensity of floods** H > 2m	
	10	9	8	7	6	5	4	3	2	1
Sub-Criteria 1: Water depth over KG 14 Avenue							4 People are at risk but only to a small extent; damage to infrastructure is to be expected			
Sub-Criteria 2: Water depth over Nyabugogo							4 People are at risk but only to a small extent; damage to infrastructure is to be expected			

For a 10-yr return period, flooding occurs on the 2 bridges of the wetland of Nyabugogo with a water depth simulated between 0.5 and 2 m. The hydraulic infrastructures are undersized and the flooding issue will need to be addressed in the rehabilitation scenarios to avoid at best flooding on roads. These results do not necessarily demonstrate the state of the wetland to mitigate floods but the overall performance of systems in which the wetland is part.

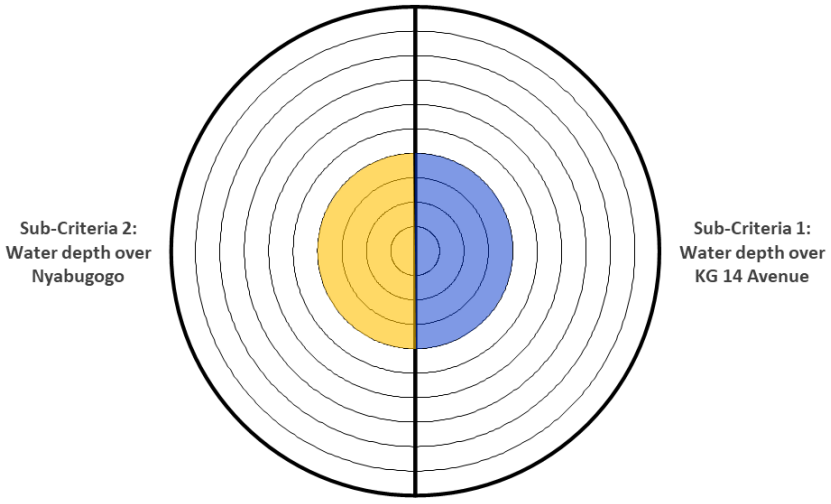


FIGURE 4-101 FLOOD MITIGATION AT BASELINE, CRITERIA RANKING FIGURE -NYABUGOGO LOWER.

4.9 BIODIVERSITY IN THE WETLANDS AND ENVIRONMENTAL CONDITIONS

4.9.1 Objectives

In order to propose restoration and rehabilitation actions adapted to the specificities of the wetlands, the project team carried out several steps, each with targeted objectives:

- Field visit of all the wetlands in order to know the ecological and hydraulic characteristics (typology of natural habitats, current management, position of the wetlands in the watershed, diagnosis of the hydraulic functioning, water inflow/outflow...). These non-exhaustive field surveys, based on a single visit and without a strict protocol, allowed us to carry out an ecological pre-diagnosis of the wetlands and to analyze their state of conservation and the existing threats.
- Establishment of a photograph of the current state of the wetlands without claiming to be exhaustive. As presented in the previous chapters, the objective is to produce summary maps allowing the location of the main wetland issues.
- Identification of sectors per wetland with natural habitats less affected by human action and which may have the potential to host native plant species. This work then allowed the launch of exhaustive botanical inventories on these sectors.
- Analysis of the possibility of implementing certain ecological actions with the objective of improving the functionality of the wetlands.
- Elaboration of the measures through the description and analysis of the related issues.

These steps will provide REMA, within the limits of a non-exhaustive field inventory, with a synthesis of the current state of the wetlands and, subsequently, a synthesis of possible actions to improve ecological and hydraulic functionality.

4.9.2 Method

4.9.2.1 Field surveys

For each wetland inventoried/studied, the project team applied the following methodological approach:

1- A **first vision on the scale of the wetlands** (office stage before the field), by photo-interpretation and study of the existing bibliography (REMA, World Bank, city of Kigali...), to analyze and understand the environmental context (topography, land use and geology), the position of the wetlands in the watersheds of the water bodies and the existing connections (hydraulic, hydrogeological and ecological).

2- A **second vision carried out in two stages**:

- 1st stage: During field surveys, on a single pass and for each wetland, topographic (slope break, direction of slope, microtopography...), hydrographic (watercourse, natural flow, depressions; water accumulation area, pools, drains, surface or deep ditches...), hydrogeographic (mode of feeding, contributing watershed...) and biological (land use, current management mode of the wetland) elements were analyzed.
- 2nd stage: After the 1st passage on site, exhaustive botanical surveys were carried out on key sectors of the wetlands in order to know the native floristic procession.

3- A **third vision (stage of complements and synthesis in the office after the field surveys)**. During this "office" phase, the field surveys were completed with bibliographic data (hydrogeographic, history of the plot, data provided by REMA...). In addition, a broader analysis was conducted to confirm and characterize the contributing watersheds of the wetlands. An assessment of the role of the wetland within the watershed was defined. This work led to a conclusion on the current status of the wetlands.

Methodology for the second vision carried out in two stages

During the first field phase (a single visit to the site), the current functional and biological status of the wetlands was assessed using several indicators (vegetation cover, hydrology, soil, etc.). These field surveys, of the ecological pre-diagnosis type, did not claim to be exhaustive, but allowed the identification of the issues for each wetland.
Following this first field visit, the sectors presenting an interesting ecological value in terms of natural habitats and position in the wetland were targeted for exhaustive botanical surveys.

As stated above, the objective of this step is to undertake comprehensive botanical surveys in selected plots within the wetlands. These floristic surveys will also identify native plant species that occur along the hydromorphic gradients (amphibious, hydrophytic, and heliophytic species).

The following areas were sampled to describe the plant species and their coverage. Inventories were conducted in March, just before the wetland flooding period.



Two survey plots of 1 ha was studied to describe plant composition.



One survey plots of 5 ha was studied to describe plant composition



One survey plots of 2.5 ha was studied to describe plant composition



Two survey plots of 4 ha each was studied to describe plant composition

To identify the habitats, the botanist first visited the perimeter to identify coherent areas and define homogeneous entities. The conservation status of each habitat was commented on by the expert on a summary table.
The botanical expert made transects (quadrats) in the homogeneous habitat. He then determined the number of transects to be covered according to the size of the area and the homogeneous habitat. Each transect is spaced at least 20 meters from the previous transects.

An exhaustive list of plant species by habitat was made and special attention was paid to finding heritage species, characteristic of wetlands, and invasive exotics. All the species observed were presented in a table with the name of the species, the patrimoniality, the wetland character and the invasive character. The exotic heritage and invasive species were presented and classified according to their different statuses, local, regional, national and global (protected, red lists, determining species...).

The flora expert then noted:

- All the plants he observed and the conditions in which the plant was observed such as shelf vegetation (dry land), emergent vegetation (foot in water or wet soil), deep water vegetation (floating plant).
- Fauna if there are any species. However, this research was optional because the purpose of the inventories was to list the plants.

Thus, for each transect, the data were recorded as follows:

- Plant name (English);
- Plant name (Latin);
- Moisture conditions observed (Choice between: Plain (dry land), Emergent vegetation (foot in water or wet soil); Deep water).
- Dominance: Plant dominance along the transect as a percentage of the transect.
- Fauna observed.
- Source of water in the wetland (spring, river, rain).
- Depth of water.

All the data were then entered into a table in the format shown below.

TABLE 4-19 FIELD VISIT DATA TABLE

Transect number		Weather condition		Date:
Source of water in the wetland (Spring, River, Rain retention) Depth of water (estimated):				
Plant name (English)	Plant name (Latin) (can be filled after the field visits)	Observed wetness conditions	Dominance of the plant	Observed fauna (if any)

4.9.2.2 Assessment of key ecosystem attributes

In order to identify the current status of wetlands and their functionality, the methodology implemented above allowed for the collection and analysis of the following information:

- Position of the wetland in the watershed: plateau / slope / valley bottom – thalweg.
- Connection to the hydrographic network: crossing / entrance and exit / side pass / no connection.

- Plant species typology: spontaneous vegetation / non-spontaneous vegetation.
- Natural habitat structure: herbaceous layer, shrub layer and tree layer.
- State of conservation of the environment: non-degraded habitat / partially degraded habitat / highly degraded habitat.
- Diagnosis of hydrological functioning: observed close to natural equilibrium / significantly degraded / degraded / very degraded.
- Current management: grazing / mowing / cultivation / clearing.
- Activities and uses: agriculture / livestock / aquaculture / fishing / hunting / tourism / urbanization / linear infrastructures / aggregate extraction / water withdrawal...
- Flooding regime: never / exceptional / regular / permanent.
- Water inflow: rivers / canals / ditches / springs / groundwater / water bodies / runoff / precipitation / flood water.
- Water outflow: rivers / canals / ditches / springs / groundwater / water bodies / runoff / floodwater / evaporation.
- Threats: drying out / landfall / creation of water bodies / landfill / land clearing / fertilization / phytosanitary / filling / presence of invasive species / urbanization / overuse / eutrophication / cultivation / soil work...

These data were complemented by extensive botanical field surveys of key wetland areas (wet natural habitats, presence of native plant species, areas less disturbed by human action...).

4.9.2.3 Review of secondary sources on fauna species inhabiting the wetlands

REMA has undertaken an ecological baseline assessment in 4 of the 5 wetlands to describe key faunal species found in the 5 wetlands (Kibumba was not sampled). The survey covered plants, amphibian, fish and birds in addition to mammals, reptiles and algae and macro-invertebrates (REMA, 2020 Rapid Ecological Baseline Assessment of the Lower Gikondo, Rwampara, Rugenge-Rwintare and Nyabarongo Wetlands of the City of Kigali).

4.9.3 Results

Overall, the 5 wetlands studied present natural habitats subject to strong anthropic pressure. This pressure can be seen in particular in:

- Intensive agricultural activities covering a large area of wetlands with an impoverishment of the diversity of environments (dominance of cultivation at the expense of wet meadows or reed beds). Drainage through surface drainage (ditches, canals, gullies...) and underground drainage (drains) contribute to the lowering of the water table and the reduction of wetland recharge areas. This hydraulic impact contributes to the decrease of the humidity level in the soil necessary for the development of the plant species that depend on wetlands. Agricultural amendments and the application of phytosanitary products also contribute to the decrease of biodiversity in these areas.
- Urbanization which consumes certain floodable parts of wetlands (filling of floodable areas) or which fragments habitats by linear infrastructures. Urban pressure also results in organic pollution from untreated wastewater or stormwater discharged directly into wetlands. These inputs promote a strong eutrophication of the water areas.
- The watersheds, feeding the wetlands, which are largely sealed. These characteristics favor runoff during rainy periods and accentuate peak flows, thus causing significant erosion of the minor beds of the hydraulic outfalls feeding/crossing the wetlands. Some hydraulic outfalls, with their strongly incised profile, also contribute to the drying out of wetlands (lowering of the water table feeding the wetlands).
- The progressive colonization of invasive plant species leading to the impoverishment of natural habitats, and even the disappearance of plant stations of native species.

In conclusion, the wetlands studied have a biological conservation status that is considered poor to low due to strong human pressures. Only a few homogeneous sectors, having been the object of specific floristic inventories, offer a panel of interesting plant species without however raising an exceptional ecological character.

4.9.3.1 Results of the botanical surveys

Within the framework of various surveys on the wetlands of the city of Kigali, ecological inventories were carried out to know the state of conservation of the natural habitats and to determine the existing attacks/threats.
In addition, these studies allowed to evaluate as exhaustively as possible the diversity of the floristic procession of certain sectors (sector in good ecological state, sectors in an interesting ecological state and degraded sectors). The final objective is to evaluate/determine the "native" reference ecosystem.

As explained in the previous chapters, a botanical survey was carried out in March 2022 following the first field visit. This additional survey targeted several areas:

- Plot registered in a wetland in good ecological status in Nyandungu;
- Plots with an interesting ecological status:
  - Nyabugogo wetland: 2 plots;
  - Wetland of Rugenge: 1 plot;
  - Gikondo wetland: 1 plot;
  - Kibumba wetland: 2 plots.
- Plots with degraded ecological status: one site in Kimicanga and another in Rwandex.

The cross-referencing of data from the field surveys allowed the identification of native plant species and natural habitats to be targeted for wetland restoration. This assessment also highlights the threats that are pressuring areas of ecological interest:

- The central part of the **Nyabugogo wetland** is heavily invaded by water hyacinth. The latter may have been introduced from adjacent nurseries in the vicinity where most of the plants are of exotic origin. The findings of the botanical report also indicate that this area is at risk of pollution from waste dumping, mainly from the nurseries. Fertilizer from the nursery is also suspected of seeping into and polluting the wetland. Despite these various threats, some plots, such as those positioned just east of the central water body, are in good ecological condition and are covered with Cyperus papyrus on permanently flooded areas. In the less degraded, seasonally flooded areas, Typha domingensis is most common.
- The target area within the **Rugenge wetland**, which appeared to be in an interesting ecological state, ended up with a floristic assemblage in which the majority of species are characteristic of ruderal vegetation. This low diversity of native species reflects the disturbance of the wetland by agriculture. Thus, no new local plant species of interest in the context of wetland restoration were identified.
- Concerning the studied plot within the **Gikondo wetland**, the dominance of Typha domingensis was identified. This plot, presenting an interesting ecological state, is unfortunately encroached upon by crops. Indeed, some Typha have been recently cut along the edge of the wetland in order to extend the cultivable area. However, in recent years, analysis of aerial photographs seems to show that agricultural practices have decreased in surface.
- The plots studied in the **Kibumba wetland** are dominated by a native plant species adapted to the wetland Cyperus latifolius. The main source of threat for this wetland is agriculture.

In addition to the wetlands studied in the framework of the project, a botanical survey was carried out on a plot of the **Nyandungu wetland**. These surveys revealed the strong colonization of a native plant species already identified in the above targeted plots. Indeed, the dominant species is now characteristic of the site. It is Typha domingensis, which occupies more than 90% of the vegetation cover. Other species are few in number, including Cyperus papyrus (less than 5%), and the understory is dominated by ferns and Leersia hexandra species.

By cross-referencing these botanical surveys with surveys conducted on degraded sites (**Kimicanga** and **Rwandex** sites dominated by plant species that do not thrive on wet soils), it was possible to identify native plant species that are native to wetlands and that could be selected for wetland restoration.

The reference ecosystem status for wetlands is based in part on a diversity of wetland plant species listed in the tables below. Indeed, the tables list some common wetland plant species in the Rwandan wetland reference ecosystems (list based on species observed on site supplemented by local botanical data).

The focus is on key indigenous species of natural habitats of the grassland or reedbed type wetlands. These natural habitats are the targets for achieving the highest ranking for sub-criteria 3.

Thus, the wetland will have a "high performance" rating for sub-criteria 3 "Species Composition" if more than 80% of the total area of the wetland (existing or restored) is covered by the native hygrophilous plant species, listed in the tables below. These species are typical of grassland/marsh habitats that are favourable for various animal taxa: insects, fish, amphibians, reptiles, birds and mammals. Associated with aquatic habitats (streams, ponds, lakes ...), these wetland habitats form mosaics of environments where plant/animal interactions and ecosystem exchanges are favoured.

TABLE 4-20 STANDING WATER OR SEASONALLY SATURATED SOILS

Habitat description: Standing water or seasonally saturated soils (14 or more consecutive days)		
Plant species characteristic of the habitat – Kinyarwanda/English name	Plant species characteristic of the habitat - Latin name	Status in Rwanda (common, rare, listed, endemic, invasive)/ IUCN status
Observed native wetland plants		
Indian pennywort	*Centella asiatica*	C/LC
Urugaga	*Cyperus dives*	C/LC
Urukanganga/Epiphytic flatsedge	*Cyperus latifolius*	C/LC
Carolina dichondra	*Dichondra micrantha*	C/LC
Ubwungo/Heartleaf drymary	*Drymaria cordata*	C/NA
Urufunzo/Papyrus	*Cyperus papyrus*	C/LC
Umuberanya/Southern Cattail	*Typha domingensis*	C/LC
Non-observed native wetland plants		
NA	*Carex mildbraediana*	C/LC
Urukirakenja/Jointed flatsedge	*Cyperus articulatus*	C/LC
Umujangaja/winged sedge	*Cyperus denudatus*	C/LC
Carolina dichondra	*Dichondra micrantha*	C/LC
Urujenone	*Enhydra fluctuans*	C/NA
Gutwikumwe/Floating pennywort	*Hydrocotyle ranunculoides*	C/NA
Ubusuna/Common rush	*Juncus effusus*	C/LC

TABLE 4-21 HYDRIC SOILS

Habitat description: Hydric soils, often in geomorphic settings where water saturates the soils or floods the soil surface at least seasonally. This habitat is a transition between permanently flooded wet habitats and upland habitats.		
Plant species characteristic of the habitat – Kinyarwanda/English name	Plant species characteristic of the habitat - Latin name	Status in Rwanda (common, rare, listed, endemic, invasive)/ IUCN status
Observed native wetland plants		
Urukembagufa/Cut grass	*Leersia hexandra*	C/NA
Ikirogora	*Brillantaisia cicatricosa*	C/NA
Umuzigangore	*Ludwigia abyssinica*	C/NA
Igorogonzo/Watersmart weed	*Persicaria decipiens*	C/LC

Igorogonzo/Watersmart weed	*Persicaria pulchra*	C/LC
Non-observed native wetland plants		
Urutaretare/	*Pycreus macrostachys*	C/LC

The absence of anthropic pressures (agriculture, urbanization...) or invasive plant species and an adapted management are also necessary to reach the status of native ecosystem of reference.

The other criteria used to define the biological quality of wetlands (sub-criteria 1, 2, 4, 5 and 6) complete the evaluation of the wetland's performance and determine its level in relation to the native ecosystem reference.

As it stands, and as indicated in the REMA 2020 preliminary report "Rapid Ecological Baseline Assessment of the Lower Gikondo, Rwampara, Rugenge-Rwintare and Nyabarongo Wetlands of the City of Kigali", the wildlife sampling inventory indicates that the water quality of the wetlands is polluted and undergoing severe disturbance due to anthropogenic activities. These pressures are leading to the decline of species populations in the Kigali wetlands and some of the species detected confirm the degraded status of the wetlands. Despite a few patches with an interesting ecological status, Kigali wetlands are far from the level of the native ecosystem reference.

Surveys found 11 species of amphibians (anurans or frogs), none of which are classified in the IUCN Red list of threatened species. Their distribution was similar in all 5 wetlands. Observed species were generalist species of disturbed wetlands. Anurans are biological indicators of the quality of wetlands.

Surveys found 7 fish species, none of which are classified in the IUCN Red list of threatened species. No fish were observed in Gikondo while other wetlands had less than 5 species. These fishes are considered as invasive.

Macro-invertebrates are indicators of water quality. In Gikondo, 11 families of macrozoobenthos were found, 9 families were recorder in Nyabugogo, 6 families were recorded in Rugenge-Rwintare wetland showing higher level of disturbances, in Rwampara 9 families were recorded.

A total of 84 species of birds belonging to 39 families were recorded. Nyabugogo wetland presented the highest bird species diversity and Rwampara the lowest. Another study (ARCOS, 2019) observed Grey-Crowned Cranes in Nyabugogo, which are endangered according to IUCN Red list. Nyabugogo may be frequented by this water bird, however, given the vast occupation of agriculture, Nyabugogo does not offer any suitable condition for breeding.

Most mammals were in the Muridea family, the family of rodent.

4.9.3.2 Results of the assessment of key ecosystem attributes

In order to rank the studied wetlands and restoration scenarios, several sub-criteria were established as indicated above. The values and characteristics of the sub-criteria were determined based on our field observations and previous wetland studies:

- **Sub-criterion 1: Threats (direct or indirect threats to the ecosystem).** In previous studies, numerous anthropogenic threats/pressures were cited:
  - The January 2018 NEMUS final report "Consultancy Services for Development of Detailed Sub-Catchment Management Plans for Gikondo and Nyabugogo Wetland Systems" states that the surface water quality of the Gikondo and Nyabugogo wetlands suffers from polluted runoff and impacts from inadequate waste disposal facilities. The discharge of waste from industrial, household, institutional and commercial establishments poses a threat to the wetlands. In addition, agricultural practices result in significant contaminant loads to aquatic environments due to the use of manure and agrochemicals.
  - The November 2019 SMEC report "Thematic Report: Volume 2C - Ecology - Technical Support for the Development of the City of Kigali Wetlands Master Plan" summarizes, in Table 2 on pages 10-13, existing anthropogenic impacts on wetland plant species. It also states that "For most wetlands in the city of Kigali, whether natural or disturbed, the main ecological threat is intensive agriculture. The Rwampara and Gikondo wetlands (towards Nyabugogo) have been drained and cleared for agriculture. It is now rare to find wetland plant species in these areas. Another threat comes from invasive and exotic species (example with the Nyabugogo wetland pond).

- The REMA 2020 preliminary report "Rapid Ecological Baseline Assessment of the Lower Gikondo, Rwampara, Rugenge-Rwintare and Nyabarongo Wetlands of the City of Kigali" also indicates the numerous impacts on biodiversity due to human activity.

In conclusion, sub-criterion 1 presents numerous data for each wetland (field observations and bibliographic data) allowing them to be classified according to the level of threats. However, to simplify the analysis of threats, two parameters were selected to facilitate comparison between wetlands:

- Soil artificialization integrating threats related to illegal dumps, urbanization, land clearing, embankments...
- Agriculture integrating threats related to dewatering, drainage, siltation, fertilization, amendment, application of phytosanitary products, presence of invasive species, agricultural overexploitation...

- **Sub-criteria 2: Soil hydrologic conditions:** The hydrological functioning (flooding regime) of the wetland necessary to maintain the target ecosystem is defined in terms of the frequency of flooding (never, exceptionally, regularly and permanently) and the extent (partially or totally). This flooding is related to water inflow/outflow: rivers, springs, groundwater, floodwaters, runoff, precipitation, evaporation... Soil hydromorphy and flooding in wetlands are also well documented in previous studies.

  The NEMUS report also highlights soil moisture problems due to the numerous drainage systems in the wetlands. Indeed, it states that water hardly stays in the wetlands: "*Drainage channels have made water scarce for irrigation. This means that there is no water in the wetland until it rains. Even then, the water flows into the canals and quickly drains out of the wetland. In addition, the report states that "to access the fertile soils of the wetlands, farmers using the Gikondo and Nyabugogo wetlands have developed a network of drainage furrows*." Thus, "*the occupation of the wetland by infrastructure and slums has led to the construction of additional drainage channels to decrease the water content of the soils. This excess drainage has dried up the valley floor of the wetland, especially during the dry seasons.*" This drying out has a strong impact on the development of plant species that are adapted to wetlands.

  In chapter "3.7 Ecological Health of Wetlands and Wetland Rehabilitation Issues" of the SMEC report, it is stated that "wetland plants require water, which may be present permanently or seasonally. Thus, one of the actions proposed in the report is to ensure "*the filling of drainage channels and ditches and the restoration of a water flow that floods a large part of the wetland*". Indeed, the report does indicate that with the drainage work, some wetlands have become permanently dry while others are only temporarily wet during the rainy season.

  Finally, the DELTARES report "Storm Water and Wetland Management Model for the delineated flood prone areas in Kigali City - Flood model and hazard assessment" of August 2020 provides information on the flood prone nature of the wetlands and also states that the soil in the wetlands is considered as a single reservoir of a certain depth, divided into a saturated and an unsaturated reservoir.

- **Sub-criteria 3: Species composition:** Native species characteristic of the appropriate reference ecosystem are present, whereas undesirable species are absent. This sub-criteria is detailed in the chapter above to better understand how wetland classification can be made under this sub-criteria. As well as the conclusions of the botanical report and the preliminary report "Rapid Ecological Baseline Assessment of the Lower Gikondo, Rwampara, Rugenge-Rwintare and Nyabarongo Wetlands of the City of Kigali", the NEMUS and SMEC reports also show the low to medium biological quality of the wetlands, mainly due to anthropogenic pressures.
- **Sub-criteria 4: Structural diversity:** Appropriate diversity of key structural components, including demographic stages, trophic levels, vegetation strata and spatial habitat diversity are present. During the field visit, it was observed that wetlands have a low structural diversity of natural habitats (wet or not). Indeed, the bushy or tree habitats are often of anthropic origin and present a use or a management not adapted to the wild animal species. Yet, in addition to their value for life history completion of certain animal species, natural shrub to tree habitats can serve as buffers between areas of human activity and the functional wetland.

  As stated in the NEMUS report, habitat heterogeneity (herbaceous, shrubby, treed) is necessary because "*there are different species with the same ecological requirements and the creation of a variety of habitats will thus allow for ecological complexification*."

The SMEC report indicates the ecological gain of the Nyandungu wetland (part of the Mwanana-Mulindi-Kanombe wetland) following its rehabilitation into different microhabitats: "*These varied habitats allow for a diversity of birds, amphibians and reptiles"*.

- **Sub-criteria 5: Ecosystem function:** Appropriate levels of growth and productivity, nutrient cycling, decomposition, species interactions, and rates of disturbance. The functionalities of the wetlands are evaluated according to 4 indicators, each receiving a score (Null, Weak, Medium and High). Wetland functions are extensively commented on in the SMEC report and the 2021 draft report without being classified. As it stands, wetland functions are severely compromised by human pressure and multiple developments within wetlands. As stated in the SMEC report, the "*capacity of wetlands to provide ecosystem and community services is severely impaired by the degradation of these natural systems*". As a result, their hydrological, biogeochemical, and ecological functions are being disrupted, including loss of biodiversity, loss of water treatment function, drafting of wetland floodability, etc. The report also informs us about the importance of "*wetlands that function as buffers against erosion and high runoff, ensuring flood control during the rainy season, recharging rivers and streams during the dry season (REMA, 2010)".* It also states that in "urban contexts, wetlands may have a different functioning system due to the anthropogenic environment (Baloi, 2014): compaction and soil sealing outside of wetlands may influence water capture as well as discharge."

  Furthermore, the 2021 draft report states that "*improving wetland functions and investing in nature-based solutions may help mitigate flooding, improve water quality, and promote resilience in the city of Kigali.*"

  This simplified functional analysis of wetlands is therefore a sub-criteria to consider when assessing the ecological status of wetlands and proposing scenarios that improve current functions.

- **Sub-criteria 6: External exchanges**: The ecosystem is appropriately integrated into its larger landscape or aquatic context through abiotic and biotic flows and exchanges. The analysis of aerial photographs and the reading of various maps, made in the NEMUS, SMEC and the preliminary report of 2021 on the ecological status of wetlands, allow to visualize the existing ecological cuts within the wetlands. Field observations have also confirmed some cuts generated by hydraulic structures (absence of wildlife passage, fall downstream of the structure...) preventing/limiting any migration of species within the wetlands.

  The NEMUS report also states that "*it is important to establish connections with the different habitats created to promote ecological connectivity*". Integrating Kigali's conserved natural landscapes (e.g., wetlands, forests, and rivers) with the city's parks, through landscape continuity, allows for "*landscape connectivity and biodiversity flow without compromising the city's development needs*". The report also calls for certain actions including "*the creation of buffer zones as riparian corridors by encouraging the planting of native species and the identification and subsequent conservation of potential connecting corridors between these natural areas*."

The SMEC report states that many of the wetlands in the city of Kigali, although named differently, are intimately connected. For example, the "*Rwampara wetland flows into the Rugenge wetland and then into the Nyabugogo wetland. Therefore, any activity in the Rwampara wetland can have an impact on the other wetlands located downstream*". This interconnection allows wetland animal species to move provided that habitats are suitable and connections are technically possible for migration.

4.9.4 Conclusion on baseline in Gikondo

TABLE 4-22 BIODIVERSITY AT BASELINE, CRITERIA RANKING MATRIX - GIKONDO

Criterion: Biodiversity enhancement in Gikondo										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
Sub-criteria 1: Absence of threats									2 Artificialization of soils: Despite the dewatering carried out on the downstream part of the wetland, there are still many backfills, often polluted (heavy metals linked to industrial liabilities). A large part is also disconnected from the central watercourse because of the existing embankments. The upstream part seems less subject to urbanization problems. Agriculture: In the upstream portion, agriculture has promoted surface drainage of the wetland and its drying out.	
Sub-criteria 2: Soil hydrologic conditions					5 Due to the former urbanization, the soil of the wetland, downstream of KK 1 Avenue, is very disturbed (compacted soil and composed of fills of various origins). Its water retention capacity is low and its waterlogging remains exceptional (flooding over the entire surface during periods of heavy rainfall). In addition, the characteristics of the central stream (deep minor bed) do not allow the soil to be waterlogged during light rainfall (surface drainage of the stream).					

Criterion: Biodiversity enhancement in Gikondo										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
					Despite the presence of numerous surface drains and an urban water diversion, the upstream portions (Southern and Northern branches) seem more conducive to regular and superficial waterlogging of the soil. The drawdown of the water table also appears to be less significant in relation to the characteristics of the hydraulic outfalls. Nevertheless, the wetland is less subject to flooding during light rainfall.					
Sub-criteria 3: Species composition									1 Based on the natural habitat typology, botanical surveys, and available literature, less than 10% of the total wetland area appears to be covered by native hygrophilous plant species.	
Sub-criteria 4: Structural diversity									1 The majority of the wetland consists of anthropogenic and disturbed habitats (fills, crops, ...). The natural habitats are of herbaceous and shrubby stratum, but only on a surface of approximately 20% Moreover, most of these habitats are disturbed by human activities.	
Sub-criteria 5: Ecosystem function							4 The Gikondo wetland has degraded functionality due to past and current human activities. Hydraulic functionality is evaluated as			

Criterion: Biodiversity enhancement in Gikondo										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
							medium (floodable area during heavy rainfall but with a limited role during light rainfall). Biological functionality is evaluated as low due to the low conservation status of the natural habitats.			
Sub-criteria 6: External exchanges							3 Numerous roads and paths in the wetland impede the movement of wildlife species. The only ecological connection is to the river. Hydraulic structures (nozzles and frame bridges) ensure hydraulic transparency but are not designed to promote the passage of wildlife. The wetland is strongly constrained by anthropization, this strongly limits the external ecological connections. Relationships with the nearest wetlands (Rugenge-Rwintare and Rwampara) are also altered by the presence of linear infrastructure and urbanization.			

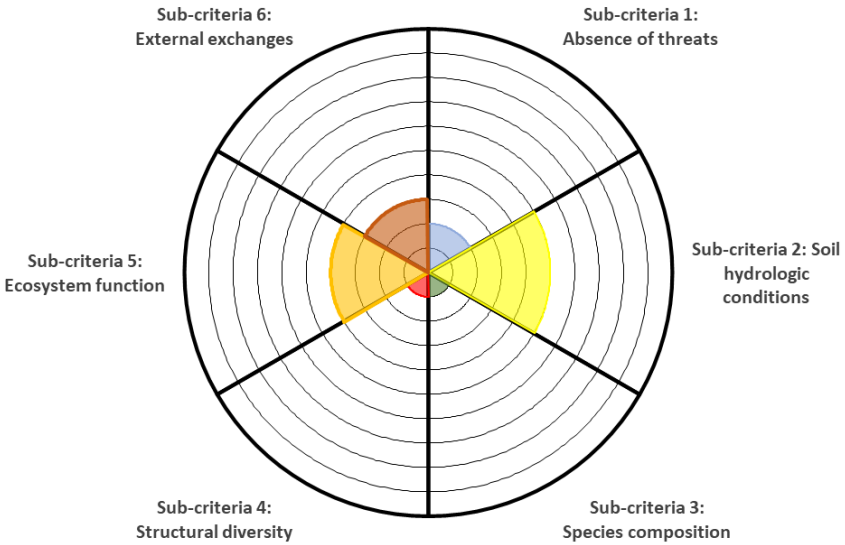


FIGURE 4-102 BIODIVERSITY AT BASELINE, CRITERIA RANKING FIGURE - GIKONDO

4.9.5 Conclusion on baseline in Rwampara

TABLE 4-23 BIODIVERSITY AT BASELINE, CRITERIA RANKING MATRIX -RWAMPARA

Criterion: Biodiversity enhancement in Rwampara										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
Sub-criteria 1: Absence of threats									1 Artificialization of soils: The current impacts/threats on the wetland are related to the impermeabilization of the watershed feeding the wetland. Indeed, erosion accentuated by urban runoff contributes to the incision of the watercourse. Urbanization also contributes to the	

Criterion: Biodiversity enhancement in Rwampara										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
									damage caused by the pipeline works undertaken on the stream downstream of the wetland. The central part is less subject to urbanization problems. Agriculture: Intensive agricultural activity results in the drainage of the wetland and the use of phytosanitary products and organic amendments. Several ornamental plant growers are present in the downstream portion of the wetland, which can lead to the spread of invasive plant species	
Sub-criteria 2: Soil hydrologic conditions								3 The Rwampara wetland is marked by the strong incision of the central watercourse on the upstream part (strong erosion linked to the impermeabilization of the watershed) then its canalization downstream. Consequently, the plots bordering the stream on the upstream part cannot be waterlogged because the stream drains and draws down the water table. On the downstream part, the modification of the watercourse has as a consequence that it does not manage its flow naturally anymore, thus increasing the flood episodes downstream. Indeed, a sinuous layout increases the surface of the linear of the watercourse and thus makes it possible to attenuate the peaks of flood. Whereas a straight alignment encourages large, redundant floods downstream, greatly increasing the flow. These anthropogenic disturbances have a strong impact on soil waterlogging. Only the middle section of the stream offers more favorable characteristics, but agriculture has favored		

Criterion: Biodiversity enhancement in Rwampara										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
							the surface drainage of the wetland and its drying out.			
Sub-criteria 3: Species composition									1 Based on the natural habitat typology, botanical surveys, and available literature, less than 10% of the total wetland area appears to be covered by native hygrophilous plant species.	
Sub-criteria 4: Structural diversity									1 The majority of the wetland is under crop or plantation cover or brownfields. The natural habitats are mainly of tree or herbaceous stratum, but only on a surface of about 25%. Moreover, most of these habitats are disturbed by human activities.	
Sub-criteria 5: Ecosystem function							3 The Rwampara wetland has degraded functionality due to past and present human activities. The hydraulic functionality is evaluated as medium (floodable area during heavy rains but with a limited role during light rains). The biological functionality is evaluated as low due to the low conservation status of the natural habitats.			
Sub-criteria 6: External exchanges							3 Several roads and paths in the wetland impede the movement of wildlife species. The only ecological connection is to the river. Hydraulic structures (nozzles and frame bridges)			

Criterion: Biodiversity enhancement in Rwampara										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
							ensure hydraulic transparency but are not designed to promote the passage of wildlife. The wetland is strongly constrained by anthropization, this strongly limits the external ecological connections. External exchanges are very limited, as the wetland is landlocked.			

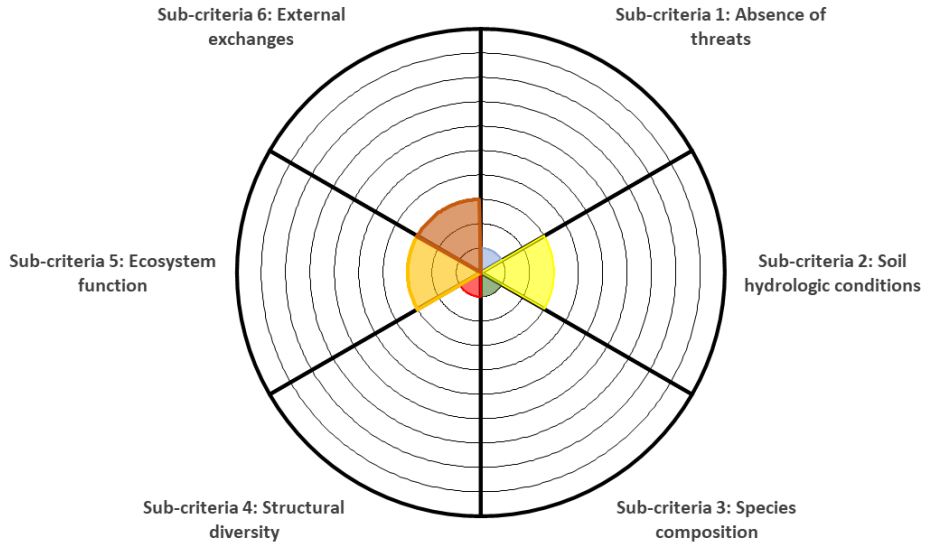


FIGURE 4-103 BIODIVERSITY AT BASELINE, CRITERIA RANKING FIGURE - RWAMPARA

4.9.6 Conclusion on baseline in Rugenge-Rwintare

TABLE 4-24 BIODIVERSITY AT BASELINE, CRITERIA RANKING MATRIX - RUGENGE-RWINTARE

Criterion: Biodiversity enhancement in Rugenge-Rwintare											
Sub-criteria	Ranking system for this criterion										
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
Sub-criteria 1: Absence of threats									2 Artificialization of soils: The urbanization of the watershed, without adapted runoff management, leads to an increase in erosion. In addition, some urbanized plots have also consumed the floodplain. Agriculture: The upstream portion of the wetland has been heavily modified by agricultural activity and the installation of drains/ditches to sanitize the plots. The use of phytosanitary products and agricultural amendments also threatens the biological diversity of the wetland.	
Sub-criteria 2: Soil hydrologic conditions					6 The Rugenge wetland is marked by the strong incision of the central watercourse and its channelization on the upstream and downstream part Consequently, the plots bordering the watercourse cannot be waterlogged because the stream drains and draws down the water table. This waterlogging is possible only during heavy rains producing an overflow of the stream on the plots. Moreover, the modification of the watercourse has as a consequence that it does not manage					

Criterion: Biodiversity enhancement in Rugenge-Rwintare										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
					its flow naturally anymore, thus increasing the flood episodes downstream. Indeed, a sinuous layout increases the surface of the linear of the watercourse and thus makes it possible to attenuate the peaks of flood. Whereas a straight alignment encourages large, redundant floods downstream, greatly increasing the flow. These anthropogenic disturbances have a strong impact on soil waterlogging. The upstream portion is an interesting headwater with a spring/well feeding the stream flow. However, agriculture has favored the surface drainage of the wetland and its drying out.				
Sub-criteria 3: Species composition									1 Based on the natural habitat typology, botanical surveys, and available literature, less than 10% of the total wetland area appears to be covered by native hygrophilous plant species.	
Sub-criteria 4: Structural diversity									2 The majority of the wetland is under crop or plantation cover. The natural habitats are mainly of tree or herbaceous stratum, but only on a surface of about 25%.	
Sub-criteria 5: Ecosystem function							4 The Rugenge wetland has degraded functionality due to			

Criterion: Biodiversity enhancement in Rugenge-Rwintare										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
							past and present human activities. The hydraulic functionality is rated as medium (floodable during heavy rainfall but with a limited role during light rainfall). The biological functionality score is evaluated low due to the low conservation status of the natural habitats.			
Sub-criteria 6: External exchanges							4 Several roads and paths in the wetland impede the movement of wildlife species. The only ecological connection is to the river. Hydraulic structures (nozzles and frame bridges) ensure hydraulic transparency but are not designed to promote the passage of wildlife. Despite the presence of some natural woodlands, the ecological connection is interrupted by crops and anthropic activities (roads, embankments, ...). The wetland is strongly constrained by anthropization this strongly limits the external ecological connections.			

Criterion: Biodiversity enhancement in Rugenge-Rwintare										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
							Relationships with the nearest wetlands (Gikondo and Nyabugogo) are also altered by the presence of linear infrastructure and urbanization.			

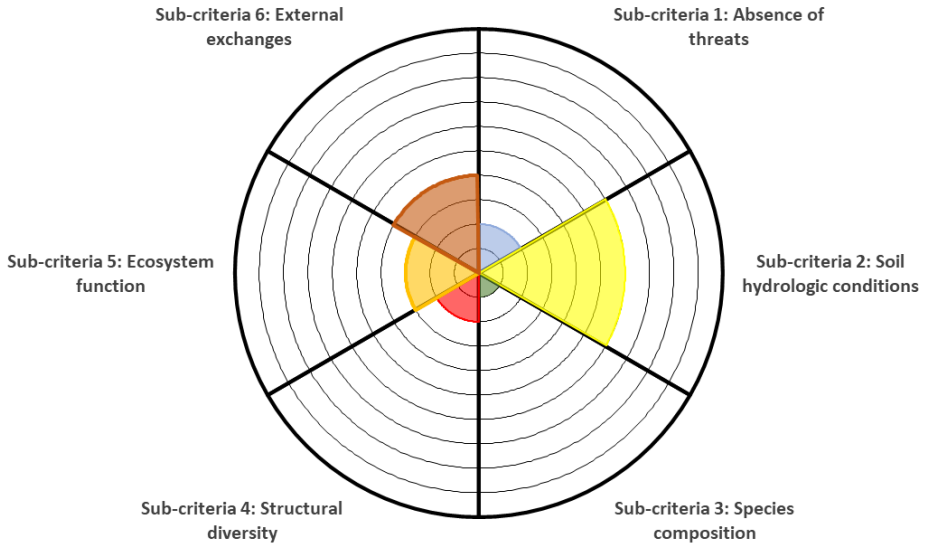


FIGURE 4-104 BIODIVERSITY AT BASELINE, CRITERIA RANKING FIGURE - RUGENGE-RWINTARE

4.9.7 Conclusion on baseline in Kibumba

TABLE 4-25 BIODIVERSITY AT BASELINE, CRITERIA RANKING MATRIX - KIBUMBA

Criterion: Biodiversity enhancement in Kikumba										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
Sub-criteria 1: Absence of threats									2 Soil artificialization: Urbanization of the watershed and the filling in of urban areas in the wetland contribute to the erosion of biodiversity in the wetland and put a strong pressure on the biological balance of the environment. Agriculture: The agricultural activity, often intensive, presents a strong anthropic pressure on the wetland and the associated biodiversity.	
Sub-criteria 2: Soil hydrologic conditions					6 Drainage of agricultural plots and channelization of the mainstream contribute to the drying out of the wetland and limit waterlogging. These characteristics have an impact on the colonization of plant species that are adapted to the wetland. These hydraulic developments also have an impact on the flooding character of the wetland. The wetland is effective during heavy rains, over its entire surface, contrary to low intensity rains whose runoff will be quickly rejected towards the receiving environment.					

Criterion: Biodiversity enhancement in Kikumba										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
Sub-criteria 3: Species composition									2 Based on the natural habitat typology, botanical surveys, and available literature, less than 10% of the total wetland area appears to be covered by native hygrophilous plant species.	
Sub-criteria 4: Structural diversity									1 Almost all of the surface of the wetland is under crop or plantation cover. The natural habitats, mainly of herbaceous stratum, has a surface area of less than 10%.	
Sub-criteria 5: Ecosystem function					5 The Kibumba wetland has a degraded functionality due to past and present human activities. The hydraulic functionality is evaluated as medium (floodable area during heavy rains but with a limited role during light rains). The state of conservation of the environment is degraded (important agricultural activity and urbanization consuming natural spaces) but the wetland presents a sector where the natural habitats are ecologically interesting (upstream part in the southeast). The biological functionality is evaluated as medium					

Criterion: Biodiversity enhancement in Kikumba										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
Sub-criteria 6: External exchanges							4 Several roads and paths in the wetland impede the movement of wildlife The only ecological connection is to the river. species. Hydraulic structures (nozzles and frame bridges) ensure hydraulic transparency but are not designed to promote the passage of wildlife. The wetland is strongly constrained by anthropization this strongly limits the external ecological connections. External exchanges from an ecological point of view are possible with the wetland in the eastern continuity, but altered by the presence of a road			

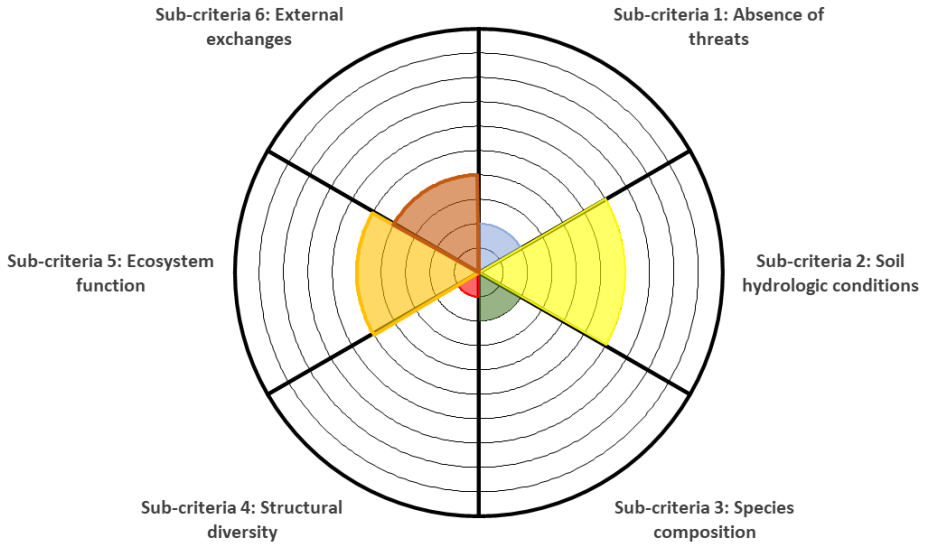


FIGURE 4-105 BIODIVERSITY AT BASELINE, CRITERIA RANKING FIGURE - KIBUMBA

4.9.8 Conclusion on baseline in Nyabugogo lower

TABLE 4-26 BIODIVERSITY AT BASELINE, CRITERIA RANKING MATRIX - NYABUGOGO LOWER

Criterion: Biodiversity enhancement in Nyabugogo Lower										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
Sub-criteria 1: Absence of threats									2 Soil artificialization: As for the other wetlands studied, the urbanization of the watershed and the filling in of urban areas in wetlands contribute to the erosion of biodiversity within the wetland and ensure a strong pressure on the biological balance of the environment. Agriculture: The agricultural activity, often intensive, presents a strong anthropic pressure on the wetland and the associated biodiversity.	
Sub-criteria 2: Soil hydrologic conditions					6 During periods of heavy rainfall, the Nyabugogo Lower wetland is flooded over almost its entire surface and allows for soil watering for several periods of the year. In addition, the pond located in the center of the wetland, also provides permanent waterlogging over a portion of the wetland. However, the numerous hydraulic outfalls provide drainage for agricultural plots over a large portion of the wetland (eastern and western portions). These facilities contribute to the drying of the soil and limit					

Criterion: Biodiversity enhancement in Nyabugogo Lower										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
					the waterlogging of the soil during light rains, whose runoff will be quickly released into the receiving environment. As a result, the development of plant species adapted to the wetland environment is limited.					
Sub-criteria 3: Species composition							4 Based on the natural habitat typology, botanical surveys and available literature, it appears that between 10 and 40% of the total wetland area is covered by native hygrophilous plant species. In fact, despite the presence of numerous invasive plant species, the central part of the wetland presents various natural habitats that are favorable to the support of native plant species that are adapted to wetlands.			
Sub-criteria 4: Structural diversity									1 The vast majority of the wetland is under crop or plantation cover The natural habitats are mainly of tree stratum, but only on a surface of about 10%.	
Sub-criteria 5: Ecosystem function					6 The wetland has degraded functionality due to past and present human activities. The hydraulic functionality score is evaluated as medium (floodable area during heavy rainfall but with a limited role during light rainfall).					

Criterion: Biodiversity enhancement in Nyabugogo Lower										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
					The state of conservation of the environment is degraded (important agricultural activity) but some sectors present an ecological interest. The biological functionality is evaluated as medium.					
Sub-criteria 6: External exchanges					6 The only ecological connection is to the river, whose flow is less intersected by roads and paths: the fragmentation is therefore considered partial. Hydraulic structures (nozzles and frame bridges) ensure hydraulic transparency but are not designed to promote the passage of wildlife. Despite the presence of some natural woodlands, the ecological connection is interrupted by crops and anthropic activities. The wetland is strongly constrained by anthropization. This wetland is in continuity with larger wetland habitats upstream, without fragmentation, which can facilitate ecological connections					

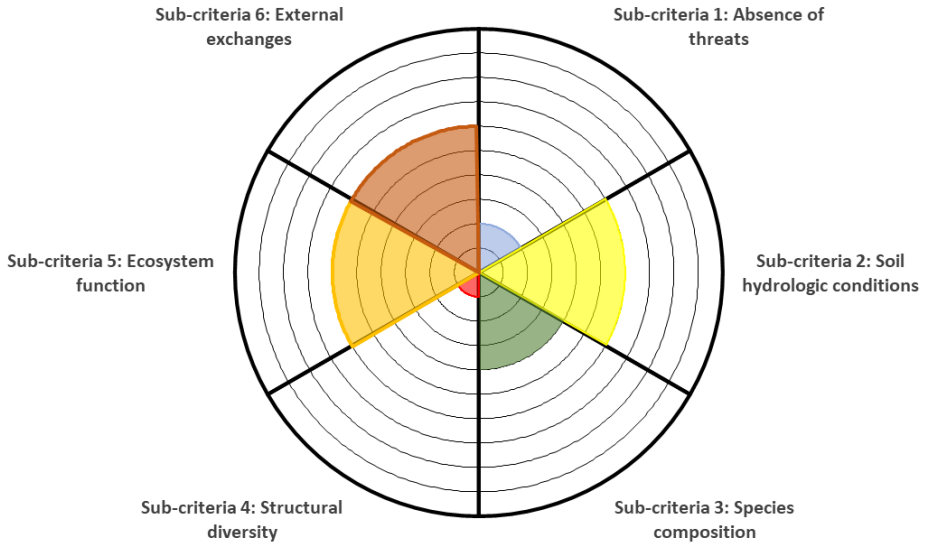


FIGURE 4-106 BIODIVERSITY AT BASELINE, CRITERIA RANKING FIGURE - NYABUGOGO LOWER

4.10 WATER QUALITY IN THE WETLAND

This section describes water quality in the wetland and wetland filtering functions to inform the multi-criteria analysis.

4.10.1 Objectives

The objectives of this chapter are to study environmental condition of the wetlands by describing various sources of pollution and to assist in the evaluation of the baseline situation of the filtering function of the wetlands.

4.10.2 Method

Most data are analyzed from secondary sources such as validated studies related to the wetlands.

4.10.3 Results

4.10.3.1 Source of pollution inside the wetland (Sub-criteria 1)

Three studies undertook inventories of sources of pollution inside the wetlands SMEC Technical Support for Development of Wetland Master Plan for Kigali City (2019), NEMUS, Detailed Sub-Catchment Management Plans for Gikondo and Nyabugogo Wetland Systems (2018) and Macfarlane, Preliminary Baseline Report: Wetlands targeted for rehabilitation under RUDP II" (August 2021).

At time of these SMEC and NEMUS reports, many industries were installed inside the wetland (as in Gikondo Industrial Park), or at the fringe of the wetlands and these were characterised and the type of pollution they were generating described. Since these two studies, most industries were removed and relocated to the Special Economic Zone (SEZ).

As for 2022, most sources of pollution inside the wetland are coming from agricultural activities. Other livelihood activities are also taking place and impacting water quality, less significantly, such as fish farming, grazing, collection of fodder and peat and sand extraction. Car washing is also reported to take place in the wetlands as well as waste disposal. Unlike agriculture, these other sources of pollution inside the wetlands are marginal.

The use of manure and agrochemicals such as fertilizers and pesticides and poor agricultural practices leading to soil erosion are contributing to surface water pollution in the 5 wetlands.

The following figure and table show the extent of agriculture in the 5 wetlands based on the consultant field visits.

TABLE 4-27 EXTENT OF AGRICULTURAL ACTIVITIES IN THE 5 WETLANDS

	Total area	**Agriculture (including bamboo plantation, horticulture and aquaculture)**		**Wasteland (including infrastructure and building) and remnant wetlands**	
		Total surface	Percentage of the wetland	Total surface	Percentage of the wetland
Nyabugogo	131 ha	84 ha	64 %	47 ha	36 %
Rugenge-Rwintare	65 ha	33 ha Including 13.2 ha of bamboo plantation	57 %	32 ha	43 %
Gikondo	162 ha	22.5 ha	14 %	139.5 ha	86 %
Kibumba	68 ha	34 ha	50 %	34 ha	50 %
Rwampara	65 ha	33 ha	51 %	30 ha	48 %
TOTAL	**489 ha**	**210.5 ha**	**43 %**	**278.5 ha**	**57 %**

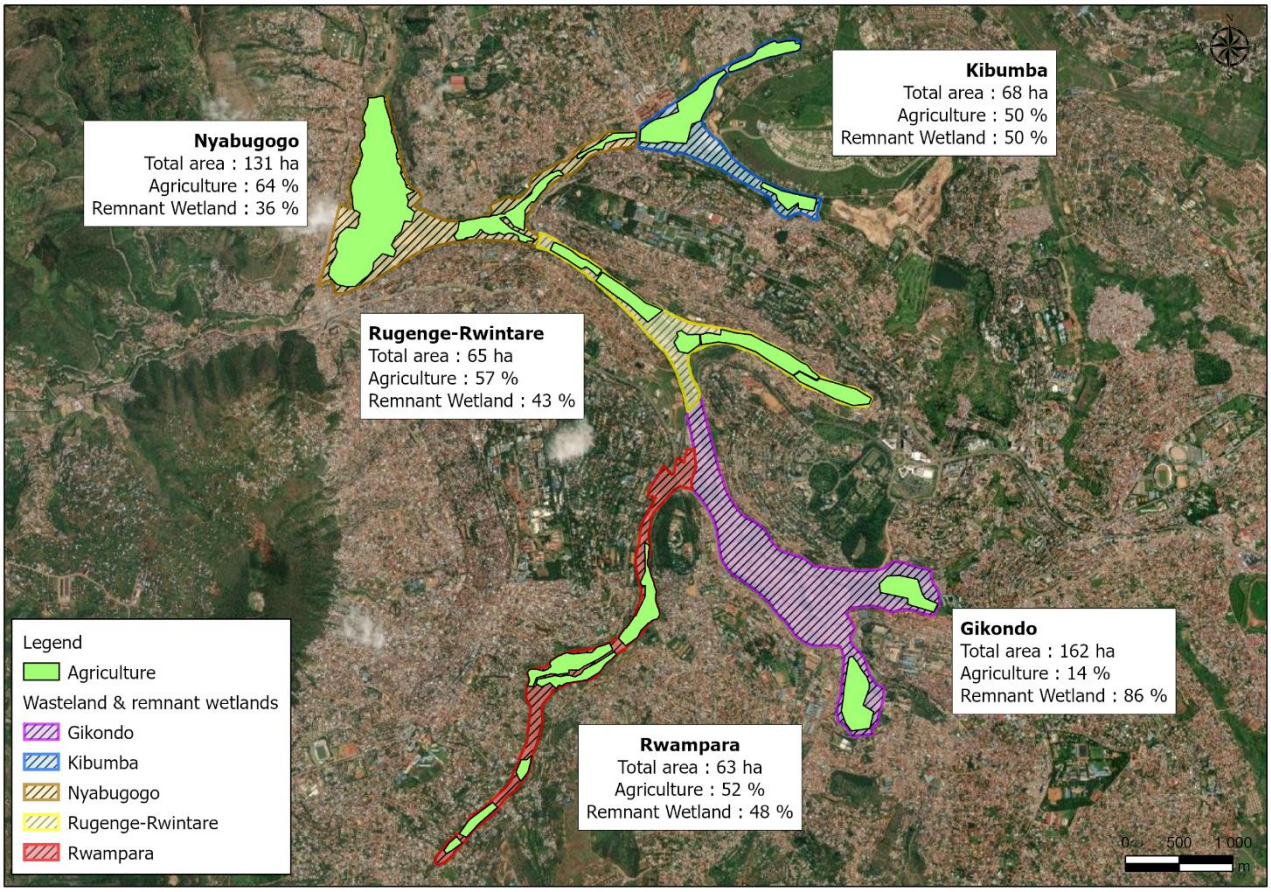


FIGURE 4-107 AGRICULTURE IN THE WETLANDS

4.10.3.2 External sources of pollution flowing in the wetland (point source and nonpoint source) (Sub-criteria 2)

External sources of pollution, both point and nonpoint, are numerous. These bring pollutants either directly, through drainage outlets or indirectly through surface runoffs. The external sources of pollution are as follow:

- **Drains outlets from stormwater drainage**: storm drainage is discharging collected water in the wetlands at several points. These are important point sources of waterborne pollution and sometimes solid waste. Storm drainage bring suspended materials, debris and pollutant into rivers. These storm drainages are intended for surface runoff water only. However, field visits and bibliographic data show that some of the stormwater conveyed in these drains are also collecting domestic and industrial wastewater. City-wide statistics indicate that 4.9% of the private households in Kigali City have 'flush toilet/WC system', presumed to include a septic tank. Fifty per cent of households have a 'private pit latrine' and about 41 % have access a 'shared pit latrine' (Atkins, 2017). There is currently no waterborne sewer network in Kigali, no sanitary sewer network and no centralized sewage treatment plant (STP) in the City of Kigali (Kigali Master Plan, 2020). According to the report "Kigali Central Sewage – Institutional, Economic and Financial Analysis" (Atkins, 2017), some septic tanks sometimes are connected to the storm drainage system, thus bringing wastewater directly in the wetlands. It is however foreseen that, in 2025, the development of a sewerage system will cover part of the city as shown in the following figure. This development will collect and treat sewage from areas designated 1a and 2a and reduce pressure on Nyabugogo and Rugenge-Rwintare wetlands and a small part of Rwampara wetland. Even if this scheme is not in place yet, the evaluation of this sub-criteria will consider the development of the sewerage network since its installation is foreseen in 2025, which corresponds to the end of the construction of the rehabilitation of the wetlands.

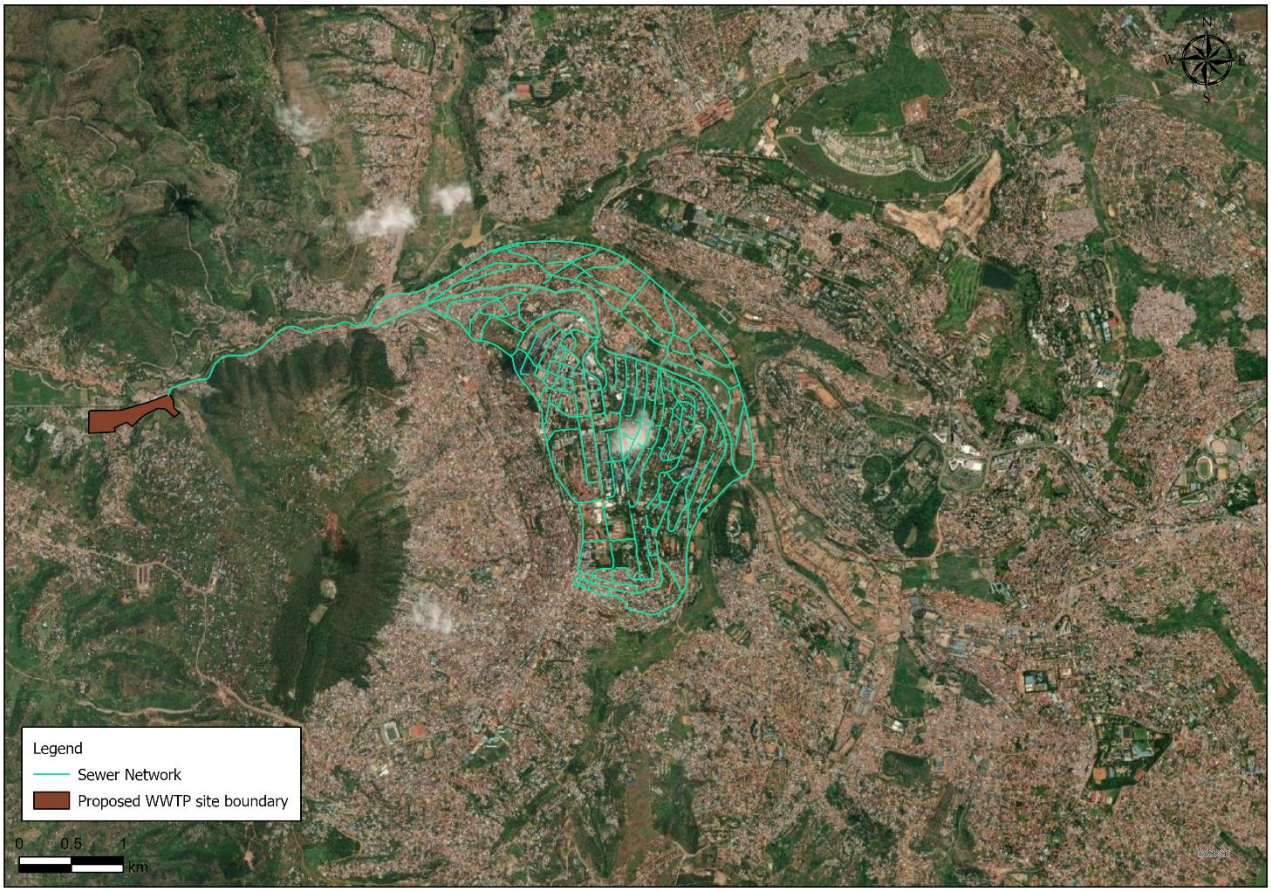


FIGURE 4-108 DEVELOPMENT OF THE SEWERAGE IN KIGALI FOR 2025 (ZONE 1A AND 2A)



FIGURE 4-109 URBAN STORM DRAINAGE DISCHARGING IN GIKONDO



FIGURE 4-110 URBAN STORM DRAINAGE DISCHARGING IN RWAMPARA

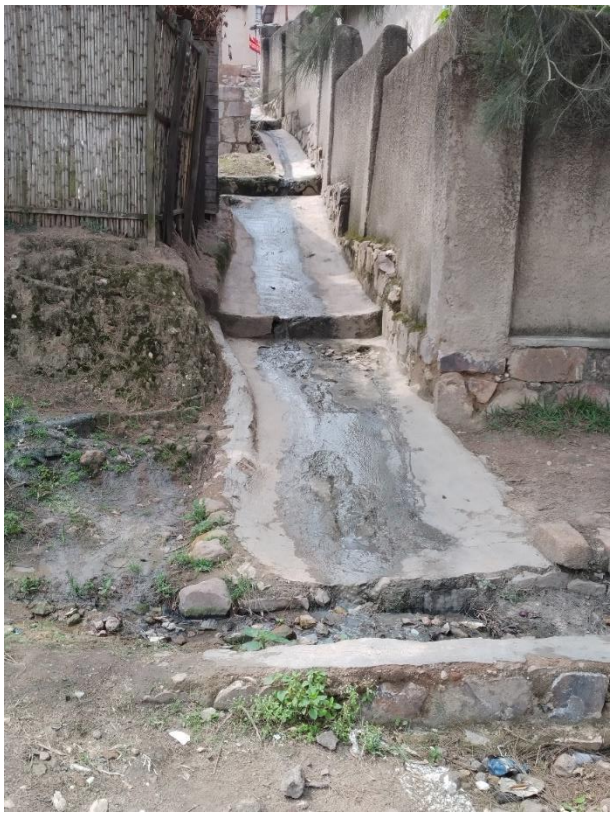


FIGURE 4-111 UNTREATED DOMESTIC WASTEWATER DISCHARGING IN RUGENGE-RWINTARE



FIGURE 4-112 STORM DRAINAGE DRAINING VISION 2000 RESIDENTIAL AREA IN KIBUMBA



FIGURE 4-113 STORM DRAINAGE COLLECTING RESIDENTIAL AREAS AND ROAD RUNOFFS AND DISCHARGING IN NYABUGOGO

WASAC has communicated the localisation of stormwater drainage in the CoK. These are illustrated in the next figure. In addition to these storm drainages, there are numerous small drainages discharging untreated domestic wastewater.

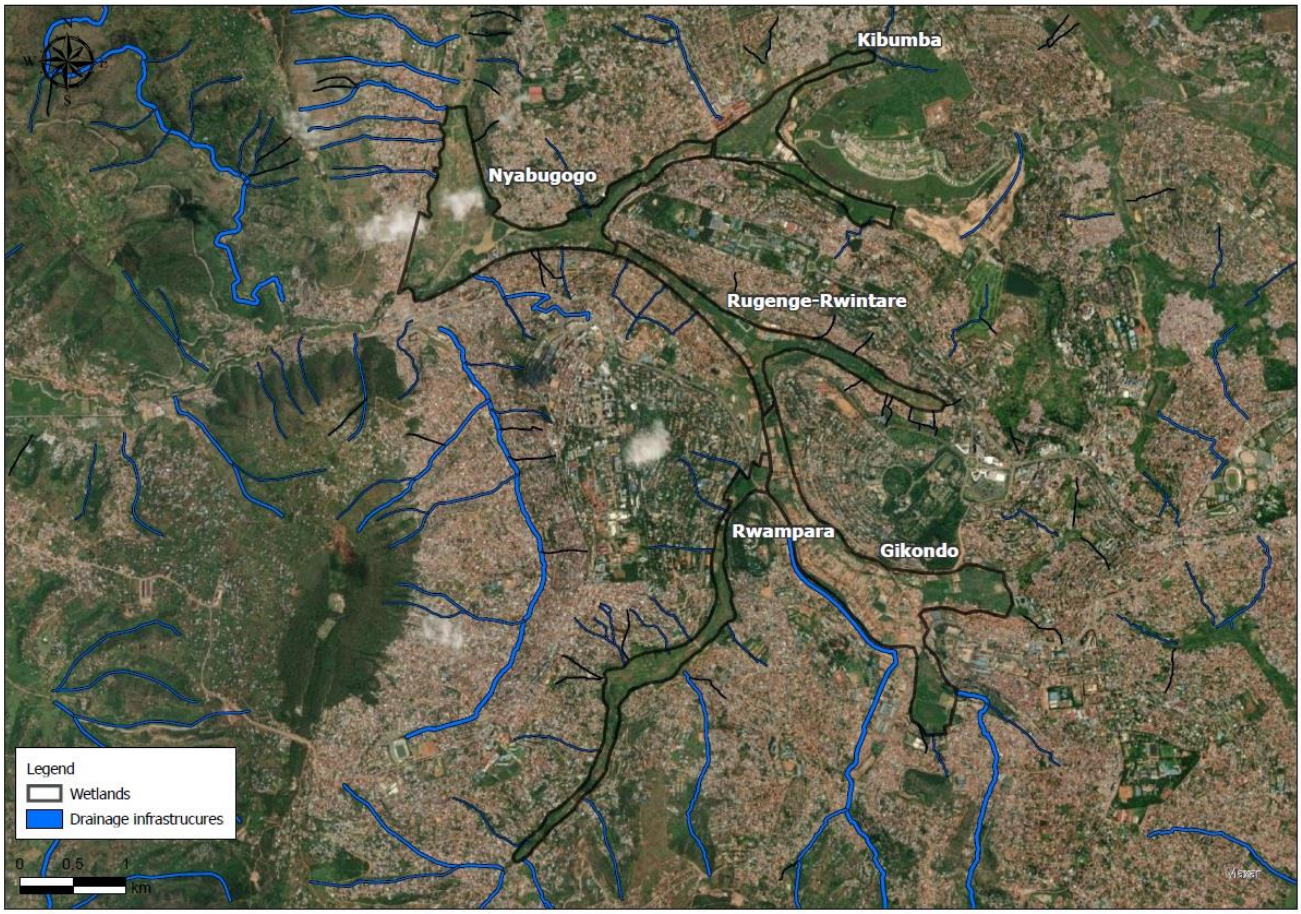


FIGURE 4-114 MAIN STORM DRAINAGE (COMMUNICATED BY WASAC, 2022)

- **Diffuse pollution (nonpoint source) from existing light industrial areas (workshops), garages, warehouses and commercial activities**. This source of pollution is difficult to quantified. Pollution hotspots were delineated by NEMUS (2018). Since this study, most industries in the wetland have been removed and related to the SEZ. However, in the wetland catchment there are remaining pollution hotspots as shown in the following figure.

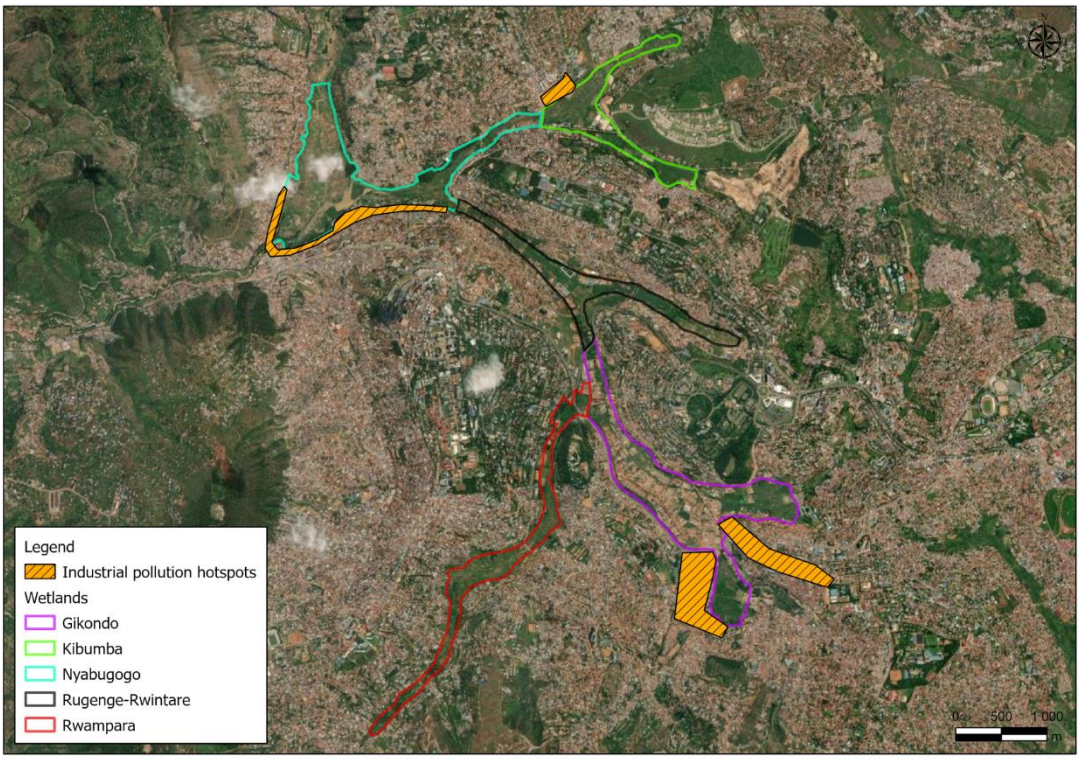


FIGURE 4-115 POLLUTION HOTSPOTS

4.10.3.3 Surface water quality (Sub-criteria 3)

According to SMEC water quality survey, Thematic Report: Volume 2B Water Pollution and Water Quality Technical Support for Development of Wetland Master Plan for Kigali City (2019), Gikondo has a high level of pollution mainly from the now demolished Gikondo industrial park valley. The area was characterized as critically polluted. BOD levels indicated high levels of organic matter and microbiological analysis.

SMEC water quality survey (2019) used a pollution rating system to characterize Kigali wetlands from 1 to 3 with 3 indicating the highest level of pollution and 1 the lowest. According to this system:

- Gikondo has a pollution rating of 3
- Rwampara has a pollution rating of 2
- Rugenge-Rwintare has a pollution rating of 2
- Kibumba has a pollution rating of 2
- Nyabugogo has a pollution rating of 3

However, since SMEC assessment, Gikondo industrial park has been removed as well as most sources of pollution identified in the report, which have contributed to lowering the pollution level.

NEMUS undertook water sampling at several locations in rivers flowing through the wetlands:

- Station 1 (Nyabugogo River upstream)
- Station 2 (Nyabugogo River downstream)
- Station 3 (Kibumba River)
- Station 4 (downstream Gikondo in a stream)
- Station 5 (downstream Rwampara River)

Results of this campaign is presented in appendix 1. The following map shows the sampling sites.

MINIRENA, NIRAS: Water Pollution Study Final Report, July 2017 also sampled two stations inside the study area at the end of the wet season. One station in Nyabugogo and one station at the junction between Nyabugogo and Rugenge-Rwintare wetland:

- Point 9 inside Nyabugogo wetland (Nyabugogo River)
- Point 10 junction between Nyabugogo and Rugenge-Rwintare wetland (on Rugenge River)

Results of this campaign is presented in appendix 1. The following map shows the sampling sites.

In the framework of the study “Preliminary Baseline Report: Wetlands targeted for rehabilitation under RUDP II” (Macfarlane, August 2021), water quality sampling and analysis was conducted in lower Nyabugogo and Gikondo wetlands. Surface water samples collected in May, June and July 2020. Since there are no national standards for surface water quality for aquatic ecosystems, this report used a mixed of several standards to establish acceptable thresholds including standards from the Rwanda Standard Board and international standards. The following stations were sampled in May (end of rainy season), June and July:

- GK-01: Is located in the northern branch of Gikondo wetland on Kagina stream
- GK-02: Is located at the junction between the northern branch of Gikondo and the main branch on Kagina stream
- GK-03: Is located in the southern branch of Gikondo on Gatenga stream
- GK-04: Is located at the outflow of Gikondo wetland and the junction with Rugenge-Rwintare wetland
- NYA-02: Is located on Rugenge River at the junction between Rugenge-Rwintare and Nyabugogo wetland
- NYA-04: Is located on Nyabugogo River at its outflow
- NYA-05: is located at the outflow of Mpazi channel
- NYA-07: is located on Nyabugogo upstream from the study area

Results of this campaign is presented in appendix 1. The following map shows the sampling sites.

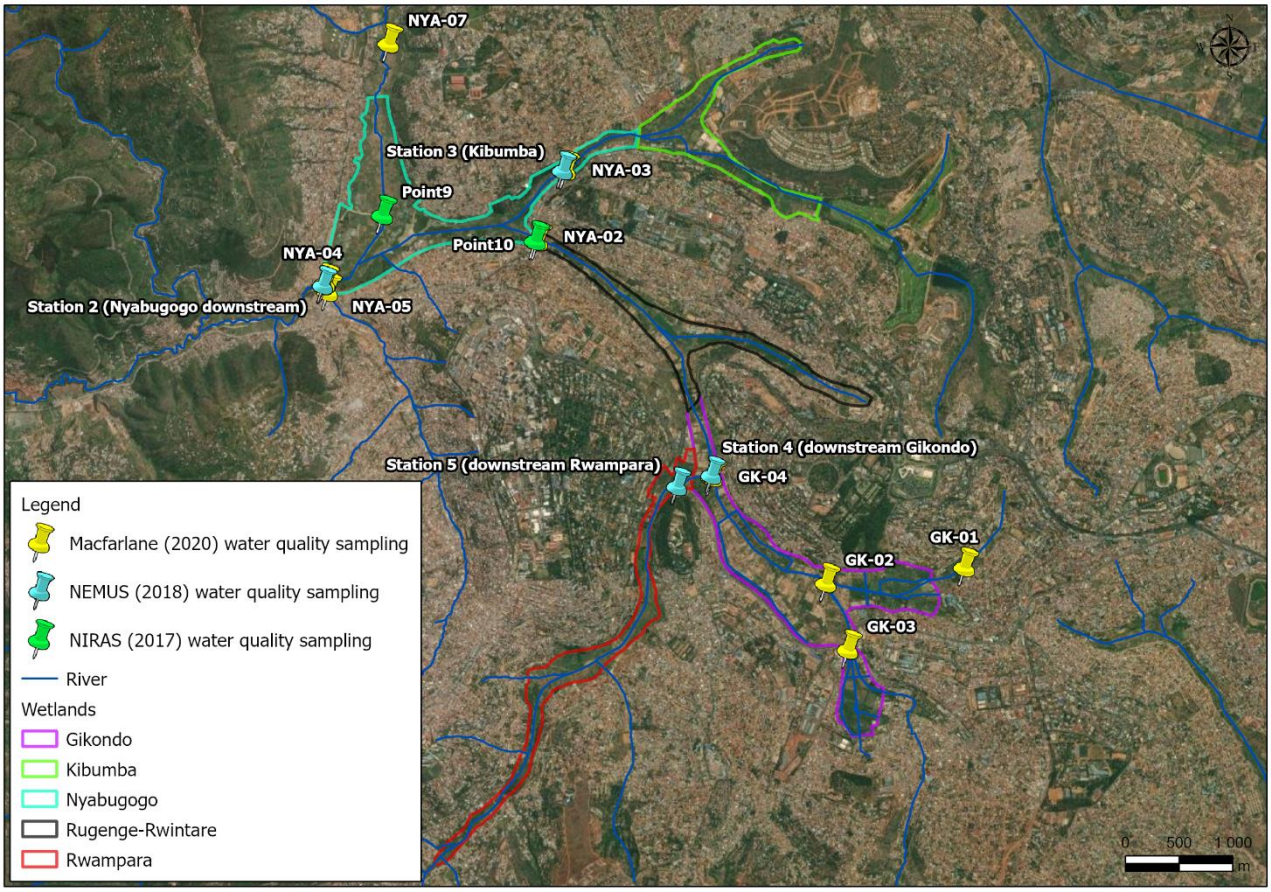


FIGURE 4-116 LOCATION OF WATER QUALITY SAMPLING STATIONS

There are no specific national guidelines for the protection of aquatic ecosystems (including eutrophication) in Rwanda. However, Rwanda National Water Resources Master Plan (MINIRENA-RNRA, 2015), has developed a classification system for a limited number of parameters (Chemical Oxygen Demand (COD); Biochemical Oxygen Demand (BOD), nitrate; phosphate; faecal coliforms and e. coli bacteria). The categories are as follow: very good, good, satisfactory, modified, strongly modified and the thresholds are presented in the next table.

TABLE 4-28 RWANDA NATIONAL WATER RESOURCES MASTER PLAN FOR WATER QUALITY

Classification for chemical quality	**Description**	**Physico-chemical water quality especially (N & P)**	**Nutrient status and impact of organic load (BOD5, DOC)**
Very good	All parameters are better than standards or recommended values, all hydrological and ecological functions of storing, filtering, purifying and providing water are vital	N < 3 mg/L and P < 0.05 mg/L	BOD < 5 mg/L and COD < 10 mg/L and E. coli < 4 cts. and Faecal Coliforms <100 cts.
Good	Parameters reach or are better than standards or recommended values, hydrological and ecological functions of storing, filtering, purifying and provision are intact	N: 3-5 mg/L and P: 0.05-0.1 mg/L	BOD < 10 mg/L and COD < 20 mg/L and E. coli < 4 cts. and Faecal Coliforms

Classification for chemical quality	**Description**	**Physico-chemical water quality especially (N & P)**	**Nutrient status and impact of organic load (BOD5, DOC)**
			100-400 cts. Per 100 ml
Satisfactory	Most but not all parameters correspond to recommended values, river section is partly affected by anthropogenic impact but still mostly responding to its ecosystem functions	N: 5-10 mg/L and P: 0.1-0.25 mg/L	BOD 10-30 mg/L and COD 20-50 mg/L or E. coli 4-10 cts. or Faecal Coliforms 100-400 cts.
Modified	Anthropogenic impacts are evident, some parameters exceed recommended values or regulations, some ecosystem functions of filtering, purifying or provisioning are affected	N 5-10 mg/L or P 0.25-0.5 mg/L	BOD 30-50 mg/L and COD 50-75 mg/L or E. coli > 10 cts. and faecal Coliforms > 400 cts.
Strongly modified	Several key parameters indicate strong anthropogenic impact, several ecosystem functions are affected, major measures need to be taken to restore ecosystem functions in the river section	N > 10 mg/L and P > 0.5 mg/L	BOD > 50 mg/L and COD >75 mg/L and E. coli > 10 cts and Fecal Coliforms > 400 cts.

Based on these sampling campaigns, the following can be concluded:

- **Rivers flowing in the wetland system are highly turbid**, indicating that the rivers are transporting high concentration of silt, clay, inorganic and organic matter. NEMUS (2018) results show some differences between seasons, for example turbidity increases during the wet season as a result of increased surface runoff and higher water velocity stirring up and suspending material from the stream bead. NEMUS and Macfarlane sampling points in Nyabugogo have the highest value for turbidity which is linked to the intense use for agriculture of Nyabugogo wetland. Agriculture leaves bare soils between harvests thus contributing to these high values. High level of turbidity affects aquatic habitat quality and causes sedimentation of the river bed. In addition, transported particles provide attachment for pollutants and bacteria (such as coliforms).
- **Conductivity results show good water quality for this parameter** in all NEMUS and Macfarlane stations and in the range of the country's value for natural water courses. The country's range is between 24 and 1158 µS/cm according to the Water quality monitoring in Rwanda from the IWRM Programme Rwanda (Rwanda Water and Forestry Authority, 2019). These results show that, at the sampling points, an acceptable volume of mineral salts enters the watercourses of the wetlands. Sampling directly at urban drains location would have shown much higher conductivity since these drains bring pollutants in the wetlands.
- **The detection of metals (Copper, Manganese, Zinc, Chromium, Mercury, Lead) indicates that there are point and nonpoint sources of pollution from industries**. Macfarlane did not detect Chromium, but its sampling points show high concentration of Copper and Lead in Nyabugogo and Gikondo. Gikondo showed also high concentration of Mercury.
- **Nitrogen in the aquatic environment can be found in the forms of Ammonia, Nitrites and Nitrates**. These are the results of municipal effluent discharges (wastewater), runoff from agricultural lands and use of fertilizers. Ammonia causes direct toxic effects on aquatic life. The EPA (Environmental Protection Agency from the United States) considers that, above 1,9 mg/l for a 30 days average duration, ammonia to be the chronic criterion magnitude for aquatic life that should not be exceed. NEMUS stations Station 1 (Nyabugogo upstream) and NEMUS Station 3 (Kibumba) and all Macfarlane stations show result above 1mg/l. Nitrites and Nitrates are causing over-enrichment of waterbodies. All NEMUS stations showed concentration below 5mg/l of Nitrate, however, Macfarlane's results show that in Nyabugogo and Gikondo almost all stations had concentration above 5mg/L showing Modified or Strongly modified conditions according to the Rwanda National Water Resources Master Plan classification.
- **Regarding phosphates, almost all stations showed poor water quality for this parameter**. Sources of phosphate are either natural from weathering and erosion or anthropogenic from fertilizers or sewage.
- **Regarding Chlorides**, most NEMUS stations showed very high values, some of which are close or higher than the highest value of 94.6 mg/l measured by the Water quality monitoring in Rwanda from the IWRM Programme Rwanda (Rwanda Water and Forestry Authority, 2019). Macfarlane stations showed high value as well, but lower than REMUS, its values ranged between 20 and 32 mg/l. High level of Chlorides often indicates pollution from industrial and sewage effluents and agricultural and road run-off.
- **Regarding biological contamination**, most stations (NEMUS, NIRAS, Macfarlane) showed contamination of E. Coli and faecal Coliforms, as a result of untreated sewage discharging into the wetlands. Macfarlane June and July results (in the dry season) showed lower biological contamination which is consistent with the fact that most urban drainage become gradually disconnected from rivers as flow and urban runoffs decrease. Coliforms come from human and animal wastes (feces). Macfarlane show much higher values than NEMUS.
- **Regarding Chemical Oxygen Demand (COD)**, NEMUS Station 3 (Kibumba) showed very high COD indicating high concentration of pollutants. High COD can deplete dissolved oxygen in water. Macfarlane did not analyze COD. Biochemical Oxygen Demand (BOD) is the amount of oxygen required to breakdown pollutants biologically with microorganisms. BOD data from NEMUS show good water quality which is consistent with the country range for natural water courses. The country's average is between 1.4 mg/l and 17.6 mg/l according to the Water quality monitoring in Rwanda from the IWRM Programme Rwanda (Rwanda Water and Forestry Authority, 2019). Macfarlane, had higher values for BOD, some of which were higher than the national range. In all cases, the BOD values were above 2

mg/l showing that all rivers receive some organic pollution. BOD decreased in the wet season probably as a result of the dilution effect of higher flows.

- **Regarding Dissolved Oxygen (DO)**, NIRAS station Point 10 junction between Nyabugogo and Rugenge-Rwintare wetland showed very low level of DO, a level that can be lethal for aquatic life. Macfarlane results show that several stations in Nyabugogo and Gikondo had concentrations of DO below 6 mg\l, which are considered to be stressful conditions for fishes.
- **Polycyclic Aromatic Hydrocarbons PAH (µg/l), Hexachlorobenzene HCB (µg/l) and Polychlorinated biphenyls PCB (µg/l)** were not detected by NEMUS sampling campaign.

In the light of these data, water quality is generally poor in the wetlands as a result of untreated sewage discharged in the wetlands, past industrial activities and agriculture activities.

Overall, as shown in the following figure, NEMUS samplings shows that more higher values were recorded during the dry season than during the wet season. With higher flows and dilution factor, rivers in the wetlands generally showed better quality during the wet season. However, during the rainy season increased flows carry heavier loads of sediment into streams from catchment activities and mobilize sediment along streamlines and from cultivated areas. During the dry season, urban drainage mixing stormwater and wastewater do not have sufficient flow to allow the discharge point to reach rivers which explains why biological contamination is lower during this season. Macfarlane results show that all rivers flowing through the study area's wetlands Kibumba (NYA-03 station), Gikondo (GK-01, GK-02, GK-03, GK-04) Nyabugogo (NYA-02, NYA-03 and NYA-04) and Rugenge-Rwintare (GK-04 and NYA-02) show high level of pollution and would be considered as Modified or Strongly modified according to the Rwanda National Water Resources Master Plan classification. Overall, results show that rivers flowing through Gikondo and Nyabugogo are slightly more polluted.

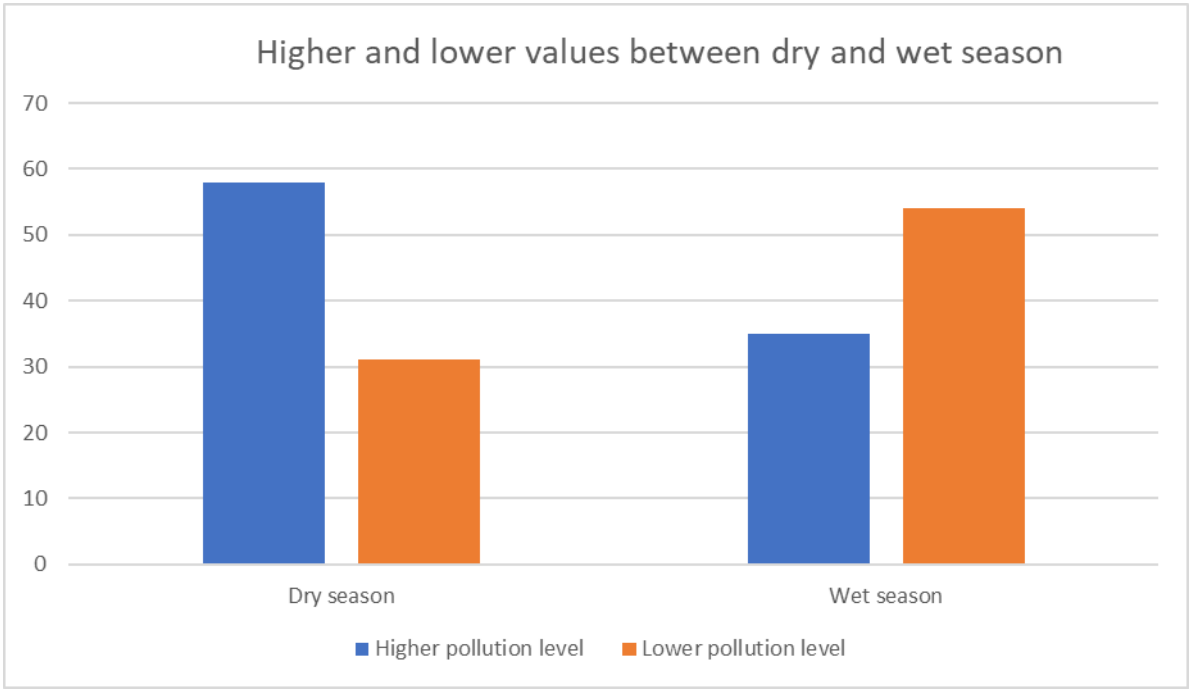


FIGURE 4-117 COMPARISON OF HIGHER AND LOWER VALUES FOR WATER QUALITY PARAMETERS

4.10.3.4 Natural filtration function of the wetland (Sub-criteria 4)

Filtering functions of wetland are possible whenever wetlands allow to retain water for some times to enable degradation processes to take place and sediment to settle. Filtering wetland are typically lagoons where sediments and pollutants are trapped and allowed to settle to be degraded where adsorption in the soils and by plant uptake via the roots take place. Most of the wetlands in the system have lost this function since water courses are channelized to rapidly evacuate water outside the wetlands and native plants are mostly replaced

by ruderal plants and agricultural plants. Minor floods are no longer overflowing on floodplains and the residence type of water is very short in most areas.

4.10.4 Conclusion on baseline in Gikondo

TABLE 4-29 WATER FILTRATION AT BASELINE, CRITERIA RANKING MATRIX - GIKONDO

Criterion: Improvement of water quality										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
Sub-criteria 1: Source of pollution inside the wetland							3 The wetland is utilized by several activities that are known to generate water pollution covering significant part of the wetland Since the industrial park has been entirely removed, only agricultural activities remain in the wetland. These occupy small part of the Southern and Northern branches (14% of the total wetland area). However, the presence of contaminated soil, which have not been removed, is probably a source of pollution, transported in rivers during floods			
Sub-criteria 2: External sources of pollution flowing in the wetland (point source and nonpoint source)									2 The wetland receives high volume of untreated external pollution According to the Kigali City Master Plan 2020, there are many commercial zones (C3) and mixed use zones (C1) around the wetland. In addition, there are pollution hotspots around Gikondo	

Criterion: Improvement of water quality										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
Sub-criteria 3: Quality of surface water flowing in the wetland							3 The quality of surface water is poor because of several types of pollutions (turbidity, high organic or high inorganic pollution) Many parameters such as Ammonia, phosphate, coliforms Chloride, metals and COD show that there is pollution from municipal effluent (wastewater) discharges, runoff from agricultural lands and use of fertilizers			
Sub-criteria 4: Natural filtration function of the wetland							3 The natural filtering function of the wetland neither performs well to trap sediment nor to assimilate pollutants Except for patches of small remain floodplains, water residence time is rather small and natural vegetation replaced by ruderal and agricultural plants			

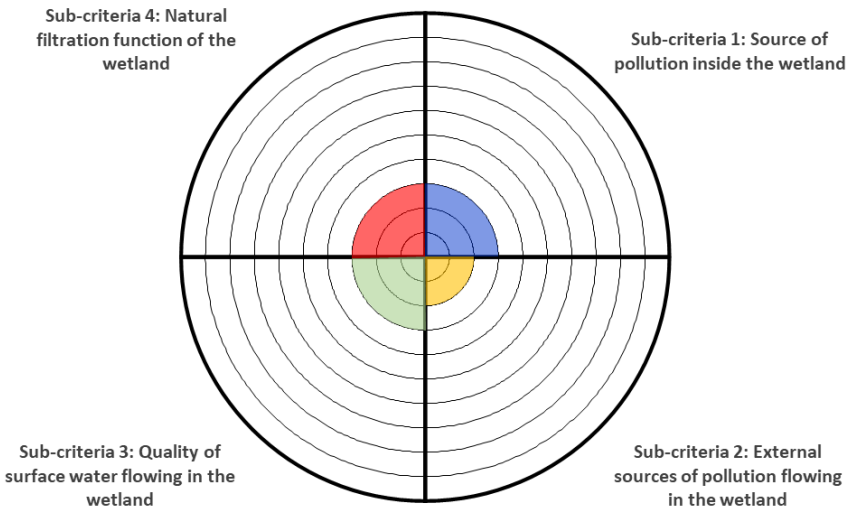


FIGURE 4-118 WATER FILTRATION AT BASELINE, CRITERIA RANKING FIGURE - GIKONDO

4.10.5 Conclusion on baseline in Rwampara

TABLE 4-30 WATER FILTRATION AT BASELINE, CRITERIA RANKING MATRIX - RWAMPARA

Criterion: Improvement of water quality										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
Sub-criteria 1: Source of pollution inside the wetland					5 The wetland is utilized by one type of activity known to generate water pollution covering significant parts of the wetland Agricultural activities are taking place in the wetland. These occupy large parts of Rwampara (52% of the total wetland area)					
Sub-criteria 2: External sources of pollution flowing in the wetland (point source and nonpoint source)					5 (project with sewerage) The wetland receives external pollution, but these are treated at their point of discharge or in part treated prior to their discharge According to the Kigali City Master Plan 2020, there are mainly medium residential - improvement zones (R2) around the wetland. However, the development of the sewerage system by 2025 will benefit a small part of Rwampara by diverting untreated wastewater to a wastewater treatment plant					
Sub-criteria 3: Quality of surface water flowing in the wetland							4 The quality of surface water is poor because of several types of pollutions (turbidity, high			

Criterion: Improvement of water quality										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
							organic or high inorganic pollution) Some parameters such phosphate, coliforms and COD show that there is pollution from municipal effluent (wastewater) discharges, runoff from agricultural lands and use of fertilizers			
Sub-criteria 4: Natural filtration function of the wetland									1 The wetland does not have any natural filtering functions Rwampara is mostly a dead wetland as the river is deeply incised or re-enforced with gabion and barely feed any floodplain	

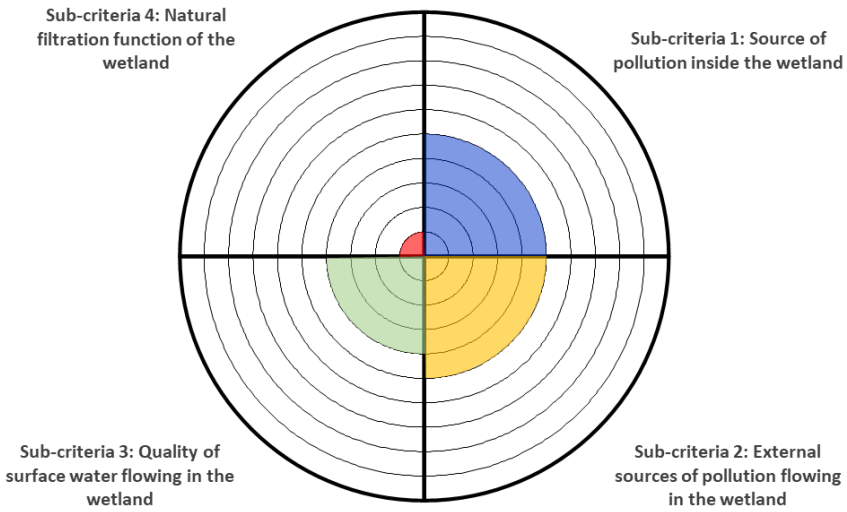


FIGURE 4-119 WATER FILTRATION AT BASELINE, CRITERIA RANKING FIGURE - RWAMPARA

4.10.6 Conclusion on baseline in Rugenge-Rwintare

TABLE 4-31 WATER FILTRATION AT BASELINE, CRITERIA RANKING MATRIX - RUGENGE-RWINTARE

Criterion: Improvement of water quality										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
Sub-criteria 1: Source of pollution inside the wetland							4 The wetland is utilized by several activities that are known to generate water pollution covering significant part of the wetland Agricultural activities are taking place in the wetland. These			

Criterion: Improvement of water quality										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
							occupy large parts of Rugenge-Rwintare (57% of the total wetland area) A small landfill, sorting and composting organic matter is operated in the wetland			
Sub-criteria 2: External sources of pollution flowing in the wetland (point source and nonpoint source)					6 (project with sewerage) The wetland receives external pollution, but these are treated at their point of discharge or in part treated prior to their discharge According to the Kigali City Master Plan 2020, the western branch of the wetland is mainly surrounded by low density residential zones (R1 and R1A) while the eastern branch is mainly surrounded by mixed use zones (C1). However, the development of the sewerage system by 2025 will benefit the southern part of Rugenge-Rwintare by diverting untreated wastewater to a wastewater treatment plant					
Sub-criteria 3: Quality of surface water flowing in the wetland							4 The quality of surface water is poor because of several types of pollutions (turbidity, high organic or high inorganic pollution) Many parameters such as Ammonia, phosphate, coliforms Chloride, metals and COD show			

Criterion: Improvement of water quality										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
							that there is pollution from municipal effluent (wastewater) discharges, runoff from agricultural lands and use of fertilizers			
Sub-criteria 4: Natural filtration function of the wetland					5 The natural filtering function of the wetland does not perform well to trap sediment or to assimilate pollutants Except for patches of small remain floodplains, water residence time is rather small and natural vegetation replaced by ruderal and agricultural plants and bamboos					

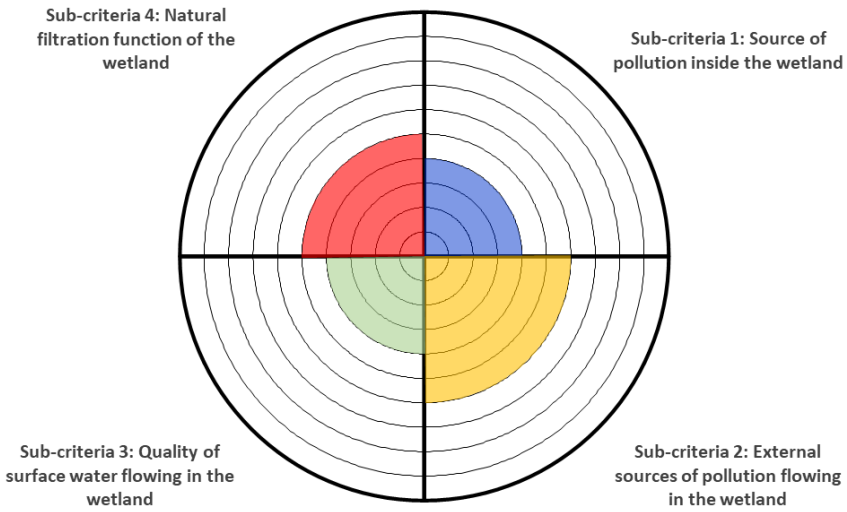


FIGURE 4-120 WATER FILTRATION AT BASELINE, CRITERIA RANKING FIGURE- RUGENGE-RWINTARE

4.10.7 Conclusion on baseline in Kibumba

TABLE 4-32 WATER FILTRATION AT BASELINE, CRITERIA RANKING MATRIX - KIBUMBA

Criterion: Improvement of water quality										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
Sub-criteria 1: Source of pollution inside the wetland					5 The wetland is utilized by one type of activity known to generate water pollution covering significant parts of the wetland					

Criterion: Improvement of water quality										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
					Agricultural activities are taking place in the wetland. These occupy large parts of Kibumba (50% of the total wetland area).					
Sub-criteria 2: External sources of pollution flowing in the wetland (point source and nonpoint source)							3 The wetland receives untreated external pollution According to the Kigali City Master Plan 2020, most of the wetland is surrounded by low density residential densification zones, however one light industrial zone is present at the fringe of the wetland In addition, Kibumba drain the nearby golf course. Golf courses are using herbicides in large quantities			
Sub-criteria 3: Quality of surface water flowing in the wetland							4 The quality of surface water is poor because of several types of pollutions (turbidity, high organic or high inorganic pollution) Many parameters such as Ammonia, phosphate, Chloride and COD show that there is pollution from municipal effluent (wastewater) discharges, runoff from agricultural lands and use of fertilizers			

Criterion: Improvement of water quality										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
Sub-criteria 4: Natural filtration function of the wetland							4 The natural filtering function of the wetland neither performs well to trap sediment nor to assimilate pollutants Except for patches of small remain floodplains, water residence time is rather small and natural vegetation replaced by ruderal and agricultural plants			

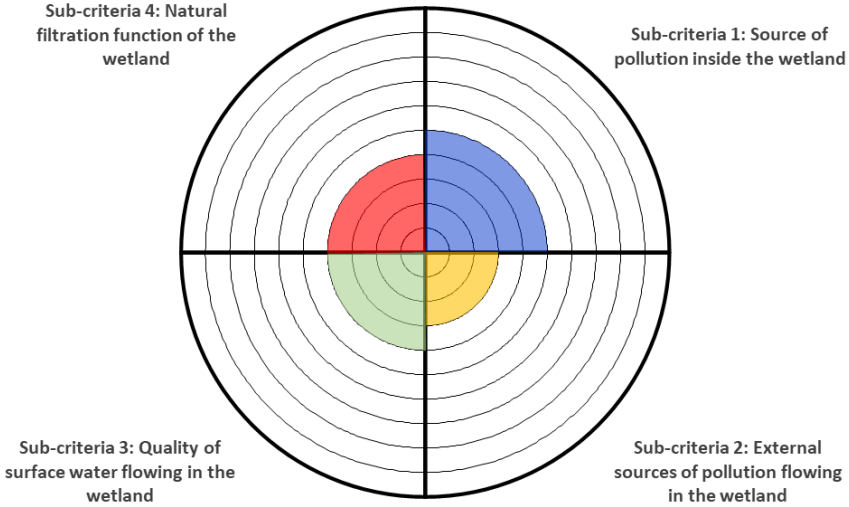


FIGURE 4-121 WATER FILTRATION AT BASELINE, CRITERIA RANKING FIGURE - KIBUMBA

4.10.8 Conclusion on baseline in Nyabugogo Lower

TABLE 4-33 WATER FILTRATION AT BASELINE, CRITERIA RANKING MATRIX - NYABUGOGO LOWER

Criterion: Improvement of water quality										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
Sub-criteria 1: Source of pollution inside the wetland							4 The wetland is utilized by several activities that are known to generate water pollution covering significant part of the wetland Agriculture covers 64% of the wetland area and several activities are still encroaching in the wetlands such as garages. The large pond is highly colonized by the water hyacinth, depleting water from oxygen. Are area is used to burn used tires in the wetland			
Sub-criteria 2: External sources of pollution flowing in the wetland (point source and nonpoint source)					5 (project with sewerage) The wetland receives external pollution, but these are treated at their point of discharge or in part treated prior to their discharge According to the Kigali City Master Plan 2020, the area west of the wetland is made of rural residential zone (R1B) and the eastern part is made of forest zone (P3B). There is one pollution hotspot along the southern part of the wetland and the size of the catchment draining the rural					

			areas is however quite large. Lastly Nyabugogo is located downstream of all other wetlands collecting pollution from them (high pollution load). However, the development of the sewerage system by 2025 will benefit part of Nyabugogo by diverting untreated wastewater to a wastewater treatment plant		
Sub-criteria 3: Quality of surface water flowing in the wetland				3 The quality of surface water is poor because of several types of pollutions (turbidity, high organic or high inorganic pollution) Many parameters such as Ammonia, phosphate, coliforms Chloride, metals and COD show that there is pollution from municipal effluent (wastewater) discharges, runoff from agricultural lands and use of fertilizers	
Sub-criteria 4: Natural filtration function of the wetland			5 The natural filtering function of the wetland does not perform well to trap sediment or to assimilate pollutants The large ponds help to increase water residence time in the wetland and allows to trap sediment flowing from the Rwenzagoro River.		

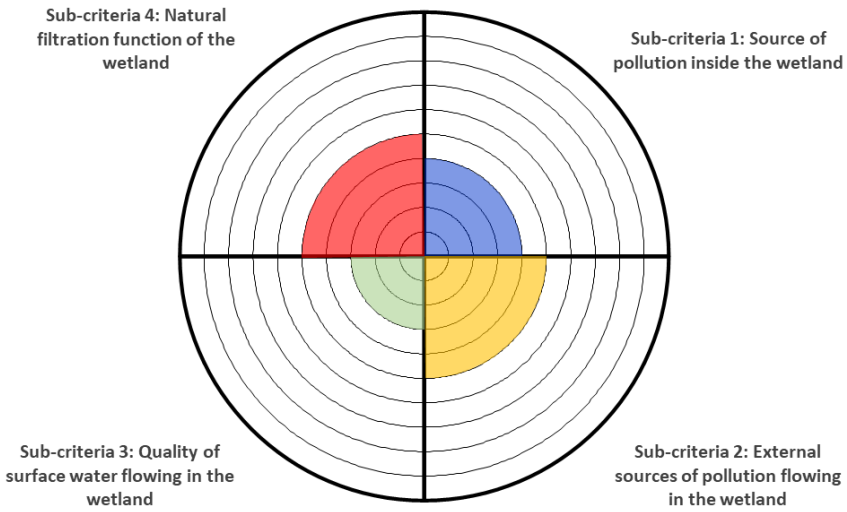


FIGURE 4-122 WATER FILTRATION AT BASELINE, CRITERIA RANKING FIGURE - NYABUGOGO LOWER

4.11 WETLAND LANDSCAPE ASSESSMENT

4.11.1 Objectives

The main objective of the landscape assessment using the multi-criteria method is to use measurable indicators to assess the aesthetic quality of the landscape and the potential of each wetland for the purpose of development of recreational/educational activities and improvement of the city's landscape, in line with the scope of the project.

The multi-criteria analysis uses a set of selected suitable indicators characterizing the current baseline in terms of quality of the landscape and recreational value against which long-term rehabilitation targets will be set.

The application of this method will allow the assessment of the quality of the landscape of each wetland, defining their vocation and providing a better basis for decision making.

4.11.2 Method

Broadly speaking, the landscape can be expressed in three major conceptual dimensions:

Ecological landscape: which refers to the development of a particular and natural ecosystems and the biodiversity of the area.

Cultural landscape: which refers to a geographic area in which the relationships between human activity and the environment have created patterns and mechanisms that govern the presence, distribution and abundance of species

Aesthetic/visual value: which refers to the perception of the landscape. The aesthetic value is considered to contribute to quality of life, health or vitality by providing inspiration, harmony and well-being.

Of the above, the aesthetic or visual dimension is the most primitive and intuitive and is related to the sensorial and perceptive aspects of the viewer. The visual dimension of the landscape, along with cultural values and the quality of the environment, plays a key role in shaping the image of attractive destinations and increasing demand for the use of their associated spaces. As the landscape constitutes a resource of singular importance for the attractiveness of a determined environment, the evaluation of its aesthetic qualities is of particular interest for planning activities under the scope of the project.

The process of analysis will consist in evaluating the elements or factors that broadly define the visual qualities of the landscape of each wetland against a set of sub criteria. Each sub-criterium is based on tangible indicators, such as material elements that compose the landscape, measured against factors that convey natural attributes and anthropic values related to the visual qualities of each wetland.

The method applied in the evaluation is based on indirect visual quality assessment by component. It is therefore a subjective method, which is essentially user-independent and whose sub-criteria are defined on professional judgment, desktop research and knowledge of the ground. Following the objectives of the project, the methodological application will focus on qualitative factors of natural and anthropic landscape and on the factors that determine existing and /or potential for recreational development.

The following factors and attributes will be used as sub-criteria. The explanations for the choice of each sub-criterium is also indicated below.

Sub-Criteria 1 — Quality of the natural landscape/environment: the increase of the quality of natural landscapes occurs where there are occurrences such as topographical irregularities, diversity of land uses and green cover, etc. As the wetlands are essentially low areas, this sub-criterium will focus on the characteristics of the green cover and diversity of land uses.

Sub-Criteria 2 — Quality of the anthropic landscape/cultural environment: cultural environments refer to the occurrence of spaces shaped by human uses and activities, it can encompass constructions and built environments of many kinds such as monuments, bridges, roads, heritage buildings, etc. In the case of the wetlands this sub-criterium will be measured by the occurrence and/or proximity to designed structures and/or landscaped areas (such as memorials, parks, etc) as well as buildings or areas characterised by human activities of special interest (craft making workshops, i.e. wood workshops, urban incubators, etc).

Sub-Criteria 3 — Exposures and visual clearances / perceptions: the level of visual intrusion resulting from the presence of human activities and/or screening forests can have a direct impact on the nature and composition of the physical components related to the landscape. The occurrence of closed views (deep and

narrow valleys, the presence of walls, gated properties and/or built-up areas, etc) can affect negatively the quality of the landscape while panoramic views and/or wide clearings allow for the composition of different layers of perspective and have a positive impact.

Sub-Criteria 4 — Occurrence and level of continuity of green routes (walking/cycling circuits): occurrence, within the wetland, of walking or cycling circuits. The level of continuity will be measured by the existence of deep linear circuits without interruptions as well as potential for connectivity between two or more wetlands or green areas.

Sub-Criteria 5 — Occurrence and/or proximity of recreation facilities (including educational and touristic activities): occurrence, within the wetland or on close proximity, of sports centres, linear parks, botanical gardens, green paths, playgrounds, touristic facilities (hotels, restaurants, etc), education facilities (university, schools, etc). Due to their potential to concentrate economic activities and attract a large flux of people, the proximity to business and/or administrative clusters will also be considered in this sub-criterium.

Evaluation is based on expert judgement, complemented by:

- evidence and main observations on wetlands from the site visits of local and international experts in the framework of this study;
- the analysis of satellite and georeferenced imagery (integrating an historical approach of imagery); and
- the Consultant's interpretations from desktop review and collected documents.

The above set of chosen sub-criteria will give a measurable character to the results obtained

4.11.3 Results

4.11.4 Conclusion on baseline in Gikondo

TABLE 4-34 RECREATIONAL ACTIVITIES AND LANDSCAPE AT BASELINE, CRITERIA RANKING MATRIX - GIKONDO

Criterion: Development of recreational activities and improvement of the city's landscape in Gikondo										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
Sub-Criteria 1: Quality of natural landscape / environment									2 Scattered monospecific green cover/ brownfield	
Sub-Criteria 2: Quality of anthropic landscape / cultural environment					6 No heritage buildings, parks, gardens, or areas of interest occur in the wetland, but some occur nearby.					
Sub-Criteria 3: Exposures and visual clearances / perceptions		9 Remarkable panoramas and highly exposed area: direct visibility (residential/commercial areas or road)								

Criterion: Development of recreational activities and improvement of the city's landscape in Gikondo										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
Sub-Criteria 4: Occurrence and level of continuity of green routes	9 Very high occurrence of pedestrian trails/routes that allow for continuous crossing of the wetland without any interruptions or barriers.									
Sub-Criteria 5: Occurrence and/or proximity of recreation facilities (including educational and touristic activities)			7 At least one facility within the wetland and/or several attractions within less than 500m distance from its limits and well connected to the wetland							

Sub-Criteria 1: Quality of natural landscape / environment

Gikondo, has a low performance in terms of quality of the natural landscape. Brownfield and agricultural areas dominate a large portion of the wetland, especially on its main branch, an area of around 100ha characterized by the presence of an old industrial area, now entirely demolished were wasteland, brownfields, ruderal plant species and earth backfill dominate the landscape.



FIGURE 4-123 MONO GREEN COVER IN GIKONDO

Where industrial activities were removed, scattered patches of monospecific green cover can be found. Although soil pollution and filling of the wetland due to industrial activities may require significant depollution and renaturation works, the presence of a small variety of ornamental trees and native trees reported by the

Report of a Rapid ecological baseline assessment for Gikondo[1] places it on the upper level of the "Very low performance" ranking. The northern branch (38 ha) is characterized by the presence of wasteland and agriculture plots without any particular landscape value.

Sub-Criteria 2: Quality of anthropic landscape / cultural environment

No occurrence of heritage buildings, landscaped areas or areas of interest in terms of human activities within the wetland. Occurrence of areas of interest on nearby neighborhood of Kimihurura (less than 500m distance from the main branch) such as gardens, crafts, emblematic building, etc.

Sub-Criteria 3: Exposures and visual clearances / perceptions

A broad valley bottom and composed by a large proportion of empty plots originated from disaffected industrial activities, the main branch of the wetland performs very well in terms of visual clearances. Long stretches of the landscape are visible from different viewpoints on different roads and urban areas surrounding the main branch of the wetland, favouring the perception of the area. On the southern branch however, the presence of brick walls surrounding an area of about 25ha impairs visual perception on the area.



FIGURE 4-124 VIEW OF THE NORTHER LIMITS OF THE MAIN BRANCH OF GIKONDO WETLAND SEEN FROM A MAIN ROAD. SOURCE: GOOGLE EARTH



FIGURE 4-125 WIDE VISUAL CLEARANCE ON THE MAIN BRANCH OF GIKONDO WETLAND. SOURCE: CONSULTANT

Sub-Criteria 4: Potential for Circuit / walking and cycling route

The wetland performs well in terms of potential for soft mobility. Occurrence of existing earth paths with good spatial continuity are visible in several parts of the main branch and presents a good potential for development of trails and paths (see figure 3 above).

Sub-Criteria 5: Availability and proximity of recreation and/touristic facilities and sites (clusters)

No remarkable recreation/touristic attractions or sites occur within the perimeter of the wetland. Proximity to a cluster of good standard hotels, restaurants, and important public administration buildings in nearby Kimihurura but connectivity to this area remains fairly low.

In addition, the wetland is well connected to road networks and high density residential/commercial urban areas, which represents a good potential for the development of recreational activities.

Some areas of interest are located within less than 500m of the wetland (the Kimihurura area on the eastern part of the main branch and the University of Lay Adventist of Kigali (UNILAK) on the western portion of the main branch), although spatial connectivity remains quite low.

[1] *Report of a Rapid ecological baseline assessment for Gikondo.* REMA draft report, 2020.

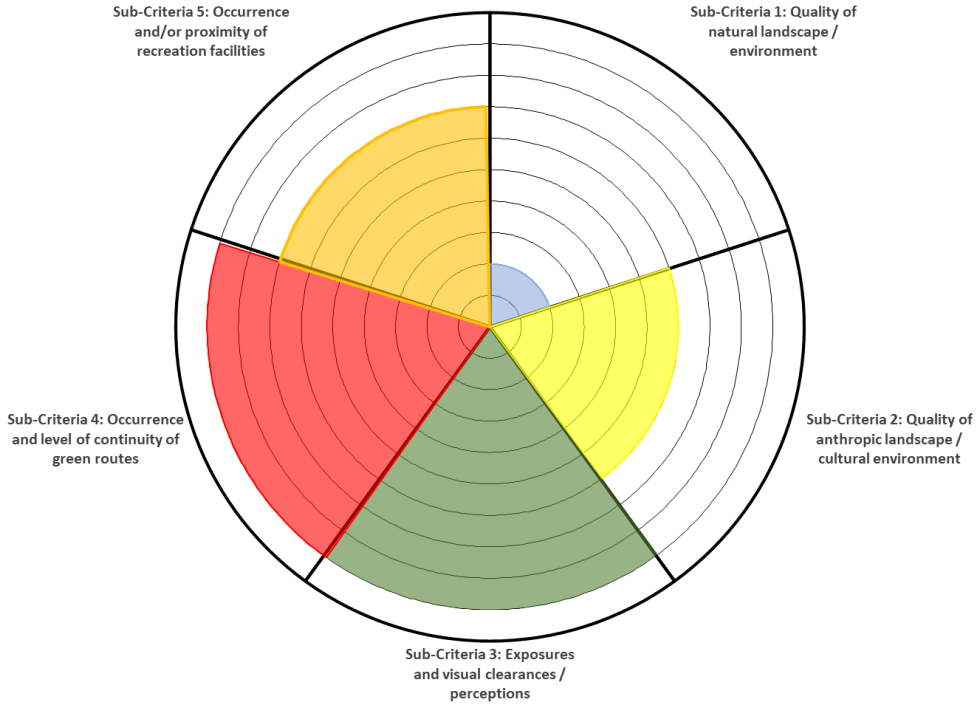


FIGURE 4-126 RECREATIONAL ACTIVITIES AND LANDSCAPE AT BASELINE, CRITERIA RANKING FIGURE - GIKONDO

4.11.5 Conclusion on baseline in Rwampara

TABLE 4-35 RECREATIONAL ACTIVITIES AND LANDSCAPE AT BASELINE, CRITERIA RANKING MATRIX - RWAMPARA

Criterion: Development of recreational activities and improvement of the city's landscape in Rwampara										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
Sub-Criteria 1: Quality of natural landscape / environment							3 Monospecific green cover			
Sub-Criteria 2: Quality of anthropic landscape / cultural environment									2 No heritage buildings, parks, gardens, and/or areas of interest of interest in the wetland or nearby.	
Sub-Criteria 3: Exposures and visual clearances / perceptions									2 Enclosed landscape (walls/physical barriers/built up areas)	
Sub-Criteria 4: Occurrence and							3 Occurrence of scattered pedestrian			

Criterion: Development of recreational activities and improvement of the city's landscape in Rwampara										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
level of continuity of green routes							trails/routes with strong ruptures or barriers (canyons, large infrastructure works as drainage canals)			
Sub-Criteria 5: Occurrence and/or proximity of recreation facilities (including educational and touristic activities)							4 Few scattered facilities in the wetland and/or at a distance of more than 1km from its limits			

Sub-Criteria 1: Quality of natural landscape / environment

Rwampara presents a low performance in terms of quality of the natural landscape and environment. A low diversity of natural wetland habitats and scattered monospecific green cover is observed across most areas of the wetland. Occurrence of urban discharges (stormwater and wastewater) directly into the wetland and river, impacts the quality of the water and increases bank/soil erosion.

Sub-Criteria 2: Quality of anthropic landscape / cultural environment

No occurrence of heritage buildings, landscaped areas or areas of human activities of interest inside the wetland or in close proximity.

Sub-Criteria 3: Exposures and visual clearances / perceptions

Consisting of a narrow wetland characterized by its deeply incised canyon-like bed, the wetland provides limited visual clearances and therefore has a low performance in terms of visual clearances. Upstream areas of the Rwampara river canyon provide a limited depth of about 10-15 meters. This depth gradually decreases moving downstream. In addition, most of the wetland is not directly connected to road networks and dense built-up areas block the visual perception of the wetland from several viewpoints.

Sub-Criteria 4: Occurrence and level of continuity of green routes

Occurrence of scattered green routes along waterway with strong ruptures mainly by concrete drainage channels that are considerably wide to allow crossing and also due to severe erosion found on some parts of the wetland. Rudimentary wood bridges in poor state were identified in some strategic points but the poor state or inexistence of the bridges can cause disruptions to the continuity of existing paths.



FIGURE 4-127 SEVERE EROSION IN RWAMPARA



FIGURE 4-128 EXISTING PATHS ALONG THE WATERWAY



FIGURE 4-129 RUDIMENTARY WOODEN BRIDGE IN RWAMPARA

Sub-Criteria 5: Occurrence and/or proximity of recreation facilities (including educational and touristic activities)

Occurrence of an important sports club on the downstream area of the wetland with football fields and tennis courts. Proximity of the University of Rwanda but no direct access (the university sits on a hilltop) and the access road is not connected to the wetland. Presence a few scattered recreational and/or educational activities near the wetland (1km).



FIGURE 4-130 FOOTBALL GROUND, SPORTS CENTRE IN RWAMPARA

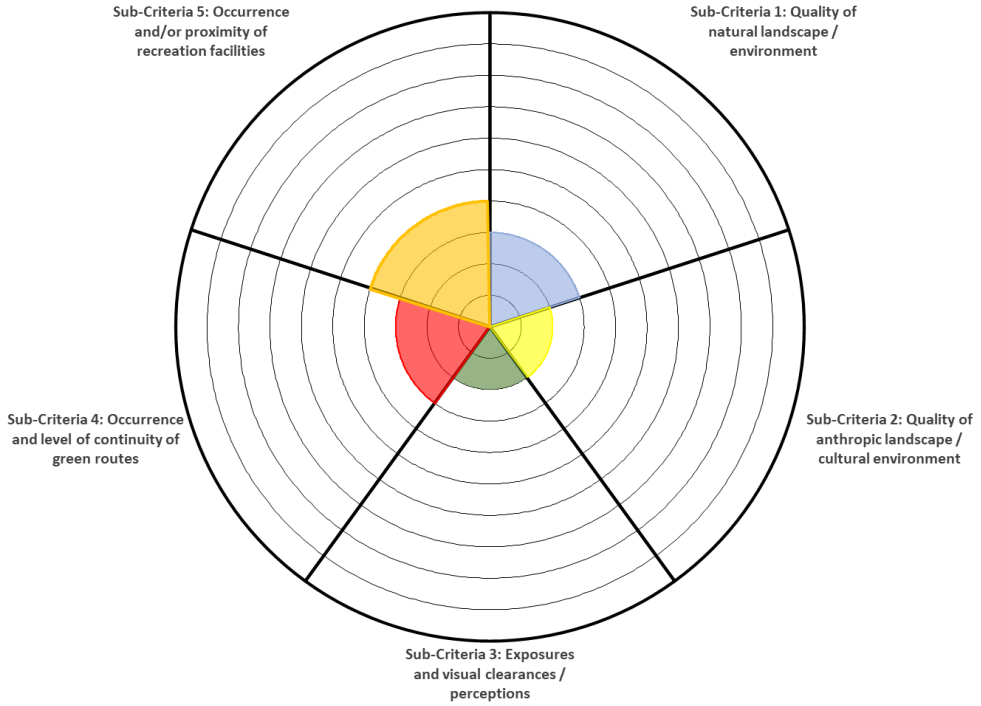


FIGURE 4-131 RECREATIONAL ACTIVITIES AND LANDSCAPE AT BASELINE, CRITERIA RANKING FIGURE - RWAMPARA

4.11.6 Conclusion on baseline in Rugenge-Rwintare

TABLE 4-36 RECREATIONAL ACTIVITIES AND LANDSCAPE AT BASELINE, CRITERIA RANKING MATRIX - RUGENGE-RWINTARE

Criterion: Development of recreational activities and improvement of the city's landscape in Kibumba										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
Sub-Criteria 1: Quality of natural landscape / environment								3 Monospecific green cover		
Sub-Criteria 2: Quality of anthropic landscape / cultural environment						6 No heritage buildings, parks, gardens, or areas of interest occur in the wetland, but some occur nearby.				
Sub-Criteria 3: Exposures and visual clearances / perceptions								4 Semi-open landscape with diffuse built-up areas		

Criterion: Development of recreational activities and improvement of the city's landscape in Kibumba										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
Sub-Criteria 4: Occurrence and level of continuity of green routes						5 Occurrence of scattered pedestrian trails/routes with some ruptures				
Sub-Criteria 5: Occurrence and/or proximity of recreation facilities (including educational and touristic activities)								3 Few scattered facilities in the wetland and/or at a distance of more than 1km from its limits		

Sub-Criteria 1: Quality of natural landscape / environment

Incidence of monospecific green cover with agriculture areas. Not significant number of a variety of wild natural green cover. The western branch where Rugenge River flows is occupied by earth backfill where land was reclaimed by removing buildings. A sedge meadow occupies the centre of the wetland. The eastern branch occupied in its upstream area by agriculture and a downstream area where bamboo plantations dominate the landscape.

Sub-Criteria 2: Quality of anthropic landscape / cultural environment

No occurrence of landscaped areas or manmade landscape elements of particular interest. Close proximity of a landscaped round about on a main road junction.

The downstream area of western branch is occupied by plant vendors and horticulture. The occurrence of a plant incubators in this area contributes positively to the quality of the cultural environment but is too localized to have a strong impact globally wetland.



FIGURE 4-132 PLANT VENDORS IN RUGENGE-RWINTARE

Sub-Criteria 3: Exposures and visual clearances / perceptions

Bamboo plantations dominate the landscape on the downstream area of the eastern branch, resulting in strong visual interference in the area



FIGURE 4-133 BAMBOO PLANTATION ON THE EASTERN BRANCH OF RUGENGE-RWINTARE WETLAND



FIGURE 4-134 BAMBOO PLANTATION ON THE EASTERN BRANCH OF RUGENGE-RWINTARE WETLAND

The far eastern parts of the wetland present a few scattered semi-open green areas with diffuse built-up areas on the foreground, which improves slightly the performance of the wetland in this sub-criterion.



FIGURE 4-135 EXAMPLE OF SEMI-OPEN GREEN AREAS FOUND IN RUGENGE-RWINTARE WETLAND



FIGURE 4-136 EXAMPLE OF SEMI-OPEN GREEN AREAS FOUND IN RUGENGE-RWINTARE WETLAND

Sub-Criteria 4: Occurrence and level of continuity of green routes

Occurrence of a few existing paths, mainly along the waterway, used by local residents and on the far western limits of the wetland with potential links to Nyabugogo wetland. Other scattered routes with strong ruptures (mainly road infrastructure) are seen in the eastern branch of the wetland.



FIGURE 4-137 EXISTING PATH ALONG THE RIVER ON THE WESTERN END OF THE WETLAND



FIGURE 4-138 EXISTING PATH ALONG THE RIVER ON THE WESTERN END OF THE WETLAND

Sub-Criteria 5: Occurrence and/or proximity of recreation facilities (including educational and touristic activities)

A school is located inside the wetland, where kids play, and areas sports areas occur. No other remarkable recreation/touristic facilities or sites occur within the perimeter of the wetland. As per the wetland of Gikondo, Rugenge-Rwintare is located in close proximity to Kimihurura, where a cluster of good standard hotels, restaurants, and important public administration buildings occur. Kigali Convention and business Centre is also located nearby (less than 1km).

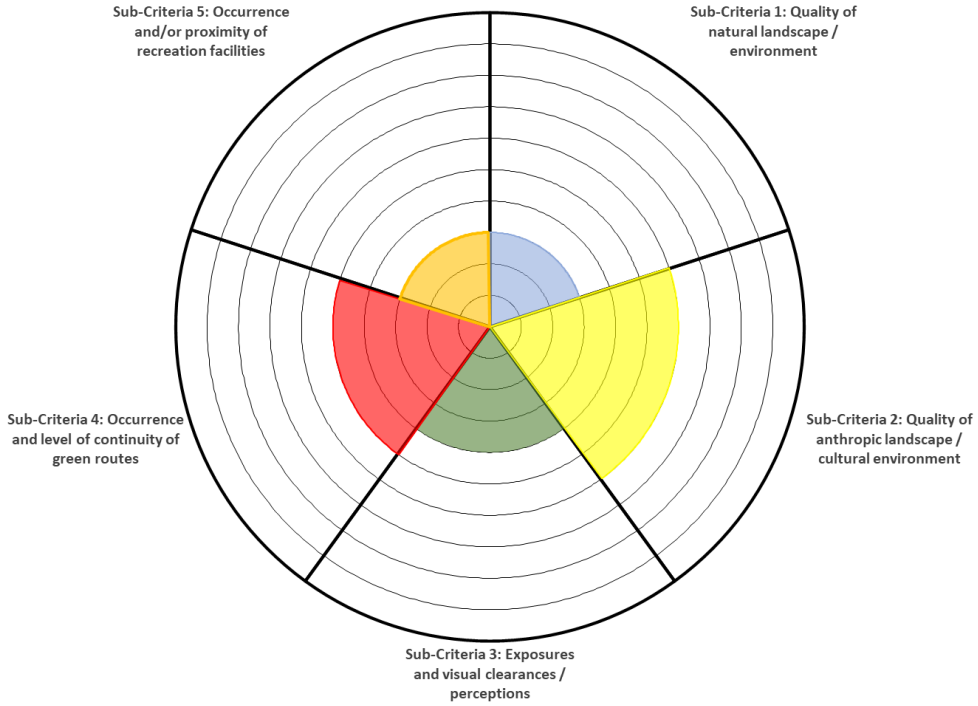


FIGURE 4-139 RECREATIONAL ACTIVITIES AND LANDSCAPE AT BASELINE, CRITERIA RANKING FIGURE - RUGENGE-RWINTARE

4.11.7 Conclusion on baseline in Kibumba

TABLE 4-37 RECREATIONAL ACTIVITIES AND LANDSCAPE AT BASELINE, CRITERIA RANKING MATRIX -KIBUMBA

Criterion: Development of recreational activities and improvement of the city's landscape in Rugenge-Rwintare										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
Sub-Criteria 1: Quality of natural landscape / environment									2 Scattered monospecific green cover/ brownfield	
Sub-Criteria 2: Quality of anthropic landscape / cultural environment							3 Only one or two heritage buildings, parks, gardens, and/or areas of interest occur in the wetland or nearby			
Sub-Criteria 3: Exposures and visual clearances / perceptions							3 Semi-open landscape with diffuse built-up areas			
Sub-Criteria 4: Occurrence and level of continuity of green routes							3 Occurrence of scattered pedestrian trails/routes with strong ruptures or barriers (canyons, large infrastructure works as drainage canals)			
Sub-Criteria 5: Occurrence and/or proximity of recreation facilities (including educational and touristic activities)		9 Several facilities within the wetland (clusters) and/or within less than 200m distance from its limits								

Sub-Criteria 1: Quality of natural landscape / environment

Kibumba has a very low performance in terms of natural landscape due to the low variety of green cover and low diversity of native wetland habitats. Parts of the wetland also present degraded natural habitats, especially due to drying out of the wetland. Former industrial activities (and a textile factory which is still in operation) contributed to soil pollution and filling of the wetland with compacted and degraded soils requiring significant renaturation.

The wetland receives poor water quality (at high speed) from the steep slopes of the densely urbanized upstream (contributing to downstream flooding that disrupts business and transportation activities)

Sub-Criteria 2: Quality of anthropic landscape / cultural environment

Although largely contributing to soil pollution and filling of the wetland, some commercial and industrial activities with small workshops (wood and iron) and garages if controlled and organized can bring some liveliness to the area.

Sub-Criteria 3: Exposures and visual clearances / perceptions

Build up areas and walls from industrial activities enclosures severely impairs visual perception in several parts of the wetland. Wider view and semi-open green areas occur in the southern ends of the wetland.



FIGURE 4-140 BUILT-UP AREA ENCLOSING THE LANDSCAPE IN KIBUMBA



FIGURE 4-141 BUILT-UP AREA ENCLOSING THE LANDSCAPE IN KIBUMBA



FIGURE 4-142 SEMI OPEN GREEN AREA IN THE SOUTHERN PART OF KIBUMBA WETLAND

Sub-Criteria 4: Occurrence and level of continuity of green routes

Green paths occur along the waterway, but severe ruptures affect its continuity. In addition, a main arterial road crosses the wetland, dividing it in two and strongly impacting its level continuity.



FIGURE 4-143 PATHS ALONG THE RIVER BUT ARE DISRUPTED IN SOME PARTS BY NATURAL BARRIERS

Sub-Criteria 5: Occurrence and/or proximity of recreation facilities (including educational and touristic activities)

Several hospitality facilities and the Red Cross recreational centre occur directly above the main arterial road that crossed the wetland, largely frequented by families as it offers playground areas for children near dining areas/restaurant. Occurrence of several water bodies for fishing activities but with no ecological value added. Direct proximity to a large high standard resort and golf club which is planned to host large tournaments and is mainly used by upper class residents of the nearby gated community.

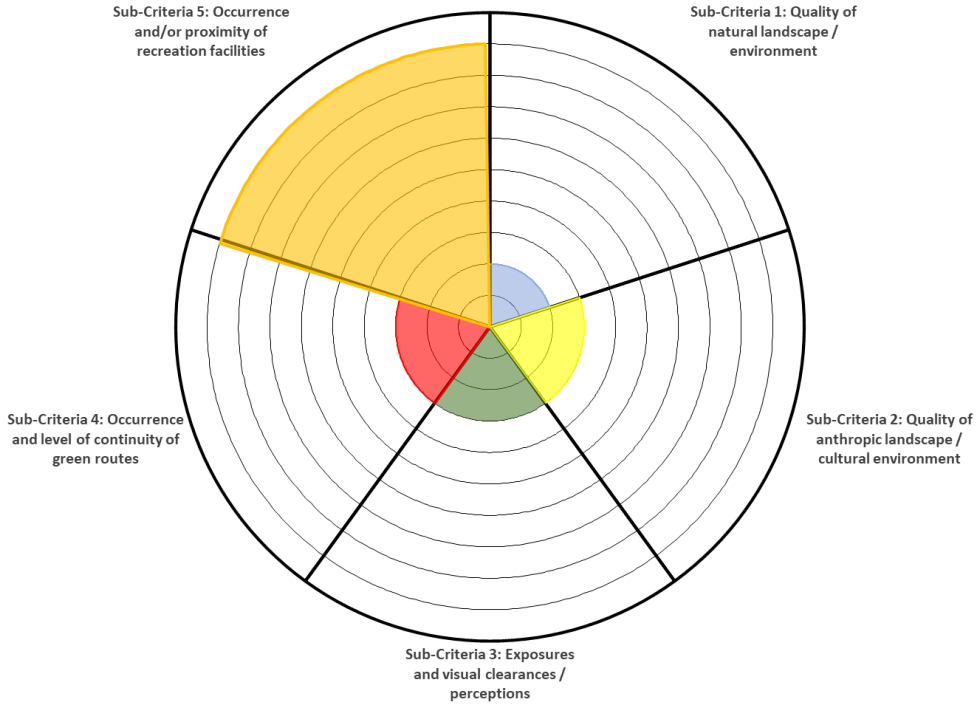


FIGURE 4-144 RECREATIONAL ACTIVITIES AND LANDSCAPE AT BASELINE, CRITERIA RANKING FIGURE - KIBUMBA

4.11.8 Conclusion on baseline in Nyabugogo Lower

TABLE 4-38 RECREATIONAL ACTIVITIES AND LANDSCAPE AT BASELINE, CRITERIA RANKING MATRIX - NYABUGOGO LOWER

Criterion: Development of recreational activities and improvement of the city's landscape in Nyabugogo Lower										
Sub-criteria	Ranking system for this criterion									
	Very high performance		High performance		Medium performance		Low performance		Very low performance	
	10	9	8	7	6	5	4	3	2	1
Sub-Criteria 1: Quality of natural landscape / environment			7 Homogeneous high-quality landscape (i.e. presence of native green cover)							
Sub-Criteria 2: Quality of anthropic landscape / cultural environment					6 No heritage buildings, parks, gardens, or areas of interest occur in the wetland, but some occur nearby.					
Sub-Criteria 3: Exposures and visual clearances / perceptions							4 Semi-open landscape with diffuse built-up areas			
Sub-Criteria 4: Occurrence and level of continuity of green routes					6 Occurrence of scattered pedestrian trails/routes with some ruptures					
Sub-Criteria 5: Occurrence and/or proximity of recreation facilities (including educational and touristic activities)					5 Several facilities within less than 500m distance from its limits and but poorly connected to the wetland					

Sub-Criteria 1: Quality of natural landscape / environment

Nyabugogo scores a high performance in terms of natural landscape due to the occurrence of areas green cover and of native habitats worth of conservation, some with the presence of Papyrus. The natural resources found in some areas, especially around the artificial lake, offers a good potential for socio-economic development and green growth. Other parts of the wetland are intensely occupied by agriculture and present a low diversity of green natural cover and habitats. Areas along the Nyabugogo river and along the northern starches of urban areas receive important volume of urban runoffs. Pollution by heavy metals due to former industrial activities also occur in the area.

Sub-Criteria 2: Quality of anthropic landscape / cultural heritage

No significant heritage buildings, parks, gardens, and/or areas of interest occur in the wetland. Occurrence of pockets of landscaped gardens/areas are observed in the eastern limits of Nyabugogo. Green Square Park, a

small gated landscaped garden, for example is located between two wetlands studied by the project (Nyabugogo and Kibumba).



FIGURE 4-145 SMALL LANDSCAPED GARDEN IN THE JUNCTION OF THE WETLANDS OF NYABUGOGO AND KIBUMBA

Source: Google Earth

Sub-Criteria 3: Exposures and visual clearances / perceptions

Large portions of the visual perception of the wetland from main roads and urban areas are impaired by high vegetation cover and/or built-up areas. Some viewpoints within the wetland offer a limited but pleasant view of the wetland and adjacent urban areas.



FIGURE 4-146 VISUAL CLEARANCE

Source: Google Earth

Sub-Criteria 4: Occurrence and level of continuity of green routes

Occurrence of some existing designed walking paths, specially at the eastern parts of the wetland between the Genocide Memorial and the neighboring wetland of Kibumba (at the level of Green Park – see figure 16). Existing paths are generally scattered, and infrastructure and agricultural areas disrupt their continuity at several points



FIGURE 4-147 BASIC DESIGN WALKING PATHS IN NYABUGOGO

Source: Google Earth

Sub-Criteria 5: Occurrence and/or proximity of recreation facilities (including educational and touristic activities)

Occurrence of attractions of cultural/tourist interest (Genocide memorial). Proximity of the western limits of the wetland to the city centre and to a busy transport hub means the area is easily accessed by people living in Kigali and in other areas.

The southwestern limit of the wetland is located close to the city centre and to a busy transport hub (Nyabugogo bus station), which provides both transport links to other cities and within the urban area of Kigali. There is a constant movement of people through the wetland and the artificial lake serving to ferry residents across the wetland towards urban areas located at the northern part of the wetland.



FIGURE 4-148 TRANSPORT HUB NEAR NYABUGOGO WETLAND

Source: Google Earth

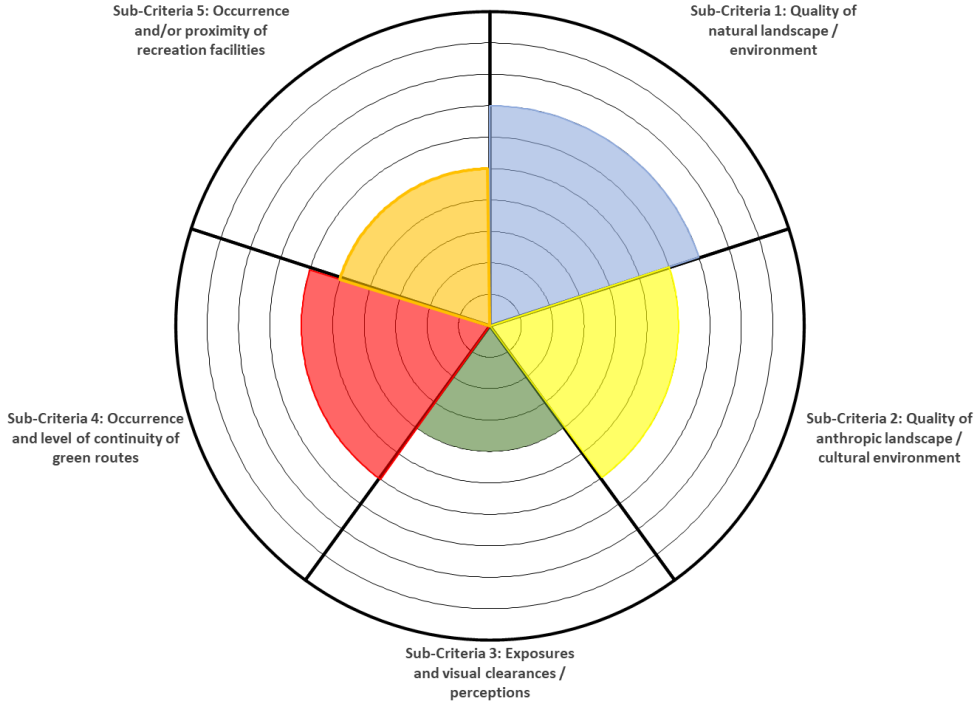


FIGURE 4-149 RECREATIONAL ACTIVITIES AND LANDSCAPE AT BASELINE, CRITERIA RANKING FIGURE - NYABUGOGO LOWER

4.12 STAKEHOLDER VIEWS AND OPINIONS ON WETLAND REHABILITATION

Several individual meetings were held with key institutions that have interest in the wetlands and may influence its fate. **This initiative was done in parallel with the development of rehabilitation scenarios and was key to ensure that a wide range of views and opinions are integrated in their development**.

The first principle of the guideline "International Principles & Standards for the Practice of Ecological Restoration" is that ecological restoration engages stakeholders.

As highlighted in this guideline, recognizing the expectations and interests of stakeholders and directly involving helps define the vision, targets, goals, objectives, and methods of implementation and monitoring. This assessment also recognizes previous work and previous studies, as well as the recent development of the CoK Master Plan has already developed the vision for the urban wetlands and integrated this vision is the zoning regulation for the wetlands.

Outcomes of stakeholder workshops are presented in a separated section. These focused on the evaluation of proposed rehabilitation scenario and were done at a later stage.

4.12.1 Objectives

Several meetings with key institutions were organized by the team of experts. Meetings were done to collect data on activities in the wetlands, to collect opinions on the causes of degradation and on what should have been done to avoid this degradation. Meetings were also the occasion to better define the needs and priorities and the desirable outcomes from wetland rehabilitation to inform rehabilitation scenarios. The method relied on open questions.

4.12.2 Method

Two approaches are used:

- One workshop with stakeholders was organized at study inception as well as curtesy visits.
- Individual meetings with key institutions, investors and NGOs at their office or virtually.

Curtesy visits were made by key experts with several institutions at inception and followed by meetings with key institutions.

A simple questionnaire, made of open questions was used for individual meetings with institutions and NGOs. The questions are as follow:

A. Does the institutions/NGO have any plans for the 5 wetlands, any projects, any programs or activities ongoing or planned?

B. According to you what are the main reasons the wetlands are so degraded now?

C. What should have been done to avoid this degradation in the past?

D. What are the expectations and interests of the institution/NGO regarding the fade of the 5 wetlands?

E. What do you consider to be a successful rehabilitation program in the wetlands, what would be the desirable outcomes? What are the needed prioritization actions to rehabilitate the wetlands?

F. If you had to prioritize indicators of success for the wetland rehabilitation program, what would they be?

   1. Improvement of flood control (wetlands will better control effects of floods)
   2. Improvement of water filtration (wetlands will better filter water quality)
   3. Improvement of the landscape features of the city (wetlands will make the city look nicer)
   4. Improvement of recreational activities (trails, bicycle path, boardwalks and walkways, activities for children and schools will be developed in the wetlands)
   5. Improvement of biodiversity conservation (wetland will be like a green lung for the city and a place where plants and animal thrive)

G. What do you think are the main challenges for the rehabilitation of wetlands for their long-term success?

H. Who would, according to you, be the main beneficiaries when wetlands will be rehabilitated?

I. Who would, according to you, be disadvantaged when wetlands will be rehabilitated?

J. What innovative ways could be proposed to ensure that wetland rehabilitation will attract businesses, what could be proposed to ensure that the wetlands are economically sustainable?

Meetings with investors, that have a plan for development in the wetlands were also held. Open questions were asked to these investors:

A. What is the stage of development of your project (feasibility, design, tender has started, permits were obtained)?

B. Has an environmental impact assessment for the development already been submitted?

C. Can you provide data about your development (plans, reports, etc.)?

The following table shows the list of stakeholders, NGOs, and investors that were met. In addition, farmers cooperatives (see next section) were also met as part of engagement activities.

TABLE 4-39 LIST OF STAKEHOLDERS THAT WERE MET

Name of the stakeholder	Rationale
Ministry of Infrastructure (MININFRA)	MININFRA will be the overall coordinating Ministry of the RUDPII and there are 3 Project Implementing Unites (PIUs) at national level at one of each implementing agency (CoK, REMA and LODA). Under MININFRA there are several institutions: • Rwanda Housing Authority (RHA) • Rwanda Transport Development Authority (RTDA) • Water and Sanitation Corporation (WASAC)
Rwanda Housing Authority (RHA)	RHA oversees resettlement under RUDPII subcomponent 1a in 4 unplanned settlements in the three districts. They may have a role to play if displacement of livelihood activities takes place due to the rehabilitation of wetlands.
Rwanda Transport Development Authority (RTDA)	There are flooding issues on roads including the Kinamba roundabout. In addition, the RTDA may have plans to develop roads along or across the wetlands.
Water and Sanitation Corporation (WASAC)	WASAC manages sanitation and sewerage, there are discharges in the wetlands and WASAC may have some plans or programs for the wetland (sewerage and wastewater treatment plants).
City of Kigali (CoK); Kigali Urban Upgrading Team (KUUT)	The Hotspot study (see section 4.1.1 and chapter 6) is under management of the KUUT.
Rwanda Forestry Authority (RFA)	RFA may have plant nurseries that could be used for wetland rehabilitation for the plantation of native species. RFA could provide advice for the restoration of wetlands and may have return of experience in wetland restoration and agroforestry.
Rwanda Water Resources Board (RWB)	RWB manages gauging stations and undertakes flow models of rivers.
Rwanda Land Management and Use Authority (RLMA)	RLMA undertakes studies related to land use and manages GIS data.
Ministry of Local Government (MINALOC)	Several institutions are under the MINALOC: • Local Administrative Entities Development Agency (LODA).

	• National Council of Persons with Disabilities.
Local Administrative Entities Development Agency (LODA).	LOCA was the Project Implementation Unit (PIU) for the RUPD I. They may have some interests in the RUDPII.
Ministry of Sports	The Ministry of Sports may have suggestions for the future of the wetlands such as recreational activities, development of sports trails in the wetlands, bicycle trails, etc.
District of Gasabo	Gikondo wetland is located in both the Kicukiro and Gasabo districts. Rugenge-Rwintare is located in both the Nyarugenge and Gasabo districts. Nyabugogo Lower wetland is located in both the Nyarugenge and Gasabo districts. Kibumba wetland is located in Gasabo district.
District of Nyarugenge	Rugenge-Rwintare is located in both the Nyarugenge and Gasabo districts. Nyabugogo Lower wetland is located in both the Nyarugenge and Gasabo districts. Rwampara wetland is located in both the Nyarugenge and Kicukiro districts
District of Kicukiro	Gikondo wetland is located in both the Kicukiro and Gasabo districts.
IUCN	IUCN is an active NGO involved in Rwanda in habitats and biodiversity protection
RECOR	RECOR (Rwanda Environmental Conservation Organization) is an active NGO involved in habitats and biodiversity protection
NUDOR	National Union of Disability Organizations of Rwanda (NUDOR) is an organization involved in promoting the rights of persons with disabilities. They were met to discuss about measures that could ensure universal access to the wetlands' parks and recreational activities.
EDCL	The Energy Development Corporation Limited (EDCL) was meet to discuss about possible interference between the wetlands rehabilitation and existing utility

4.12.3 Results

The following sections details the outcome of engagement activities with stakeholders. **Most stakeholders provided their opinions for the 5 wetlands, without providing specific recommendation for individual wetlands**.

4.12.3.1 Ongoing or planned activities, program and projects in the 5 wetlands

According to meeting with institutions and NGOs, the following activities or intentions may interact with the wetland:

- Wetlands are in depressions and will always receive stormwater from surrounding urban spaces. Rwanda Water Board will develop storm water management plans to cover for the entire city.
- Several existing roads that pass along-side the wetland will be rehabilitated by the Rwanda Transport Development Authority. These will be rehabilitated as part of the KIP (Kigali Infrastructure Project). According to provided data, there are no planned land reclamation that may impact the wetlands.
- Four informal settlements in the vicinity of the wetlands will be upgraded by the Rwanda Housing Authority (RHA) as part of the RUDP II subcomponent 1. Activities include civil works for road access, pedestrian walkways, streetlights and flood infrastructures.

- The City of Kigali (CoK), Kigali Urban Upgrading Team (KUUT) has launched the Feasibility Study, Preliminary Design, Detailed Engineering Design and Elaboration of Tender Documents for the 6 Flood Risk Hotspots in CoK called the “flood hotspot study”. Recommendations from this study will influence wetlands’ hydrology and hydraulic.
- The Ministry of Sports explored the options to have playgrounds in the wetlands as well as football and volleyball fields.
- District authorities have mentioned they had envisaged activities for the development of the wetlands such as bamboo plantation in Rwampara wetland.
- NGOs that were met did not have any on-going programs in the wetlands.
- According to WASAC, there are no water or sanitation project located inside the wetlands (however, as mentioned in this report, a wastewater treatment plant is foreseen in the catchment).

4.12.3.2 Opinions on the reasons wetlands are degraded

Stakeholders were asked why wetlands are degraded and what should have been done to avoid this degradation. The following answers were collected, those most frequently reported are presented first:

- The most common collected opinion was that wetlands are degraded because of conversion of wetland to cropland. Agriculture and other livelihood activities such as fish farming brings pollution in the wetlands. Channelization and drainage for agriculture has also degraded the wetlands.
- The second most collection opinion was that past encroachment for settlements and past commercial and industrial activities that have reclaimed land and polluted land are responsible for the degradation of wetlands. One stakeholder also mentioned the lack of enforcement of zoning regulations when giving construction permits has led to the construction of buildings in the wetlands.
- Rapid unplanned upstream development with poor housing system and rapid urbanization in the water shed has led to poor management of waste, increased permeability leading to increase stormwater and runoff, and wastewater that flows in the wetlands. Since wetlands are located downhill from urban areas, with steep slopes, they receive important loads of sediment and debris leading to their sedimentation. This opinion is the third most common collected opinion.
- Other collected opinions are worth mentioning:
    - Poor awareness on the value and benefits of wetlands and low socio-economic level of surrounding communities.
    - Soil erosion in the fridge of the wetlands.
    - Climate change effects bringing heavier rain and consequently more siltation and depositions of debris.
    - Lack of maintenance of the wetland.
    - Car washing in the wetlands.
    - No current management of the wetlands.
    - Waste deposition in the wetlands.

Stakeholders also gave their opinions on what should have been done to prevent this degradation. Collected opinions on this topic is useful to understand what may still threaten wetlands and influence their rehabilitation and learn from return of experience. Overall, they allow to understand what needs to be done, in addition to their rehabilitation, to ensure the long-term success of rehabilitation. Collected opinions are presented in order of significance:

- The most common identified opinion is the need for stormwater management within upstream settlements to control runoff as well as efficient waste management in surrounding settlements.
- The second most common identified opinion is that there is a need for management of wastewater to prevent it from entering in the wetlands.
- The third common collected opinion is the need for community engagement activities around the wetlands and to incentivize society to raise awareness on the protection of wetlands.

- The need for sustainable urban planning, clear policy and compliance with the new city master plan and the need for integrated planning of wetlands, as rehabilitation will be dependent on how upstream areas are developed, was also commonly mentioned.

Other collected opinions are also worth mentioning, according to stakeholders there is a need:

- For more law enforcement against pollution and encroachment and the development and enforcement of robust wetland policies.
- To clearly delineate wetlands with visible signs and with buffer zones.
- To develop and implement wetland conservation plans.
- To develop wetlands into green parks.
- For better drainage system in urban areas associated with Nature-Based Solutions (NBS).
- To create jobs to raise the income of surrounding communities to reduce pressure on the wetlands.
- For continuous protection of wetlands against human activities (residential, commercial and industrial).
- For the development of PPPs (Public-Private Partnership) to invite private investors for the management of Kigali wetland.
- To enhance biodiversity and species richness including planting trees for erosion control and a need to control invasive plant species.
- To involve farmers in the decision-making process for the fade of wetlands.
- To develop organic agriculture or more modern agriculture to avoid the use of fertilizers and pesticides by farmers.

4.12.3.3 What are the expectations of the stakeholder on the fate of the 5 wetlands

Stakeholders were requested to share their expectations on wetland rehabilitation.

Expressed expectations and interests are presented in order of significance:

- Several stakeholders expect the wetland rehabilitation to allow for better biodiversity conservation and sustainable land management.
- Several stakeholders expect the wetlands rehabilitation to allow for their protection while allowing their sustainable economic use to serve current and future generation including the sustainable use for agriculture.
- Several stakeholders expect ecosystem services to improve thanks to wetland rehabilitation. Highlighted ecosystem services are as follow:
    - Reduction of road flooding.
    - Removal of water pollution (eutrophication and sedimentation).
    - Improve of health conditions of urban population by providing a wholesome space to enjoy themselves and have physical activities.
    - Improved agriculture in the wetland.
- Wetland rehabilitation shall be the opportunity to plant trees.
- Wetland rehabilitation shall allow for clear planning with clear demarcation for recreational and agriculture activities in these wetlands as well as buffer zones, long term management and protection mechanisms by involving all key stakeholders and riparian communities.
- Wetlands shall become attractive and provide a waterfront to the resident of Kigali, such as: artificial lakes, ponds and other attractive features such as: suspended bridges, cycles paths, etc.
- Wetlands rehabilitation shall remove invasive plants.
- Wetland rehabilitation shall promote recreational fishing activities in wetlands.
- Wetland rehabilitation shall include a program to promote awareness on the value of the wetlands.

- Wetland rehabilitation shall allow for the removal of remaining construction material and other solid wastes.
- Wetland shall allow communities take part in planning, restoration, utilization and management of the wetlands. Wetlands rehabilitation shall also create jobs and be income generating.
- Some stakeholders expect to take part or be informed in the scientific monitoring of wetland on their capacity to mitigate floods and on the change of behaviour the wetlands will experience after rehabilitation.
- Wetlands shall be universally accessible to persons with disabilities.

4.12.3.4 What would be the desirable outcomes of the rehabilitation project

Stakeholders were asked what they consider to be a successful rehabilitation program in the wetlands and what would be the desirable outcomes of the rehabilitation. Stakeholders were also asked what the needed prioritization actions are to rehabilitate the wetlands.

A success rehabilitation program would:

- Show successful NBS and functional wetlands with diverse biodiversity to avoid having the wetlands returning to a degraded state.
- Address societal needs for recreation, jobs and clean water.
- Resize channels to prevent flood and the improvement of flood control.
- Be associated with the development of green parks and water ponds in the city.
- Allow for the good management of liquid and solid waste.
- Be associated with strong community engagement, mobilizing communities, stakeholders, public and private sectors and raising awareness of communities on the value of the wetland.
- Be associated with an increase in capacity of decision makers and urban planners for the safeguard of wetlands.
- Be associated with an improvement of the knowledge on wetlands ecosystems.
- Be associated with the development of sustainable management of natural resources and sustainable livelihood activities and support livelihood diversification to enhance incomes for local communities, especially amongst farmers using the wetlands.
- Be associated with a better enforcement of the regulations in the wetlands (zoning regulation) and better delineation of the wetlands.
- Be universally accessible to persons with disabilities.

When presented with some the following 5 indicators of success, stakeholders were asked to determine what would be best indicator of success of the rehabilitation project:

- Improvement of flood control
- Improvement of water filtration
- Improvement of the landscape features of the city
- Improvement of recreational activities (trails, bicycle path, boardwalks and walkways, activities for children and schools will be developed in the wetlands)
- Improvement of biodiversity conservation

The following table graph show the collected answers. According to collect answers, flood control is the most cited high-ranking priority, followed by biodiversity conservation, while landscape development and recreational activities are, according to stakeholders that were met, least priorities. Water filtration was almost equality mentioned in all categories.

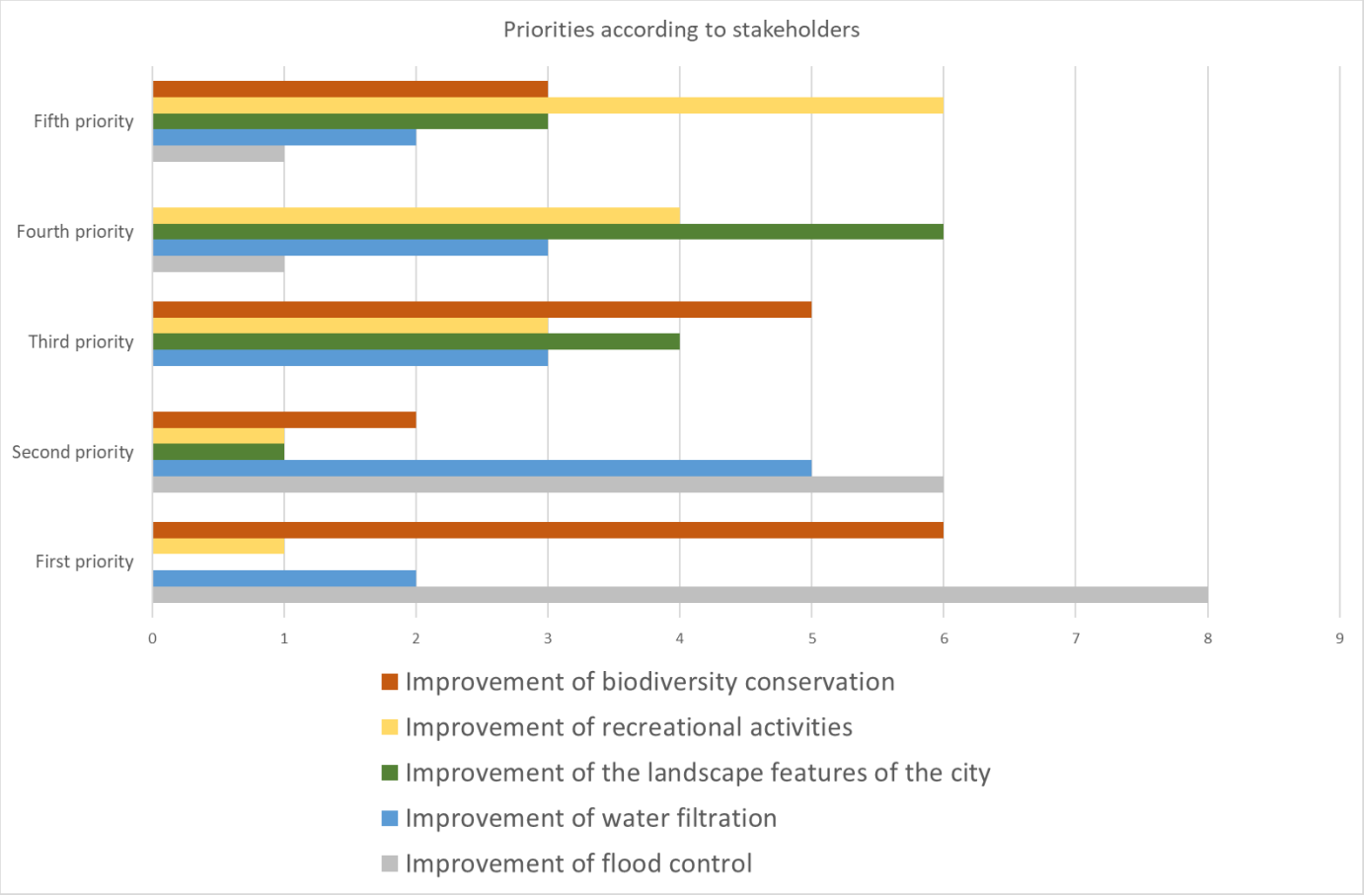


FIGURE 4-150 PRIORITIES FOR REHABILITATION ACCORDING TO STAKEHOLDERS

4.12.3.5 Main challenges on successful rehabilitation

When asked on the future challenges or risks to successful rehabilitation (once wetlands are rehabilitated), stakeholders provided the following answers presented in order of significance:

- Insufficient human and financial resources, governance issue, or lack of expertise allocated to the management of the wetland and its maintenance, and the rehabilitation project and poor maintenance structure was the first most mentioned challenge.
- The effect of current climate or future climate on built infrastructure was the second most common challenge mentioned by stakeholders. Stakeholders mentioned that heavy rains, devasting floods that can negatively affect the wetlands during or after the rehabilitation project and destroy what has been built. The accuracy in forecasting future climate change effects and the effect of climate change on water scarcity leading to overexploitation of the wetlands could also affect or destroy what was been achieved through rehabilitation.
- Resistance of people already occupying the wetland (individuals and or cooperatives), not enough support from local leaders and absence of inclusiveness of key partners and riparian communities in the management and protection of wetlands, lack or low community awareness on values and functions of wetlands was the third most common challenge raised by stakeholders.
- Ongoing degradation of the wetlands caused by several factors was also frequently mentioned such as ongoing high level of wetlands pollution, wastes dumped in wetlands, construction of prohibited structures, upstream urban areas that will continue to discharge wastes in the wetlands and excessive use of the wetlands by nearby settlements.

Other collected opinions on future challenges that may affect long term reliability of the rehabilitation project are worth mentioning:

- Lack of enforcement mechanisms, monitoring and evaluation, to ensure that regulation for the protection of those wetlands is applied.

- The accuracy in forecasting of future urban trend and population growth and the pressure they will exert on the wetlands may also be a challenge.

4.12.3.6 How will rehabilitation benefit society

Stakeholders were asked how rehabilitation will benefit society and who will the main beneficiaries be. Provided answers are listed here below:

- Tourism (eco-tourism) will benefit the city, thanks to revenues from tourism. Overall, the CoK will be the main beneficiary according to the majority of stakeholders.
- Protection again floods, loses of life and damage to infrastructures will be reduced which will benefit road users and the government.
- Citizen of the city will also benefit from improved ecosystem services such as cleaner water, improved health thanks to universal access to recreational facilities. Providing recreational facilities, health, sport and wellbeing would be a key component for community engagement and ownership of the project.
- Those that have houses along the wetland will see the value of their houses increase.

When asked about the category of people that may be negatively impacted, stakeholders unanimously mentioned traditional farmers using the wetlands, unless they get support for livelihood restoration and diversification. Those whose property were previously removed but are still cultivating will be significantly impacted. One stakeholder also mentioned the owners of commercial infrastructure to be removed such as garages, warehouses, parkings and gas stations will be negatively impacted.

4.12.3.7 Proposition to attract business

When stakeholders were asked what can be proposed to ensure that the wetlands are economically sustainable, stakeholders mentioned:

- Development of eco-tourism and recreational activities should be associated with the development of hospitality business such as restaurants or business points where people can enjoy have a drink and purchase souvenir gifts or rent bicycles. These activities include hiking, bicycling, fishing, bird watching, photography.
- Wetland should be developed as green parks to attract tourists, with water ponds for beautification and fishing.
- Development of cultural expositions and development of areas where small events can be organized.
- Development of off-farm activities to allow farmers to sell their produce to visitors.
- According to one stakeholder, entry fees should be avoided as this will be an obstacle to communities' access to the wetlands.
- Plantation of plants of with economic values to be collected and sold. It is recommended to explore how sustainable harvesting of selected natural resources from the wetlands could economically benefits local communities.
- Incentives for PPP for development of activities in the wetlands.
- Educational centres in the wetland which can provide meaningful opportunities to educate the public regarding wetlands science, wetlands protection, and the value of water resources as well.
- Leveraging investments, bringing onboard co-finance through partnerships, bringing philanthropic, government and private sector investments together in financing development of innovative programs.
- Indirect economic benefits will be gained thanks to improved ecosystem services.

4.13 LIVELIHOOD ACTIVITIES IN THE WETLANDS

4.13.1 Objectives

This baseline survey is conducted in order to understand how local communities are currently using the wetlands for their livelihood activities and to understand what the main socioeconomic impacts and social constraints to the development of the rehabilitation project are. Even though the recent local zoning of the CoK does not allow the current type of agriculture to continue, it is important to analyze the "social feasibility" to implement rehabilitation of the wetlands and to understand the local context. Another objective of this baseline study was to evaluate the level of informality or organization in the wetlands and to determine what is the status of farmers using the wetlands.

4.13.2 Method

During the field visit undertaken at inception, a preliminary delineation of agricultural activities and identification of livelihood activities was undertaken. After this site visit, a team of local agronomist and social specialists were mobilized to undertaken field surveys. This team:

- Carried out a first visit of the 5 wetlands to: i) identify boundaries of cropland; ii) get a broad view on agricultural features; iii) identify cooperatives to be interviewed. Information on key informants were later collected from District/Sector offices and from other stakeholders.
- Met with key informants from Government institutions included: i) Minagri-Rwanda Agriculture and Animal resources Development Board; ii) Local government officials in Gasabo, Nyarugenge and Kicukiro District; iii) extension officers and other technical staff in the three districts.
- Met with key informants from wetland users: i) Farmers' cooperatives/groups operating in the targeted wetlands; ii) cooperatives managing nurseries and selling trees and ornamental plants; iii) private companies/organizations operating in the wetlands.
- Interviews were followed by capturing the position of different stakeholders in the wetlands by using a DGPS. That exercise led to developing a map to visualize agricultural activities across the 5 wetlands. Pictures were also taken in different places survey by the consultants. Additional data on lands, agriculture, inputs, and markets were also collected.

The survey only focused on farmers' cooperatives, but farmers' groups as they consider themselves as cooperatives where also met, even if they are not/not yet officially registered by the Rwanda Cooperative Agency (RCA).

The methodology adopted was based on interviews with the key informants described in the above paragraph. Questionnaires with open questions were used, the questions focused on understanding how the wetland are used for livelihood activities (the full report is in appendix 3).

4.13.3 Key findings

4.13.3.1 Identified stakeholders

Interviews and direct observations on the field showed that there were four main categories of stakeholders engaged in agriculture, and agriculture-related activities in the studied wetlands, namely:

- Farmers' cooperatives;
- Farmers groups;
- Individual smallholder farmers;
- Private /businesses.

The following table provides an overview, based on field work and surveys, of the different wetland users.

TABLE 4-40 MAIN WETLAND USERS

Category of stakeholders engaged in agriculture	Type of production system	Key activities
Farmers Cooperatives	- Market-oriented - Medium to Low level of intensification	- Production and selling vegetables - Production and selling staple crops (rice, maize, soja , beans) - Fish farming - Bamboo production
Other cooperatives	- Market oriented - Specialization	- Production of trees and ornamental plants in nurseries
Farmers' groups	- Market-oriented or subsistence farming - Low level of intensification - Low productivity/yields	- Production and selling vegetables - Production of staple crops mainly for subsistence (maize , soja , beans)
Individual farmers	- Subsistence farming - Low level of intensification - Low productivity/yields	- Growing banana, sugar cane mixed crops (cassava, maize, beans) - Production of seasonal crops in rotation (maize, beans, soja) - Vegetable production - Fodder crops (*Penisetum* grass)
Private/businesses	- Market oriented - Intensification	- Production of trees and ornamental plants in nurseries - Improved seeds multiplication - Sugar cane - Rotation of vegetable production and seasonal crops (maize, Irish potato) - Fodder crops
Other organizations (Red Cross; Gatenga Training Center)	- Leasing land to private/businesses	- Seed production - Vegetable production - Other crops (soja; maize)

Farmers cooperatives are registered at the Rwanda Cooperative Agency (RCA). RCA is a public institution in charge of regulating and promoting economic, social and other activities of general interest. The core activities of the Agency are: i) Registration of cooperative; ii) Arbitration and settlements of disputes/conflicts; iii) Legal and technical assistance to cooperatives; iv) Promotion and capacity building; v) Supervision, control and audit of cooperatives.

The registration process does not depend on where the cooperative is located. It starts from district level where people committed themselves to work under cooperatives submit a compiled document of (letter requesting provisional certificate, cooperative status, fundamental principles, and list of members, list of leaders and a business plan). After district approval, application is moved to RCA for approval and a temporarily working permit of 1 year. Permanent permit of working as a cooperative can be given to a cooperative based on performance. There is no fee charged for registering a cooperative.

There are many benefits of being in a cooperative: i) it is a public policy to work under cooperatives to ensure facilitation of citizens and raise up their livelihoods; ii) collective investments are possible under cooperatives ; iii) 80% of Cooperative incomes is back shared by members; iv) cooperative ease access to market.

Cooperatives have a governance structure including a general assembly, an executive committee and specific commissions. The day-to-day management is delegated to a Manager (when the cooperative has the resources to pay salaries) under the direct supervision by the President of the cooperative.

4.13.3.2 Farming practices

The key crops developed in the 5 wetlands were grouped in the following 3 main categories:

- Vegetables:
  - They are mainly cultivated in Rwampara and Kibumba wetlands and a bit less in Rwintare wetland.

- The main species cultivated are Cabbages; Eggplants; Spinach; Carrots; Amaranths; French beans.

- Cereals and legumes:
  - Cereals (maize, rice) and legumes (climbing beans and soya) are the typical seasonal crops in the 5 wetlands. Soya is grown on a smaller scale compared to the other crops.
  - Rice is only cultivated in the lower Nyabugogo.
  - The other crops were observed in all the 5 wetlands, but at different levels of crop intensification (e.g., very poor status of crops in the former Gikondo industrial area compared to Rwampara or Kibumba).
- Perennial crops:
  - Banana is the traditional perennial crop, and it is predominant in some areas of the Rwampara wetland, and at a lower level in Rugenge-Rwintare wetland.
  - Sugar cane is mostly developed in Rugenge and Nyabugogo wetlands. As the risks of floods have been increasing over the last years, farmers have been replacing rice by sugar cane in Nyabugogo wetlands, as sugar cane is more resistant to floods

Small scale agriculture (smallholder farming system) is predominant in the 5 wetlands, it has the following features:

- Polyculture is the dominant cropping pattern in Rwintare and the Gikondo wetlands where farmers use to mix different crops on the same parcel of land. This is a type of subsistence farming that is characterized by the low use of agro-inputs and low yields.
- Maize is mostly grown as a monoculture in Rwampara, Kibumba as this is promoted across Rwanda as part of the Minagri-Crop Intensification Programme (CIP).
- Farmers growing vegetables are well organized and specialized, especially in Rwampara and Kibumba wetlands. The production of vegetables is market-oriented and farmers do well-planned crop rotations to continuously supply different types of vegetables to the market.
- Regarding rice crop, there are two cropping seasons per year but many farmers in Nyabugogo wetland are only able to do one harvest per year because of problems of flooding that occur in March-April.

Farmers use agricultural inputs in their activities:

- Most of farmers growing vegetables, rice and maize regularly use fertilizers, and agro-chemicals (insecticides and fungicides). No use of banned agro-chemicals was reported.
- The use of manure is essential for getting good yields and some farmers manage to produce their own compost or purchase manure from other farmers or middle-men.
- Three particular cases related to manure were observed during interviews and field works: i) In Rugenge wetland, the Dukundisuku Cooperative produces compost through managing a landfill, sorting and composting organic matter and sending other inorganic matters (plastic, metal , bottles) to the main Kigali landfill in Nduba, Gasabo District; ii) In Rwampara wetland, cattle owners are growing fodder crops or harvesting fodder from the wetland to feed their cows, and are in return selling manure to vegetable producers; iii) In Rwintare wetland, Girubuntu women farmers' cooperative produced compost using the grass cut from public gardens in Kimihurura or produce compost from toilets.

Farmers are using intensive forms of use, mainly through drainage, of large parts of the wetlands.



FIGURE 4-151 EXAMPLE OF DRAINAGE DITCH ALONG RUGENGE WETLAND

4.13.3.3 Agriculture production and access to market

Interviews with key informants have confirmed that agricultural activities in the 5 wetlands play a key role in the livelihoods of farmers both as a source of food and revenues.

Most of farmers in Gikondo, Rwintare and some farmers in Rwampara wetland are engaged in subsistence farming. Their production of banana, beans, maize, cassava, sweet potato contribute to households' food intake, but the level of production and productivity is low.

On the other hand, interviews and field observations have shown that there are many farmers who are specialized in producing crops for the market.

Vegetable producers in Kibumba, part of Rwampara and part of Rwintare wetlands are engaged in an intensive production system, where they grow a wide variety of vegetables on a continuous basis across the year and supply them to different marketplaces in the City of Kigali. The production system combines different planting dates and crop rotations to enable a consistent and competitive supply of their produce to the market. In most of cases, farmers have developed relationship with buyers, who come to purchase the produce directly from the field.

The produce of maize in Kibumba, Rugenge wetlands is sold to the local market. As urban consumers prefer to consume maize as a snack, farmers growing maize from the wetlands harvest maize before full maturity and sell it on cobs while it is still green. The demand for such a product is high.

Sugar cane constitute the other product targeting urban consumers from the Kigali low-income neighborhoods. It is mainly produced in Nyabugogo and Rugenge wetlands, in areas probe to floods. When harvested, fresh sugar cane is consumed (chewed) as a source of calories by residents of urban poor neighborhoods. Sugar cane is harvested after one year.

4.13.3.4 Challenges to agriculture

The main challenge for agriculture in the wetlands is related to excess of water and floods, which either destroys crops or delays planting periods. The other challenge is related to lack of extension support that affect the capacity of farmers to produce more or to carry out farming activities in a more sustainable way. Farming activities are not generally well organized because of the lack of extension support services

Regarding the excess of water in the wetlands, the scale of this problem varies according to the wetland and across time.

The problem of inundation is most acute in the Nyabugogo wetland where it regularly damages rice crops and transforms some rice land parcel into ponds. According to farmers, that is the consequence of the following three factors: i) the depth of the Nyabugogo river has decreased over time (now 1m-1.5 m) due to continuous accumulation of sediments, causing inundations when the volume of waters increase during heavy rains; ii) when upgrading the road that links Gatsata and Gisozi through the wetland, the 2 canals that used to collect water to the bridge were destroyed; iii) the low velocity of waters at the confluence with the artificial lake is also causing floods in the adjacent fields (rice and sugar cane).

In Kibumba wetland, the inundation that occurred in 2022 destroyed maize crops in the downstream part of the wetland. The wetland is surrounded by residential areas and the main canal is narrow.

In Rugenge wetland, farmers have created deep trenches across the wetland to increase the velocity of water and address the issue of flooding. But the environmental consequence of such practices for the wetland can also be huge.

In the upstream part of the Gikondo wetland (Gatenga, Southern branch of the wetland), 3 concrete canals have been created to evacuate the waters, but the small size of the drainage infrastructure at the confluence with the Rwandex crossroads creates accumulation of waters that flow back to the wetland and destroy crops.

In Rwampara wetland, the high velocity of waters has created a very large/deep gully that present a risk for people and cattle (in some area the depth of the canyon can be close to 10 meters). Flooding occurs in the median and downstream part of the wetland.

4.13.3.5 Overview of other livelihood activities in the wetlands

Plant nurseries

The management of nurseries to produce trees, flowers and other ornamental plants is a key characteristic of the Kigali wetlands. This is a flourishing business that has attracted cooperatives and private businesses. The clients are households and institutional buyers such projects and other organizations.

Nurseries are most developed in the Nyabugogo and Rugenge wetlands, along the Poids-Lourds road. These nurseries are managed by the Imbuga-itoshye cooperative and the Ornamental Plants Producers Cooperatives (OPPC) as well a large number of individual businesses.

In Gikondo wetland, there is no producers' cooperative of ornamental plants: However, private nurseries are located on both sides of the Rwandex crossroad, and near the Kanogo roundabout.

In Rugenge-Rwintare wetland, the Kwigira Family Cooperative (Reserve Forces members) has nurseries with a capacity of 150,000 trees/ornamental plants. They have specialized in producing many species of indigenous trees.

Bamboo production

The production of bamboo is managed by the COPAKIKA Cooperative in Rwintare wetland. That cooperative has started planting bamboo in 2007 and has so far planted an area of 13Ha. There is another private bamboo producer in Kibumba wetland, Kinyinya Sector.

The objective of the COPAKIKA Cooperative was to produce bamboo as a raw material for producing tooth pics, 'imishito' for brochettes and provide construction materials.

Fish farming

Fish farming is done in Kibumba and Nyabugogo wetlands.

In Kibumba wetland, fish farming is one of the activities conducted by the KOABIGA Farmers' Cooperative, in addition to growing vegetables and maize. The cooperative has 18 fishponds on surface area of 3 Ha. However, the productivity of fishponds is constrained by lack of adequate feeds and fingerlings.

In the upper part of Nyabugogo wetland, there are 6 fishponds that are managed by individual farmers.

4.13.3.6 Estimated number of farmers in the 5 wetlands

Based on surveys, the estimated number of farmers using the wetland is about 1,065.

	Total area in hectare	**Agriculture (including bamboo plantation, horticulture and aquaculture)**		**Estimated number of farmers**	**Typical size of parcel in hectare**
		Total surface (Ha)	Percentage of the wetland (Ha)		
Nyabugogo	131	84	64%	300	0.28
Rugenge-Rwintare	65	33	51%	190	0.17
Gikondo	162	22.5	14%	150	0.15
Kibumba	68	34	50%	200	0.17
Rwampara	63	33	52%	225	0.15
TOTAL	489	210.5	43%	1,065	0.20

4.13.3.7 Impacts on livelihood

Based on surveys, about 1065 farmers in the wetland will be directly impacted if wetland rehabilitation puts an end to agriculture in the wetlands. Farmers are willing to adapt their activities, so they become more sustainable. Their capacity to adapt is however limited and most will see a permanent and direct impact on their livelihood and see their vulnerability and poverty worsen. An analysis on zoning regulation has also identified important constraints to the continuation of agricultural activities in the wetlands (see section 4.5).

In addition to potential economic displacement, many members of cooperatives were previously physically resettled and renting houses in nearby neighborhood to continue cultivating in the wetlands.

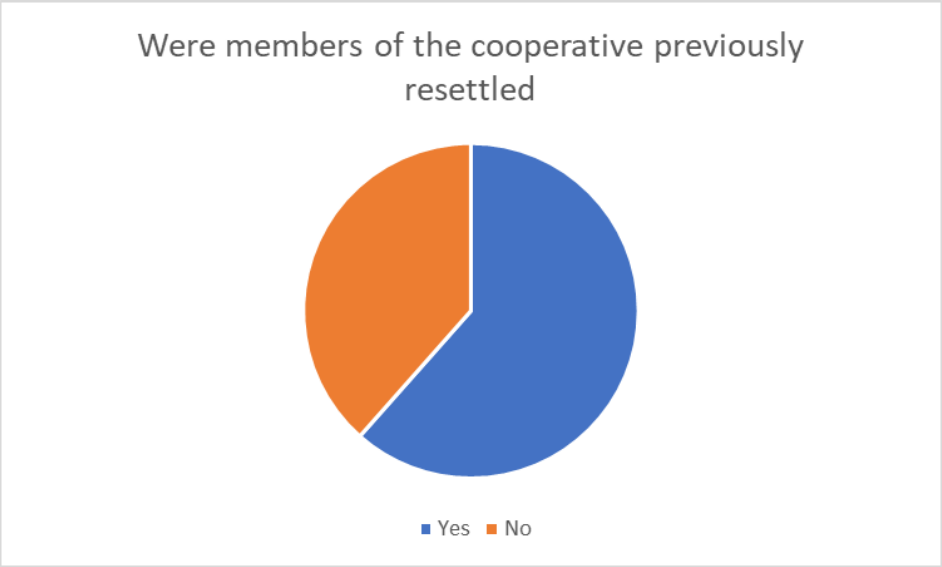


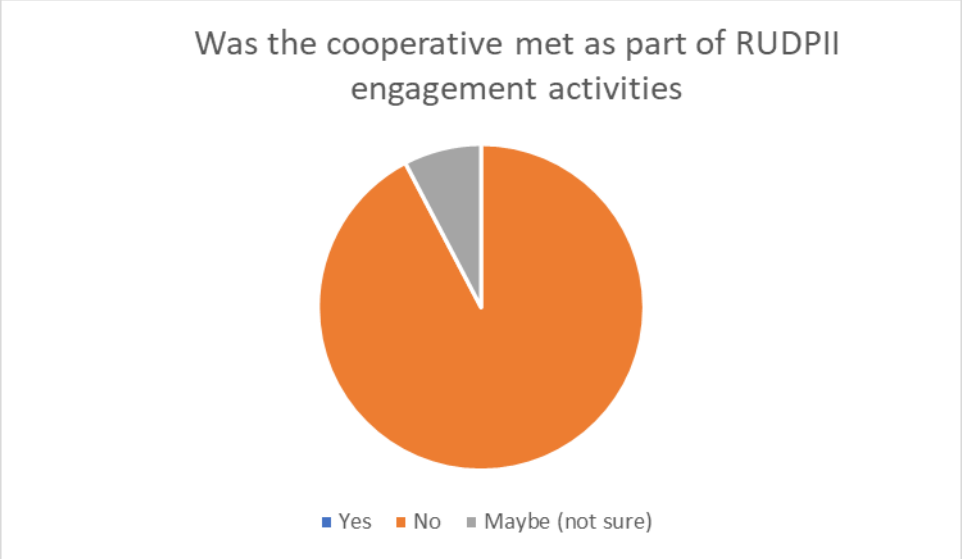
FIGURE 4-152 PHYSICAL RESETTLEMENT IN THE WETLANDS

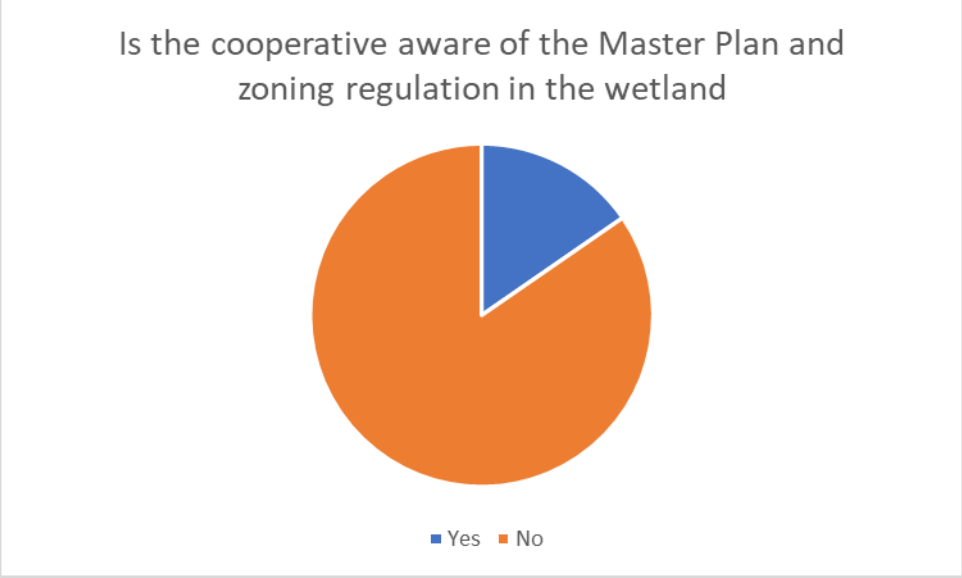
According to the survey, persons that cultivate land in the wetlands are aware that the wetland is public land not destined at agriculture, farmers are therefore knowingly cultivating the wetlands. Farming is informal as land users do not pay any taxes and have no land titles or rental agreements.

Previous studies undertaken in the wetlands for their rehabilitation also highlighted the impact of removing agriculture on communities' livelihood. For example, a survey was undertaken by SEMC (2019) with 102 persons around the wetlands in the framework of the Technical Support for Development of Wetland Master Plan for Kigali City to collect the perceptions of people if the government decides to restrict farming activities and give priority to tourism and recreation activities in wetland. According this this survey, 73.5% of respondents said that they would be unhappy with the loss of plots as they are essential for their life even if wetland users know very well that the wetland is public property.

4.13.3.8 Need for additional engagement with wetland users

During surveys with farmers cooperatives, none were not aware of the RUDPII (except for one respondent who was not sure) and the majority were not informed on the plan to rehabilitate the wetlands. Many were also not aware of the zoning regulation from the city's Master Plan as shown in the following figures. Additional stakeholder engagement activities will therefore be needed at the Environmental and Social Impact Assessment stage to better prepare wetland users on the outcome of the rehabilitation project, these activities will have to be further strengthen if a Resettlement Action Plan or a Livelihood Restoration Plan is required. Engagement activities will have to be done following the principles of the World Bank Environmental and Social Standard, ESS10: Stakeholder Engagement and Information Disclosure.





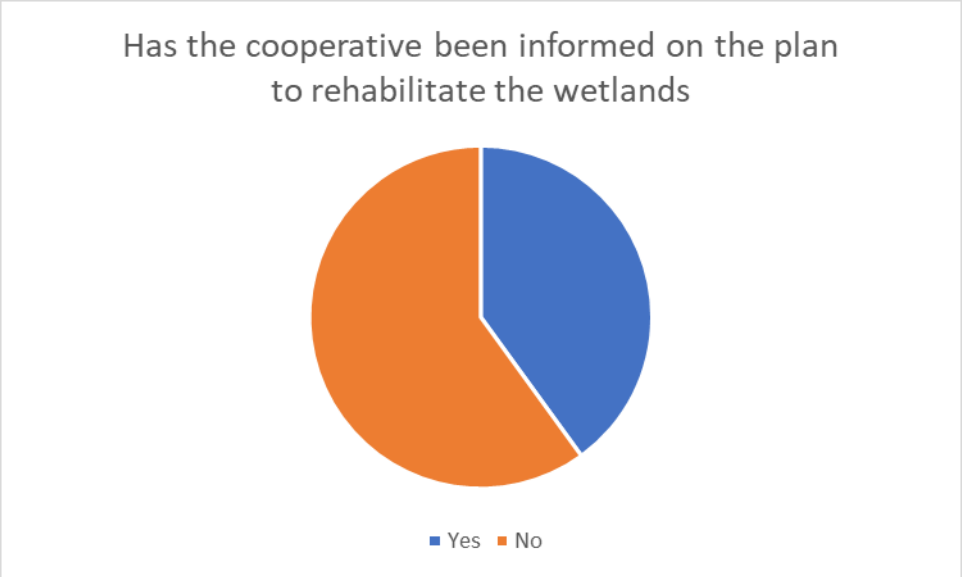


FIGURE 4-153 RESULTS FROM SURVEYS WITH FARMERS' COOPERATIVE

4.13.4 Specificities in Gikondo

The main branch of Gikondo wetland is not an area dedicated for agricultural activities. Therefore, one of its characteristics is that there is no organized cooperative or group of farmers operating in that part of the wetland. However, since the recent relocation of the industrial park, many individual farmers coming from neighboring sectors started growing some traditional crops such as beans and maize in the wetland.

As indicated in the next table, the users of the Gikondo wetland can be summarized as follows:

- Main branch of Gikondo wetland: i) Individual farmers who came to plant crops after the relocation of the industrial park; ii) owners of nurseries
- The Southern branch of Gikondo wetland (Gatenga tributary arm): i) Individual farmers; ii) Gatenga Youth Center
- The Northern branch of Gikondo wetland (Rukili-Rugando tributary arm): i) Individual farmers; ii) UNILAK students nursery; iii) YEAN Hydroponic Training Center.

TABLE 4-41 CATEGORIES OF WETLAND USERS IN GIKONDO

Zone of the Gikondo wetland	Categories of users	Key activities
Main Gikondo wetland	Individuals	Scattered subsistence agriculture done by farmers after the relocation of the industrial park. The vegetative aspect of the crops was very poor as the current status of the soil is not suitable to agriculture.
	Individual/small businesses	Private nurseries for production of trees and ornamental plants are located near the junction of the main wetland and its tributary arm (Rukili-Rugando). The other group of nurseries is located between the Kanogo roundabout and the downstream of the Gikondo wetland.
	Individuals	Scattered subsistence agriculture in the upstream part of the wetland

Zone of the Gikondo wetland	Categories of users	Key activities
Southern branch (Gatenga tributary arm)	Individual/small businesses	Private nurseries for production of trees and ornamental plants are located between the Rwandex crossroad and the Zion Temple Church in Gatenga.
	Gatenga Youth Center	Gatenga Training Center is managed by a congregation affiliated to the Catholic Church: They are Leasing land to a private seed company, whereas the remaining land is used for fodder production.
Northern branch (Rukili-Rugando tributary arm)	Individuals	Subsistence agriculture, mainly maize, beans and sweet potato.
	Individuals	Fish farming (2 fishponds not well maintained)
	YEAN Training Center	Hydroponics Training Center: YEAN is a social enterprise that provides agriculture extension focusing on young in agribusiness. They have installed a demonstration green-house where strawberries are grown under hydroponics.
	UNILAK University	UNILAK University has a partnership with the YEAN Training Center to provide opportunity for practices to students (rural development and environment): A tree nursery (capacity 50,000 seedlings) was put in place by UNILAK students.

4.13.5 Specificities in Rwampara

The study has identified the following four categories of users of the Rwampara wetland:

- Farmers' cooperatives/groups: As presented in the next table, four cooperatives were identified during the study. They are engaged in market-oriented production schemes.
- Individual farmers: They are main group of users of the wetland, and they are engaged in traditional, subsistence agriculture. The key crops grown are banana, maize, beans and sweet potato.
- Livestock owners: A number of urban residents own cows or goats and use Rwampara marshland to produce fodder and as a source of water for cattle. Some cows and goats were observed grazing in the wetland during the study. Farmers who cannot produce enough fodder can also buy fodder that is harvested from the wetland.
- Other users (such as recreational facilities).

TABLE 4-42 CATEGORIES OF WETLAND USERS IN RWAMPARA

Name of the cooperative	District	Date of creation	Number of members	Surface area exploited (Ha)	Main activity
Abishyizehamwe-Rwampara	Nyarugenge	2007	32	5 Ha	Vegetable production
Avega Nyarugenge	Nyarugenge	2010	12	1Ha	Maize
Duhuguke Dukora	Kicukiro	2009	18	2Ha	Maize; Soja Vegetables

Name of the cooperative	District	Date of creation	Number of members	Surface area exploited (Ha)	Main activity
Tecocoki	Kicukiro	2007	12	2.8 Ha	Maize; Soja, Beans, Vegetables

The key challenge for agriculture in the Rwampara wetland is the permanent risk of floods, especially in its median zone and downstream zone, but also the intense erosion that has created a large and deep gully in the upstream part of the wetland. The other challenge is that farmers do not have access to small irrigation equipment and training/technical support to improve their farming practices.

4.13.6 Specificities in Rugenge-Rwintare

The main users of the wetland are classified in the following categories:

- Farmers 'cooperatives: Despite the small size of the wetland (65Ha), there are 8 farmers' cooperatives, mainly operating in the Rwintare subsidiary, indicating the pressure on land in that particular area. These are presented in the next table.
- Individual farmers.
- Three tree and ornamental plants producers Cooperatives.
- Individual tree nurseries.
- Private businesses/organizations.

TABLE 4-43 COOPERATIVES IN RUGENGE-RWINTARE

Name of the cooperative/Farmer group	District	Number of members	Surface area exploited	Main activity
Imbuga-Itoshye cooperative	Nyarugenge	20	5-20 Ares per member	Nursery
OPPC (Ornamental Plants Producers Cooperative)	Nyarugenge	15	5-15 Ares per member	Nursery
Koperative y'Abahinzi ba Kimihurira na Kacyiru (KOPAKIKA)	Gasabo	37	17Ha	Bamboo (13Ha) Vegetables and maize (3Ha)
Kwigira Family Cooperative (Reserve Force members)	Gasabo	12	1.5 Ha	Nursery with specialisation on indigenous trees
Dufatanye farmers Group	Gasabo	22	2	Banana, Vegetables on the site of former APABENA Association
Girubumuntu Farmers' cooperative	Gasabo	17	0.7Ha	Vegetable production; other subsistence crops
Dukundisuku Cooperative	Gasabo	16	1 ha	Production of compost from landfill; nursery
KOKAWI Cooperative	Gasabo	30	3.5Ha	Mixed crops. Not well organised.

Agricultural activities across the Rugenge-Rwintare wetland can be subdivided into five categories:

- Nurseries: This is the most visible intervention in the wetland, and its importance is justified by the number of stakeholders engaged in nursery management (3 cooperatives and many individual small businesses) as well as its contribution to the beautification of the City of Kigali.
- Bamboo production: This is a unique intervention done by a farmers' cooperative (KOPAKIKA) in Rwintare wetland, Gasabo District. The cooperative has 37 members, with the majority of female members mainly widows. The objective of the cooperative is to produce bamboo as a raw material for producing tooth pics, 'imishito' for brochettes and provide construction materials. When the cooperative sell bamboo, the revenues are redistributed to members and the cooperative has a saving scheme.
- Market-oriented crop production: This is done by farmers' cooperatives (e.g. KOPAKIKA and Girubuntu Cooperatives) that produce vegetables for the Kigali market. The production of vegetables, Irish potato on a consolidated area estimated at (5Ha) was observed on the site where were removed the facilities of the ULK University.
- Fodder production: Field of Penisetum grass and Umutete grass were observed on the site where were removed the facilities of the ULK University.
- Subsistence agriculture: This is one of the characteristics of Rwintare wetland where farmers continue to grow banana, beans and cassava for subsistence.

TABLE 4-44 CATEGORIES OF WETLAND USERS IN RUGENGE-RWINTARE

Zone of the wetland	Categories of users	Key activities
Rugenge	Cooperatives of producers of Trees and Ornamental plants	There are 2 two cooperatives of producers of Trees and Ornamental plants who operate along the Poids-Lourds road, namely Imbuga-Itoshye Cooperative and OPPC (Ornamental Plant Producers Cooperative)
	Individual/small businesses	Private nurseries for production of trees and ornamental plants are located along the Poids-Lourds road. Their number is not known by local authorities/agronomists.
Rwintare	Farmers' Cooperatives	- Bamboo production - Maize and vegetable production - Production of compost
	Individuals	Scattered subsistence agriculture in the upstream part of the wetland
	Cooperatives of producers of Trees and Ornamental plants	The Kwigira Family Cooperative composed of members of the Reserve Force manage a nursery of 150,000 seedlings. They are specialised in producing indigenous trees.
	Individual/small businesses	Private nurseries for production of trees and ornamental plants are located near Kimicanga and la Colombière School
	ULK University	- Fodder production - Production of Vegetables and Irish potato.

4.13.7 Specificities in Kibumba

The Kibumba wetland was exploited by smallholder farmers, who gradually organised themselves into farmers' groups until they joined the KOABIGA Cooperative in 2017. KOABIGA Cooperative is organised into 5 zones, with each zone corresponding to a particular sector/wetland. In Kibumba wetland, KOABIGA cooperative has 200 members who are organized in 9 groups (8 groups for agriculture and 1 group for fish production). Each group is composed by at least 20 farmers, whose houses are located on the hills surrounding the wetland. The cooperative is engaged in market-oriented agriculture production schemes. The strategic location of the

Kibumba wetland near the Gisozi commercial park (Agakiriro) and the densely populated urban area provide an opportunity for market as the demand for vegetables and other fresh produce is high. The produce is purchased directly at farm site by traders who re-sell it to the population in Kinyinya and Gisozi Sectors. Despite the key constraint of flooding, especially in the downstream part of the wetland, farmers can do 3 to 4 cropping seasons for vegetables in a year which is quite intensive and shows a good level of internal organisation. They use inputs (seeds, fertilizers, and pesticides), showing that they are following a clear crop intensification path. Farmers have in general the required skills to grow vegetables and maize and they closely work with 2 agricultural advisors who provide extension support and training on agricultural practices. The cooperative has 18 fish ponds on surface area of 3 Ha that were put in place with the support of PAIGELAC, a Government Project funded by the African Development Bank. Surveys have confirmed that farming was the main activity of the members of the KOABIGA cooperative and it is therefore their key source of income. It was estimated that 75% of the crops were sold whereas 25% was used for household food needs.

The Cooperative has submitted a project to the Ministry of Environment with a request to get an official lease to use the wetland for 30 years, but they had not yet got the authorization in April 2022 when the surveys were held.

The other users of the wetland are:

- Gaculiro Technical Education and Vocational Center (TVET): They have land and a playing ground within the limits of the wetland. The Center is managed by a congregation affiliated to the Catholic Church.
- Croix-Rouge: This an international Organization with a large property both on hillsides (Kacyiru sector, Gasabo District) and in the Kibumba wetland, starting at the end of the Kigali Golf Club. The land in the wetland is leased to private operators for recreational activities and for agriculture.
- There is another private bamboo producer in Kibumba wetland, Kinyinya.

In 2019, the District of Gasabo in collaboration with other government institutions has relocated houses from the wetland, in Kabuhunde 2 and Kadobogo villages. The people affected by this action are renting houses in the neighbourhood and continue to do agriculture in the wetland.

4.13.8 Specificities in Nyabugogo Lower

Rice cultivation was introduced in the main Nyabugogo wetland (Kabuye) in 1962, under the responsibility of the Ministry of Agriculture. The scheme was later transferred to a public entity Soproriz until 2003 and then to cooperatives. CORIKA is the rice producers' cooperative in the main Nyabugogo wetland, whereas farmers in the lower Nyabugogo are organized into the KOPRORIKI Cooperative regrouping 50 members. The rice perimeter is subdivided into blocs of 25m by 25m and each farmer is allocated between 2 and 4 blocs. The crop calendar is organized into 2 seasons as follows: i) Season A: June-December; ii) Season B: December– June

In addition to growing rice, farmers in Nyabugogo wetland are cultivating sugar cane, especially in zones not suitable to rice due to flooding or lack of adequate irrigation system. Some parts of the wetland are also used to growing seasonal crops (maize) and vegetables.

Four main categories of users have been identified in the lower Nyabugogo wetland:

- Farmers cooperatives: Two cooperatives were identified, one for rice production, another one for the production of maize and vegetables.
- Ornamental plants producers' cooperatives: Two cooperatives were identified (the same ones that also operate in the Rugenge wetland).
- Individual farmers: These are those who are mainly growing sugar cane in the wetland, whereas others were growing maize or vegetables. Some individual farmers managed to create 6 fishponds in the upper part of the wetland, near the Kinamba Bridge.
- Private/businesses:
    - These are owners of trees nurseries, who have not yet decided to join the cooperatives or who left those cooperatives.
    - A private owner has developed a proposal for a recreational facility near the confluence with Kibumba wetland, and is growing sugar cane in the remaining part, while waiting for the decision of the Ministry of Environment to his request to develop a bigger recreational facility in the zone.

The four cooperatives are described in the following table.

TABLE 4-45 FARMERS' COOPERATIVES IN NYABUGOGO LOWER

Name of the cooperative/Farmer group	District	Number of members	Surface area exploited	Main activity
Imbuga-Itoshye cooperative	Nyarugenge	20	500 to 2000 m2 per member	Nursery
OPPC (Ornamental Plants Producers Cooperative)	Nyarugenge	15	500 to 1500 m2 Ares per member	Nursery
Coproriki Cooperative	Gasabo	75	30Ha; 1250 m2 per member	Rice, sugar cane
Abunzubumwe Cooperative	Gasabo	27	3 Ha; 500 to 3000 m2 per member	Vegetables, Maize

4.14 PREVIOUS STUDIES ON WETLAND REHABILITATION

Several recent studies have made proposals for wetland rehabilitation:

- SMEC Study (2019) Kigali Wetland Master Plan.
- NEMUS study (2018) Detailed Management Plans for the Gikondo and Nyabugogo Wetland Systems. *The original 35 design plans were however not provided to the team for this study. Described interventions are not location specific in the tables.*
- World Bank, Macfarlane (2020). Technical support to inform detailed wetland rehabilitation planning: Gikondo and Nyabugogo (Lower) wetlands, Kigali, Rwanda.
- DELTARES Study (2021) Storm Water and Wetland Management Model for the delineated flood prone areas in Kigali City Final report.

The following tables outline the key actions proposed by these studies for each wetland.

4.14.1 Gikondo

SMEC Study (2019) Kigali Wetland Master Plan	NEMUS study (2018) Detailed Management Plans for the Gikondo and Nyabugogo Wetland Systems	DELTARES Study (2021) Storm Water and Wetland Management Model for the delineated flood prone areas in Kigali City Final report	World Bank, Macfarlane (2020). Technical support to inform detailed wetland rehabilitation planning: Gikondo and Nyabugogo (Lower) wetlands, Kigali, Rwanda
Soil and water quality analyses at sites with potential contamination. Import of topsoil, plantation of native trees in riparian zones. Removal of agriculture drainage ditches (drainage furrows). Restoration of wetland hydrology. Creation of a green space with a meandering stream (reshaping the stream).	Removal of polluted soils. Sequence of lagoons to purify water, and to serve as retention ponds for storm water. Several small water channels are proposed on the side of the valleys, to collect the tributaries from the urban areas, and conduct them to the wetlands and the proposed depuration ponds. Sand traps. Excavation of shallow and deep areas to maintain water in ponds and create habitats. Re-opening and rebuilding of the watercourses with a larger profile. Wetland vegetation planting. Two new pedestrian passages. Rehabilitation to be done in two phases (one to decontaminate soil and one phase for the rehabilitation) for a total cost of about 21 million USD	Deltares referred to World Bank, Macfarlane (2020) for rehabilitation scenarios	World Bank, Macfarlane reported 2 scenarios Scenario 1 assumes relatively high pollutant loads, providing treatment beds that are spatially separated from peak flow flood conveyance. The total cost was estimated at 10 million USD Scenario 2 is simpler from an engineering perspective with a lower level of water quality treatment achieved by re-establishing more natural wetland dynamics. The total cost was estimated at 7.3 million USD. In both cases recreational use is included, and Scenario 1 gives space for continued agricultural use. Both scenarios include sediment basins at the outfall of major stormwater outfall See figures below

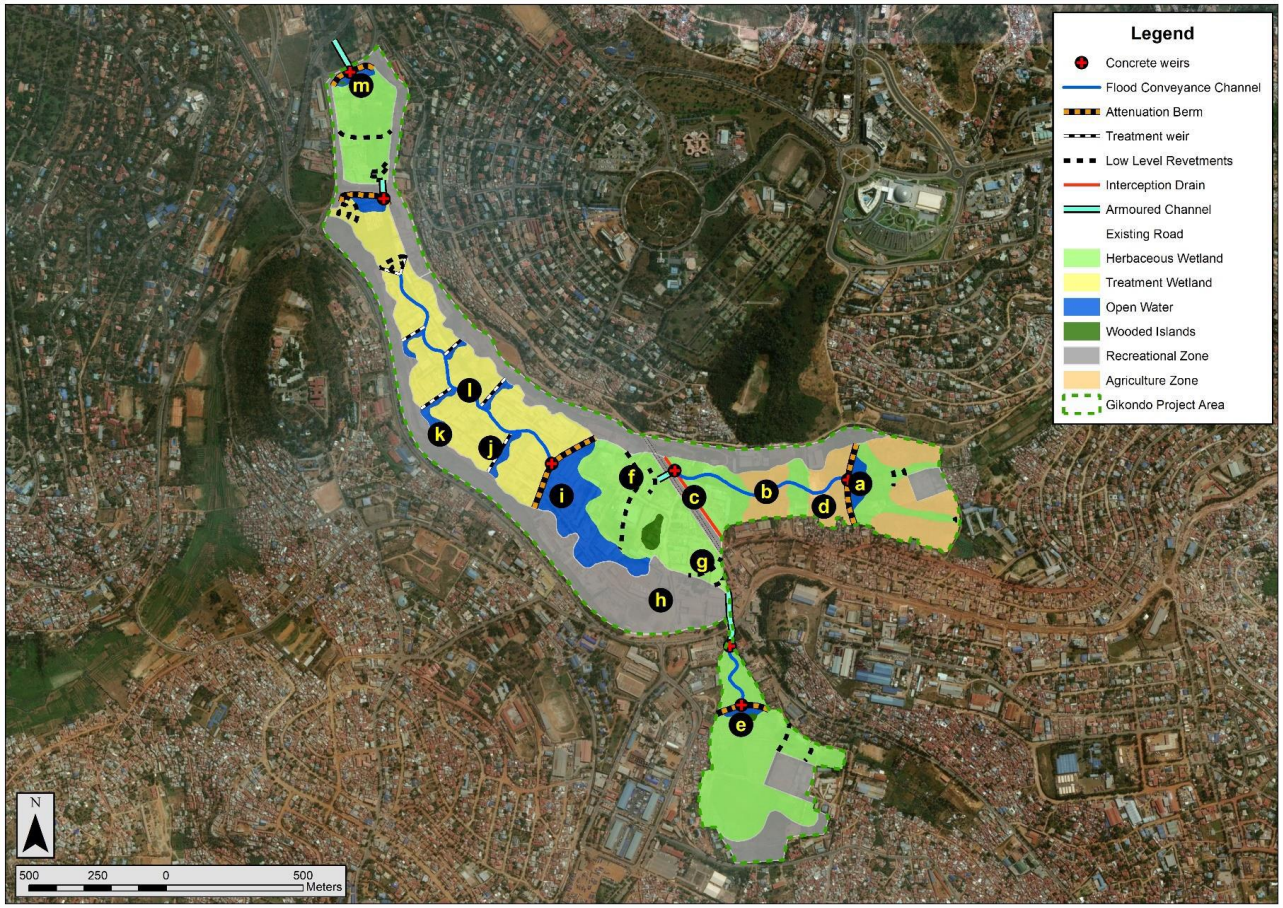


FIGURE 4-154 WORLD BANK 2020: VARIANT 1: MAP INDICATING THE LOCATION OF POSSIBLE INTERVENTIONS FOR GIKONDO WETLAND

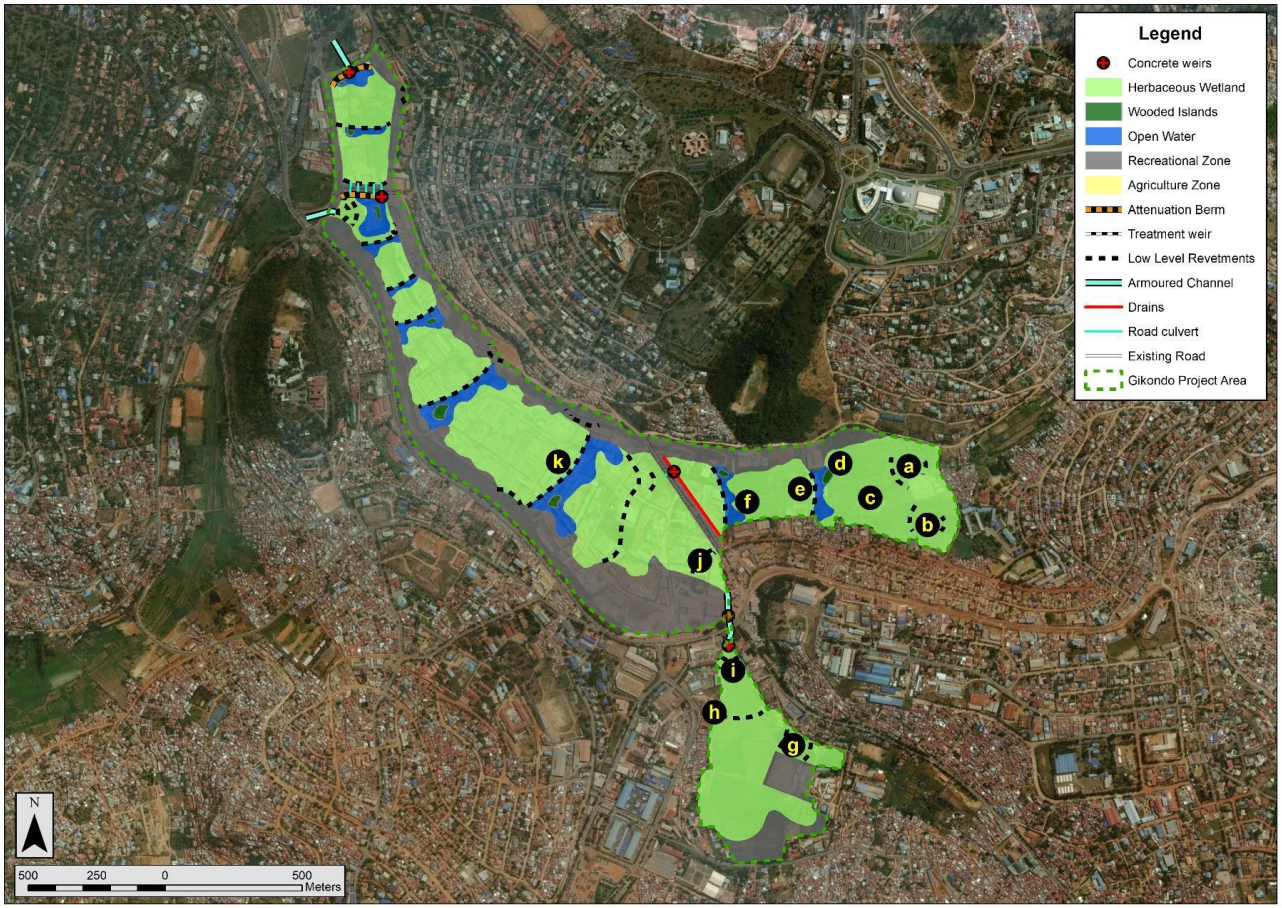


FIGURE 4-155 WORLD BANK 2020: VARIANT 2: MAP INDICATING THE LOCATION OF POSSIBLE INTERVENTIONS FOR GIKONDO UNDER THIS ALTERNATIVE SCENARIO

4.14.2 Rwampara

SMEC Study (2019) Kigali Wetland Master Plan	NEMUS study (2018) Detailed Management Plans for the Gikondo and Nyabugogo Wetland Systems	DELTARES Study (2021) Storm Water and Wetland Management Model for the delineated flood prone areas in Kigali City Final report	World Bank, Macfarlane (2020). Technical support to inform detailed wetland rehabilitation planning: Gikondo and Nyabugogo (Lower) wetlands, Kigali, Rwanda
Removal of agriculture drainage ditches (drainage furrows). Restoration of wetland hydrology. Remedial work of the central channel to limit erosion.	Removal of agriculture ditch. Split of the river into two or more waterways to collect drainage from the hill slopes. Between newly created water ways and the main river, excavation to create lagoons, working as sediment traps and water retention areas. Vegetation plantation in the wetland and in the lagoon to reinforce the bioretention process. New pedestrian passages. Rehabilitation to be done in a single phase for a total cost of about 3 million USD	Not studied	Not studied

4.14.3 Rugenge-Rwintare

SMEC Study (2019) Kigali Wetland Master Plan	NEMUS study (2018) Detailed Management Plans for the Gikondo and Nyabugogo Wetland Systems	DELTARES Study (2021) Storm Water and Wetland Management Model for the delineated flood prone areas in Kigali City Final report	World Bank, Macfarlane (2020). Technical support to inform detailed wetland rehabilitation planning: Gikondo and Nyabugogo (Lower) wetlands, Kigali, Rwanda
Arm B (for Rugenge): Remedial work of the central channel to limit erosion. Arm C (for Rwintare): Removal of agriculture drainage ditches (drainage furrows). Restoration of wetland hydrology.	The same wetland is called Rwezangoro Removal of agriculture ditches. Several small water channels are proposed on the side of the valleys, to collect the tributaries from the urban areas and conduct them to the wetlands proposed depuration ponds. Excavation of sand traps. Excavation of shallow and deep areas to maintain water in ponds. Wetland vegetation planting. Two new pedestrian passages across the wetland. Rehabilitation to be done in two phases (one to decontaminate soil and one phase for the rehabilitation) for a total cost of about 7.2 million USD	Deltares reported 2 scenarios Scenario 1 enhances the flood attenuation potential of the wetland whilst also creating a central lake to enhance the aesthetics of the area. The conveyance capacity of the existing road culverts is maintained, whilst main drains are infilled and the valley bottom is re-shaped to establish herbaceous wetland habitat and optimize diffuse flows for water quality treatment. An open water area, excavated to a depth of at least 1m, is included. Scenario 2 aims to reinstate natural wetland functions, including pollutant assimilation but without specifically enhancing flood attenuation potential. Again, the conveyance capacity of the existing road culverts is maintained, whilst main drains are infilled and the valley bottom contains herbaceous wetland habitat. Low-level revetments act as base-flow controls that promotes diffuse flows (for water quality treatment) and reduces erosion risks See figure below	Not studied

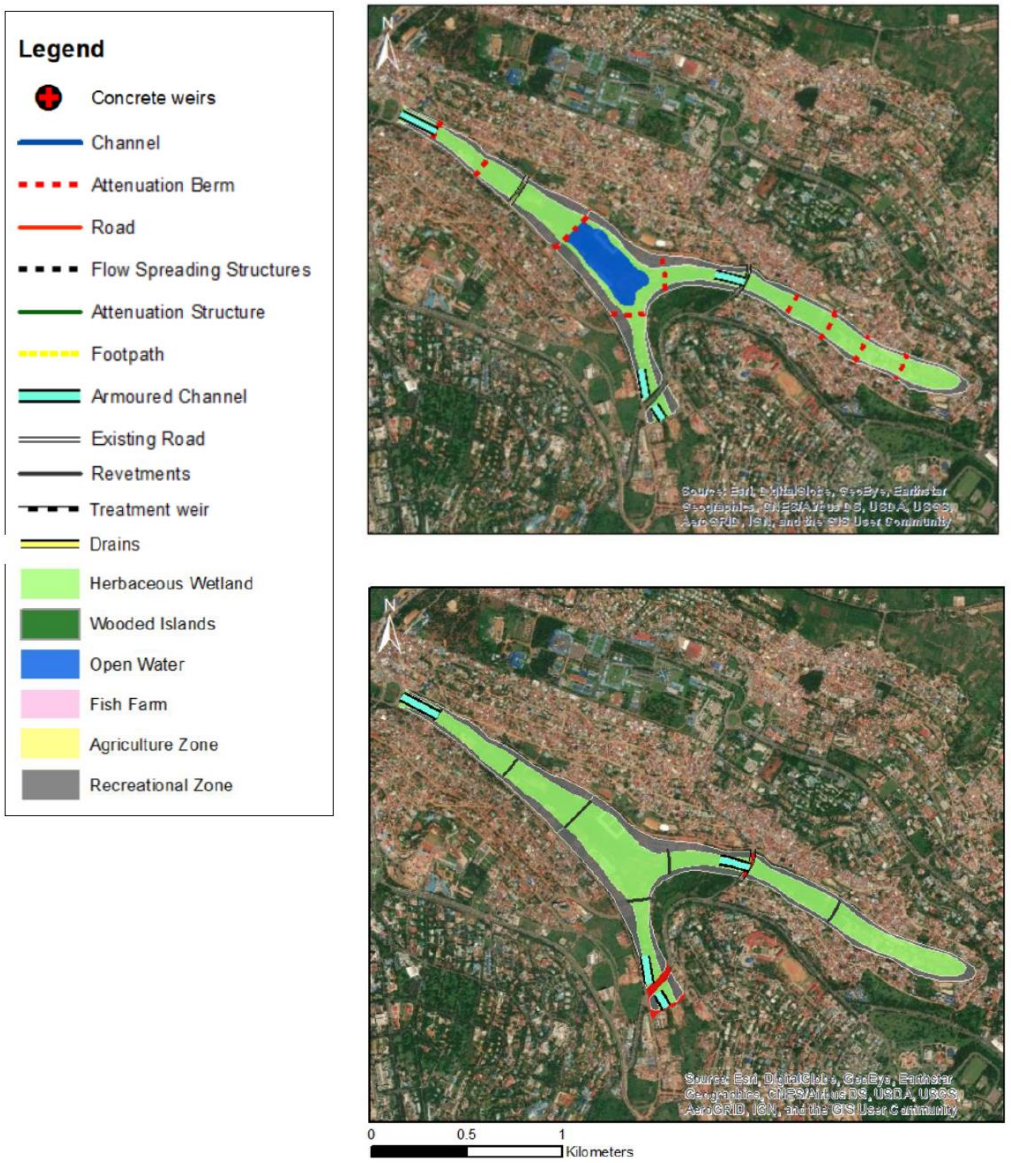


Figure 8-17. Map of the Rugenge-Rwintare wetland restoration – Scenario 1 (top) and Scenario 2 (bottom).

FIGURE 4-156 DELTARES REHABILITATION VARIANT FOR RUGENGE-RWINTARE

4.14.4 Kibumba

SMEC Study (2019) **Kigali Wetland Master Plan**	**NEMUS study (2018)** **Detailed Management Plans for the Gikondo and Nyabugogo Wetland Systems**	**DELTARES Study (2021)** **Storm Water and Wetland Management Model for the delineated flood prone areas in Kigali City** **Final report**	**World Bank, Macfarlane (2020). Technical support to inform detailed wetland rehabilitation planning: Gikondo and Nyabugogo (Lower) wetlands, Kigali, Rwanda**
The same wetland is called Rwampara Arm D Development of hiking and biking trails. Removal of agriculture drainage ditches (drainage furrows). Restoration of wetland hydrology. Plantation of native trees.	Although the name Nyabugogo Downstream – Kibumba is mentioned, NEMUS did not assess the Kibumba section that concerns this study Not studied	Not studied	Not studied

4.14.5 Nyabugogo Lower

SMEC Study (2019) Kigali Wetland Master Plan	NEMUS study (2018) Detailed Management Plans for the Gikondo and Nyabugogo Wetland Systems	DELTARES Study (2021) Storm Water and Wetland Management Model for the delineated flood prone areas in Kigali City Final report	World Bank, Macfarlane (2020). Technical support to inform detailed wetland rehabilitation planning: Gikondo and Nyabugogo (Lower) wetlands, Kigali, Rwanda
The same wetland is part of Nyabugogo and Rwezangoro Rwezangoro: Removal of agriculture drainage ditches (drainage furrows). Restoration of wetland hydrology. Plantation of native trees along the north bank of the wetland. Control of water hyacinth. Nyabugogo: Removal of agriculture drainage ditches (drainage furrows). Restoration of wetland hydrology. Development of a scenic backdrop to the waterfront. Creation of detention basins and floodplain areas that will lead to flood mitigation.	The same wetland is called Nyabugogo Downstream - Kibumba Removal of agriculture ditched. Two depuration lagoons with sand traps along Nyabugogo River at the intersection with its tributaries. Four sand traps along Rwezangoro watercourse at the intersection with its tributaries. Interventions to create meanders along Nyabugogo and additional channel to divert water into the wetland. Wetland vegetation planting and creation of minor depressions to allow water to accumulate. New pedestrian bridge across the Nyabugogo river. Pathways are proposed along both sides of the valley for pedestrian and bicycles. Buffer bands of vegetation between the wetland and urban areas. Rehabilitation to be done in two phases (one to decontaminate soil and one phase for the rehabilitation) for a total cost of about 5.5 million USD	Deltares referred to World Bank, Macfarlane (2020) for rehabilitation scenarios	World Bank, Macfarlane (2020) reported 2 scenarios In both scenarios, the main drain constructed through the lower reaches of the Nyabugogo wetland is blocked (in filled), promoting the distribution of water across the wetland. Scenario 1 aims to create a balance between agricultural use and enhanced ecological functions, whilst Scenario 2 aims to optimize water quality functions. The total cost was estimated at 6 million USD for scenario 1 and 5 million USD for scenario 2 Both scenarios include sediment basins at the outfall of major stormwater outfall See figure below

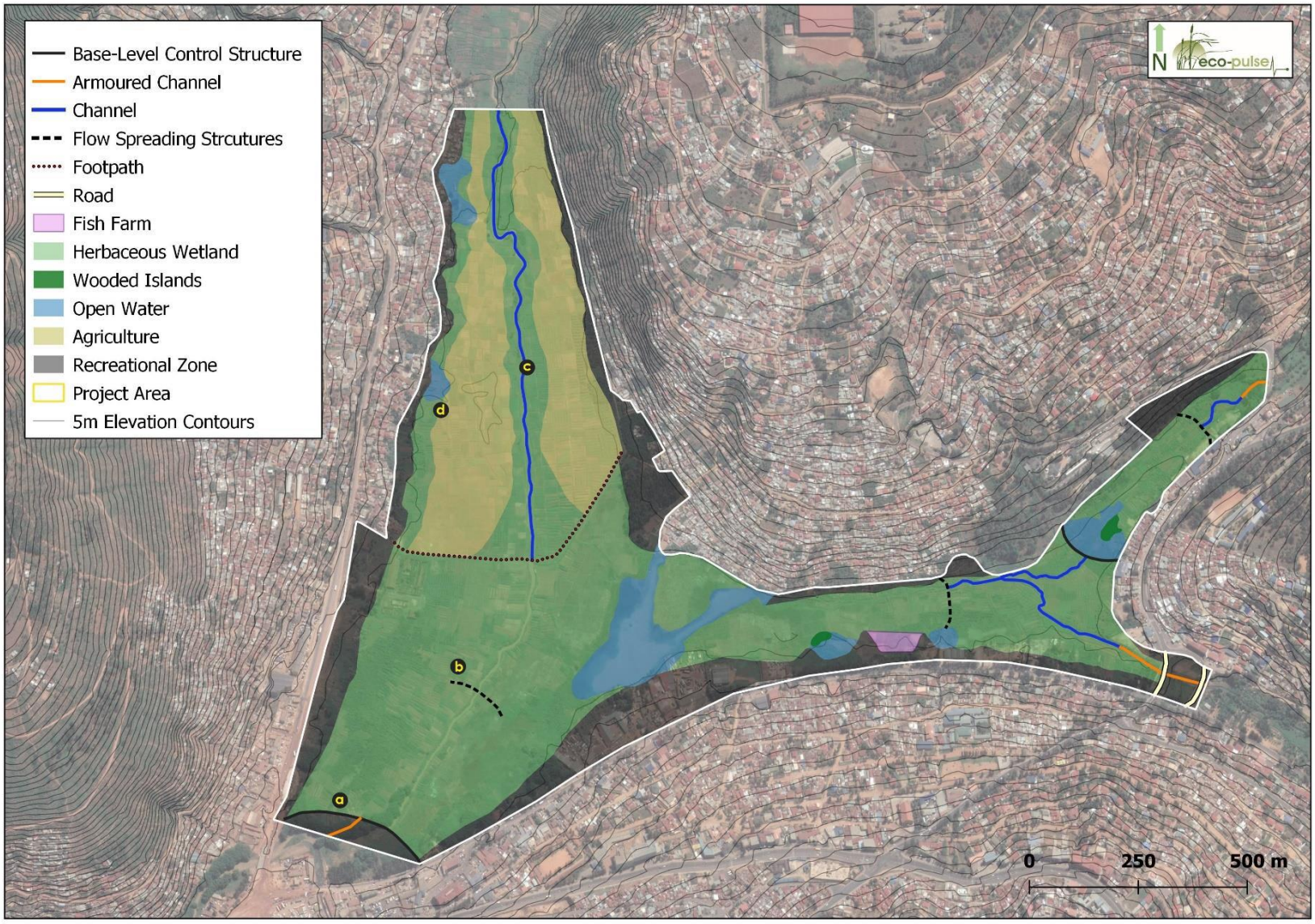


FIGURE 4-157 WORLD BANK 2020: VARIANT 1: MAP INDICATING THE LOCATION OF POSSIBLE INTERVENTIONS FOR NYABUGOGO WETLAND

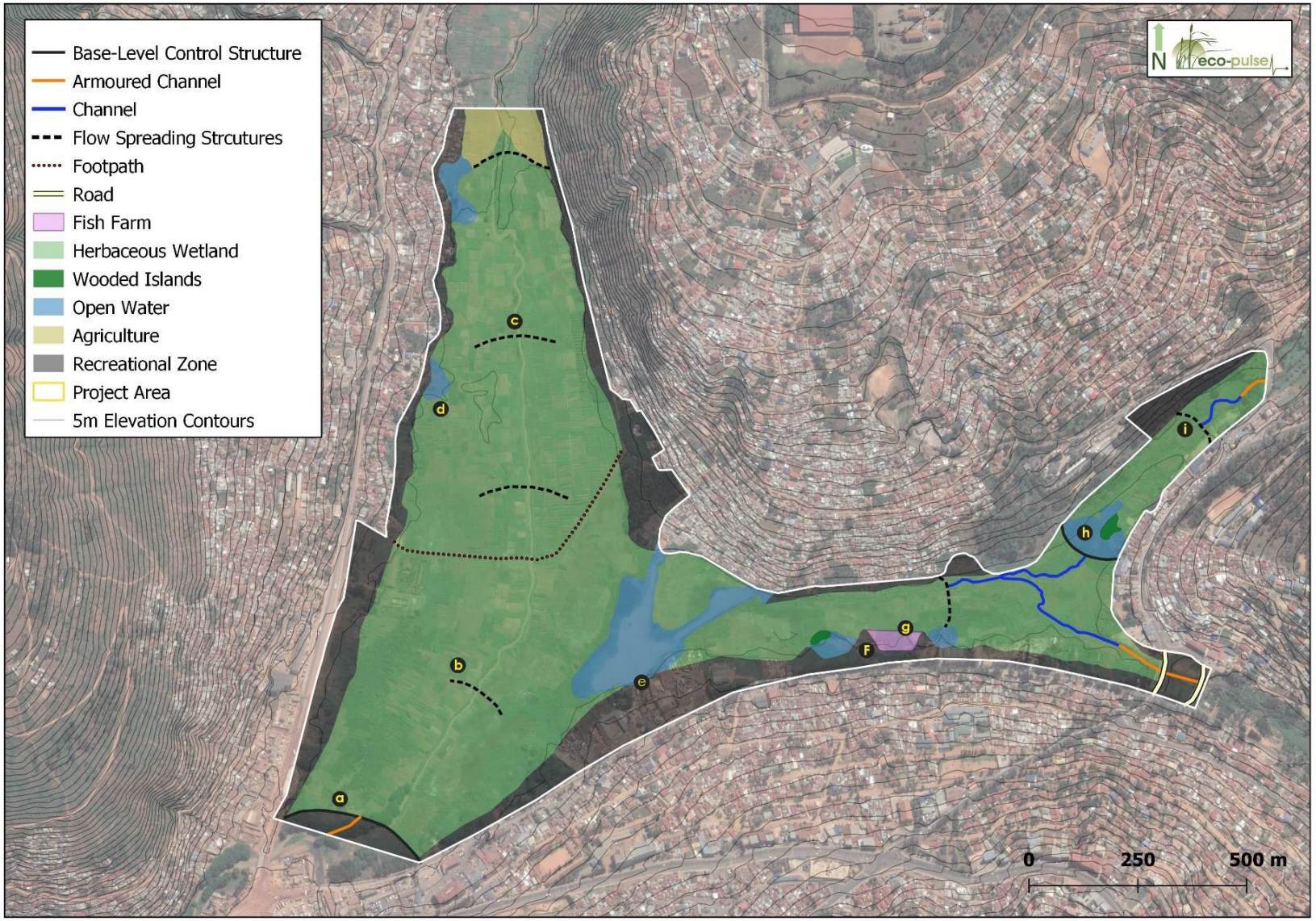


FIGURE 4-158 WORLD BANK 2020: VARIANT 2: MAP INDICATING THE LOCATION OF POSSIBLE INTERVENTIONS FOR NYABUGOGO WETLAND UNDER AN ALTERNATIVE SCENARIO

4.14.6 Comparison of costs of previous variants

NEMUS (2018) and Macfarlane, World Bank (2020) studies have made detailed estimates of costs. These are presented in the following table. Both studies have considered costs for decontamination of soils due to past industrial or commercial activities (that are most likely present in Gikondo and potentially present in some areas in Nyabugogo).

Wetlands	NEMUS study (2018) Detailed Management Plans for the Gikondo and Nyabugogo Wetland Systems	World Bank, Macfarlane (2020). Technical support to inform detailed wetland rehabilitation planning: Gikondo and Nyabugogo (Lower) wetlands, Kigali, Rwanda
Gikondo	Rehabilitation to be done in two phases (one to decontaminate soil and one phase for the rehabilitation) for a total cost of about **21 million USD** (including decontamination at a cost of 11.3 million USD)	The total cost was estimated at **10 million USD** for scenario 1 and **7.3 million USD** for scenario 2. This cost included, in both scenarios, rehabilitating 10% of potentially contaminated soil (covering 6.7 ha) at a cost of 746,200 USD and removing foundations from the old industrial area and existing services at a cost of 1,150,000 USD
Rwampara	Rehabilitation to be done in a single phase for a total cost of about **3 million USD**	Not studied
Rugenge-Rwintare	Rehabilitation to be done in two phases (one to decontaminate soil and one phase for the rehabilitation) for a total cost of about **7.2 million USD** (including decontamination at a cost of 2.4 million USD)	Not studied
Kibumba	Not studied	Not studied
Nyabugogo Lower	Rehabilitation to be done in two phases (one to decontaminate soil and one phase for the rehabilitation) for a total cost of about **5.5 million USD** (including decontamination at a cost of 1.4 million USD)	The total cost was estimated at **6 million USD** for scenario 1 and **5 million USD** for scenario 2. This cost included, in both scenarios, rehabilitating 10% of potentially contaminated soil (covering 1.2 ha) at a cost of 133,600 USD and removing existing services at a cost of 150,000 USD

4.14.7 Conclusion on previous variants

As highlighted in the World Bank, Macfarlane study (2020), developed scenarios from previous studies will need to be refined through a better understanding of baseline conditions and agreed rehabilitation objectives. Due consideration of broader town planning and stakeholder views also needs to be considered,

including how to optimize opportunities in recreational zones around the wetlands. This Study has allowed to undertake flow and flood models as well as more in-depth stakeholder engagement activities to identify needs and fine tune the rehabilitation objectives. The previous studies did not undertake detailed flow and flood models to design their scenarios, which is a key difference with this study. Also, this Study has built the rehabilitation scenarios taking into account collected opinions and aspirations from a wide range of stakeholders while acknowledging the strong potential for recreational and landscape development in the wetlands while these aspects were not covered in depth in the previous studies. One important aspect that was almost completely overlooked in previous studies is the human environment, the fact that the wetlands are surrounded by people using the wetlands for their livelihood.

Previous scenarios included costs for site-clean and soil decontamination at large scale up to remove foundations of buildings and services in the wetlands, mainly in Gikondo. NEMUS had foreseen that this decontamination would require the wetland rehabilitation to be done in several phases as shown below:

- Phase 1 – short-term: actions to implement in four years (2018-2021);
- Phase 2 – mid-term: actions to implement in four years (2022-2025);
- Phase 3 – long-term: actions to implement in four years (2026-2029).

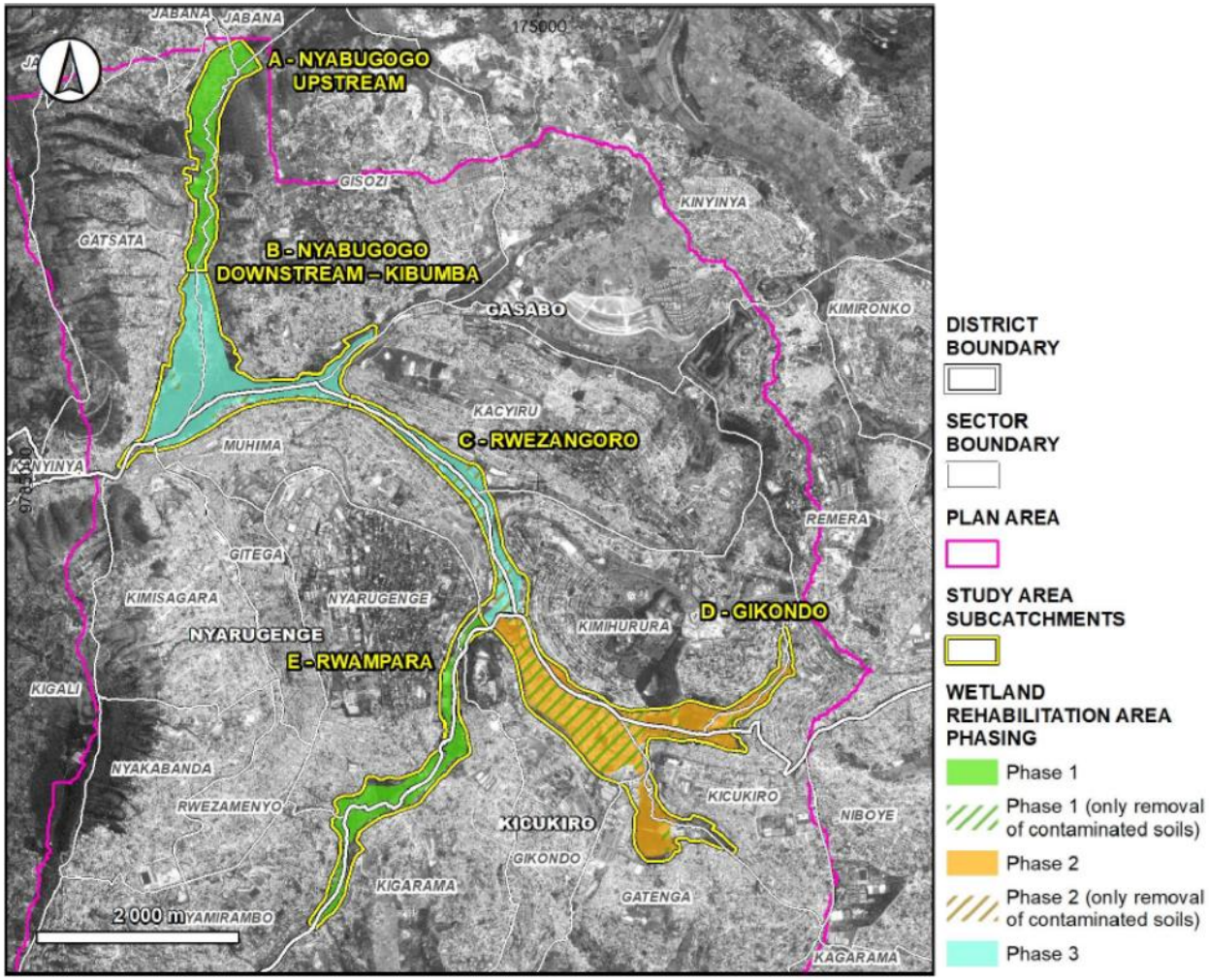


FIGURE 4-159 PHASES OF NEMUS REHABILITATION

The proposed scenarios in this study does not intend to remove embankments and limits earth movement by building recreational or educational structures on embankments that were recently freed from construction. As presented at chapters 5 and 7, removing of contamination soils is not part of the rehabilitation scenario. The reason is that areas with potential contaminated soils are located in sector destined for recreational purposes or not destined to be rehabilitated where only surface development will be implemented with minimal land levelling. Localized soil decontamination could be necessary whenever excavation will take place, based on sampling that will be undertaken at detailed design.

4.15 CASE STUDY ANALYSIS

This chapter projects in similar urban environments that have carried out wetland restoration. It presents the factor of success and the various obstacles that these projects have faced. In addition, it presents how can these projects apply to the context of the Study and analysis how flood control, biodiversity enhancement, water quality improvement and recreational and landscape were considered in the planning.

4.15.1 Case study 1: Nantes, France 6ha of wetland

<table>
<tr><th>Case of wetland restoration or creation</th><th>Work and management costs</th><th>Criteria</th><th>Positive points</th><th>Negative points</th><th>Possible application for the restoration project in Kigali</th></tr>
<tr><td rowspan="2">Geographic Location: Nantes, France</td><td rowspan="2">Work: 110 000$</td><td><u>Flood mitigation:</u> Not affected by the restoration project</td><td>/</td><td>/</td><td rowspan="4">- Apply actions of grading and stripping favorable to the stimulation of the soil seed bank
- Propose the restoration of natural habitats by encouraging the spontaneous colonization of native species, provided that the environmental context is favorable (environment not polluted by invasive species)
- Limit open water areas where aquatic invasive species have already been identified
- Control rather than eradicate invasive species that have already been found to be present in significant numbers at baseline
- Involve qualified partners in the restoration and management of the wetland</td></tr>
<tr><td><u>Biodiversity enhancement:</u> Restoration of natural habitats degraded by human activity and lack of appropriate management</td><td>- Restored natural habitats spontaneously colonized by native species, some of which are locally protected
- Creation of new natural habitats with ponds
- Progressive colonization of a fauna adapted to wetlands</td><td>- Removal of invasive species partially satisfactory. The water primrose (a plant species of aquatic environments) has not been eradicated and has even colonized other open water areas
- Work company lacking in skills/experience for the realization of this work</td></tr>
<tr><td rowspan="2">Area: 6ha</td><td rowspan="2">Management: 20 000$/year</td><td><u>Water quality improvement:</u> Not affected by the restoration project</td><td>/</td><td>/</td></tr>
<tr><td><u>Development of recreational activities and landscape:</u> Not affected by the restoration project</td><td>/</td><td>/</td></tr>
<tr><td colspan="6"><u>Objectives:</u> The project consists of the restoration and ecological management of a wetland. The work consisted of:
- Reopening of former grasslands;
- Removal of primrose willow, David's Buddleja and Pampas grass (invasive plant species);
- Creation of ponds;
- Differentiated management of the restored area.
 
Credits photos et illustrations: SCE Aménagement et Environnement</td></tr>
</table>

4.15.2 Case study 2: Shanghai, China 36 ha of wetland

Case of wetland restoration or creation	Work and management costs	Criteria	Positive points	Negative points	Possible application for the restoration project in Kigali
Geographic Location: Shanghai, China Area: 36ha	Work: 17 000 000$ Management: 700 000$	Flood mitigation: Not affected by the restoration project	/	/	- The implementation of wetlands for water treatment requires a sizing adapted to the collected watershed and an assiduous management to guarantee sustainable purification performances. - In the case of Kigali, the positioning of wetland buffers on the flows perpendicular to the watercourse seems to be more appropriate to avoid the creation of areas with too large a footprint. - In the case where the water collected by the wetland is laden with organic elements, open water areas should be kept to a minimum to avoid future nuisance.
		Biodiversity enhancement: The work allowed for the creation of various habitats typical of wetlands that are favourable to native species	The diversity of natural wetland habitats (predominantly reedbeds) contributes to a favourable reception for local plant and animal species.	- The proximity of many invasive plant species and the desire for rapid colonization of wetland species led to the planting of many wetland species - The water levels in the different compartments have been poorly fixed and this has led to the disappearance of certain reedbeds that do not need more than 10cm of water. Some sectors have therefore remained in open water, which are less favourable to biodiversity and to the qualitative treatment of water	
		Water quality improvement: The sizing and design were designed to ensure a qualitative treatment of water according to the incoming flow. The space presents a buffer role to treat the water.	The first results on the purification performance of the wetland were interesting with regard to the incoming pollutant flows.	- The purification performance can be maintained if a management of vegetation and sediments is applied methodically. - In order to achieve appropriate treatment performance, the hydraulic design of the wetland depends on the flow rates and pollutant flows entering the wetland. In order to limit the size of the wetland, it is advisable to work on catchment areas of limited size (e.g., urban drains) rather than on flow axes such as watercourses - The open water areas were limited due to the nature of the incoming effluents (rich in organic elements). These open water areas were generally positioned downstream of "reed bed type" areas in order to ensure prior treatment of the water.	
		Development of recreational activities and landscape: Different urban furniture and educational centre have been set up to facilitate the reception of the public	/	The site is difficult to access for the public as it is located in an industrial zone	
Objectives: This wetland creation aims to rehabilitate the existing 13 hectares of wetland built by landfill, and to design an extension of 23 hectares. This area is located downstream of the wastewater treatment plant operated by SUEZ. It is designed not only to carry out tertiary treatment of effluents, but also includes guarantees for the elimination of pollutants, thus improving the quality of water discharged into the environment. This ecological engineering innovation will improve the quality of the wastewater treated by the SCIP industrial site: Chemical Oxygen Demand (COD), metals, phosphorus, nitrogen, etc. More than a hundred plant species will be chosen according to their treatment capacities, their tolerance to salinity (due to the high level of salinity of the park's effluents) and their ecological characteristics. The diversity of habitats created will allow the colonization of local plant and animal species adapted to life in wetlands.					


WETLAND



Credits photos et illustrations: SUEZ Eau France

4.15.3 Case study 3 : Rouen, France, 6 ha of wetland

Case of wetland restoration or creation	Work and management costs	Criteria	Positive points	Negative points	Possible application for the restoration project in Kigali
Geographic Location: Rouen, France	Work: 1 600 000$	Flood mitigation: - Restoration/Creation of wetlands flooded during high water or overflow of the Seine - Restoration/creation of wetlands to increase the flood expansion area of the Seine	Wetland flooded by rising water table	- No flooding events to confirm the role of wetlands in flood expansion - Need to know precisely the water table levels in order to set a depth of excavation that will allow the wetland to be fed - Significant costs of excavation to restore the water table and propose landscaping.	- Realization of depressions is possible provided that the topography of the land and the fluctuation of the water table are well known - Biological and hydraulic functionalities with high values if the study plans and the works integrate well the input parameters (water table and topography) - Pre-vegetation necessary to avoid rapid colonization of invasive plant species
		Biodiversity enhancement: Restoration/Creation of wetland habitats with biological and hydraulic functionalities typical of wetlands in the floodplain of the Seine	Rapid colonization of the environments created by native plant species and fauna that are native to the wetland	- Strong development of invasive plant species on sectors that have not been previously vegetated - Need to revegetate to avoid rapid colonization of invasive plant species	
Area: 6ha	Management: 60 000$	Water quality improvement: Not affected by the restoration project	/	/	
		Development of recreational activities and landscape: Not affected by the restoration project	/	/	

Objectives: As part of its activities, the Port of Rouen has obtained authorization to develop the "Rouen Val de Seine Logistique amont" logistics hub. To compensate for the environmental impacts that could not be avoided or reduced, compensatory measures have been defined by the Grand Port Maritime de Rouen. These include the creation of corridors and biodiversity nuclei over a total area of 17.5 hectares, including approximately 15 hectares of wetlands. The compensatory measures consist in the creation of wetlands intended to host amphibians, odonates, paludicolous birds or associated with water bodies...





Credits photos et illustrations: SCE Aménagement et Environnement

4.15.4 Case study 4: Casablanca, Morocco, 7 ha of wetland

Case of wetland restoration or creation	Work and management costs	Criteria	Positive points	Negative points	Possible application for the restoration project in Kigali
Geographic Location: Casablanca, Morocco Area: 7ha	Work: / Management: /	Flood mitigation: Flood flow management from the upstream urban watershed	The lake allows to buffer flood waters in case of strong storms	The system will be undersized if the downstream urbanization continues to increase in density	The Lake of El Oulfa is a witness of the risks generated by the creation of a water reservoir in urban area. Indeed, even if the source of supply of the lake is of pluvial origin (separative network of the urban basin), the accumulation of the sediments and the various nutritive contributions of the urban basin lead to an eutrophication of the system and to the creation of nuisances (olfactive, sanitary...). This system requires complex management techniques and costs which do not seem to be adapted to the Kigali restoration project.
		Biodiversity enhancement: The banks of the lake of El Oulfa are characterized by the presence of a cliff on the western part and vegetated banks on the eastern part. This diversity of habitats and the particularity of their establishment in the urban environment allow a remarkable reception for the avifauna.	Several protected and/or heritage birds have been recorded on the water body. It is a favorable site for nesting, reproduction and feeding of the taxon. The site is also monitored by the Research Group for the Protection of Birds in Morocco (GREPOM).	- The maintenance of good quality water on the site is a key element in the maintenance and development of this biodiversity. On the other hand, this bird population can also be a source of pollution in the environment via dejecta, and therefore a source of odors. It is therefore important that areas with a high density of birds be the object of special maintenance, respecting their presence, but allowing a good renewal of the water in the vicinity. - Mosquitoes are known to be present on the site. The areas of stagnant water (sewer outlets, waste areas near the banks, etc.) identified on site are potential larval nests.	
		Water quality improvement: Its positioning downstream of several urban drains (diameters from 1000mm to 2000mm) allows to buffer the water and to limit the pollution downstream of it.	- There is little robust and comprehensive data at the site to conclude on water quality. However, the data seem to indicate that the water quality is correct. - The lake has a definite buffering role and allows the collection of all the suspended matter coming from the upstream basin.	The elements collected seem to show a rather low water level in the downstream basin, a lack of renewal and therefore of mixing in the basin, especially during dry periods, and a lack of flow at the outlets linked either to siltation, vegetation or the presence of macro-waste. All these observations can explain the appearance of foul odors in the vicinity, as well as the presence of mosquitoes.	
		Development of recreational activities and landscape: Walks along the lakefront are possible but there is little street furniture to make the lake a quality rest area.	/	There is little landscaping/urban development to provide recreational space for lakefront residents.	
Objectives: Within the framework of the urbanization plan of the city of Casablanca and the major issues targeted by the Urban Development Master Plan, the site of the former Schneider quarry, now named "Lake El Oulfa", currently represents a water management area in the middle of the urban space. This site is moreover a component of the project of green frame of the territory of the big urban project of Casablanca-Anfa, as an essential articulation of the green frame between the site of Anfa and the dense districts of El Oulfa. It is thus envisaged to carry out an ecological park around the lake El Oulfa, by integrating the ecological rehabilitation of this one. Nevertheless, at the present time, nuisances are reported such as odor problems, cyanobacteria, and the presence of mosquitoes around the lake.					





Credits photos et illustrations: SUEZ Eau France

4.15.5 Case study 5: Montpellier, France 1.3 ha of wetland

Case of wetland restoration or creation	Work and management costs	Criteria	Positive points	Negative points	Possible application for the restoration project in Kigali
Geographic Location: Montpellier, France	Work: 230 000$	Flood mitigation: Reduction of discharges from the water treatment plant during low water periods	Scientific monitoring of the site since 2012 has confirmed the role of the buffer zone in treating pollutants. The abatement of certain parameters of the water phase, especially during the summer period, is significant.	During periods of anoxia (low water renewal, covering of water areas with dense floating vegetation, high oxygen consumption and high-water temperature), risks of pollutant release downstream are possible. It is therefore necessary to ensure appropriate management to limit these phases of anoxia.	Within the framework of the Kigali wetlands restoration project, the creation of buffer zones with the same biological, hydraulic and biogeochemical functions is relevant. However, the system will work well if it is sized according to the characteristics of the incoming effluent and the contributing watershed. The area will not function well if untreated wastewater is discharged directly into it.
		Biodiversity enhancement: Creation of natural habitats favourable to animal and plant species that depend on wetlands	Numerous animal species (birds, amphibians, and reptiles) have been identified in the buffer zone during scientific monitoring.	Revegetation of the buffer zone was necessary in order to establish a plant community adapted to the hydric and trophic hazards. Some wetland species are more robust than others to thrive in these environments.	
Area: 1,3ha	Management: 20 000$/year	Water quality improvement: Additional treatment of treated water from the wastewater treatment plant to control micropollutants	In summer, the buffer zone allows for the infiltration of part of the wastewater treatment plant's discharges and thus limits the risks for the downstream watercourse.	In winter, the rise in the water table leads to an increase in the volume of water in the buffer zone, which can occasionally create hydraulic dysfunctions.	
		Development of recreational activities and landscape: Installation of devices to facilitate the visit of the site	The site is often visited by schools and elected officials to understand the functioning of a wetland on a reduced size. The animation is carried out by the operator of the site.	Since it is a buffer zone located downstream of a wastewater treatment plant, the area is completely fenced off to avoid the risk of degradation by third parties.	

Objectives: The design principle is based on the passage of treated effluent from the Saint-Just (Montpellier) wastewater treatment plant through a succession of vegetated and water compartments. The project was designed to optimize the physical, chemical and biological mechanisms allowing the removal of pollutants present in the water. The project also allowed to take these ecological engineering devices to a new level so that they present pollutant purification guarantees and that they respond to the ecological, societal and landscape specificities of wetlands.







Credits photos et illustrations: SUEZ Eau France

4.15.6 Case study 6: Melbourne, Australia, 10 ha of wetland

Case of wetland restoration or creation	Work and management costs	Criteria	Positive points	Negative points	Possible application for the restoration project in Kigali
Geographic Location: Melbourne, Australia	Work: 11 000 000$	Flood mitigation: Creation of wetlands to quantitatively manage urban stormwater in various forms of vegetated compartments	- Removal of a concrete lined channel and a grassed channel, in natural surface flow - Harvesting a portion of the rainwater from the wetland for irrigation of the adjacent open space - Creation of a meandering stream to improve the hydraulic dynamics of the flows and the environmental and landscape setting for the users.	- Need to effectively monitor hydraulic continuity to avoid hydraulic plugs that may load the system - The sizing of the wetland is based on an urbanized watershed with a low slope and an area proportionate to the project	- The works proposed in this restoration/creation are all applicable to the Kigali project provided that the system is fed by stormwater only. - The positioning of this type of wetland should not be proposed on the main flow paths but in line with the urban drains.
		Biodiversity enhancement: Improve ecological connections by removing the old water pipe and creating a new surface waterway	Improve aquatic and terrestrial habitat and connectivity with greater biodiversity.	Differentiated management necessary to maintain the ecological and landscape quality of the site	
Area: 10ha	Management: /	Water quality improvement: Create multi-compartment wetlands for urban stormwater management	- Use of constructed wetlands to qualitatively treat rainwater - Proposal of natural sedimentation basins to reduce the amount of sediment in upstream stormwater	- Need to effectively monitor hydraulic continuity to avoid hydraulic plugs that may load the system - Need for regular maintenance of the water areas to avoid sediment accumulation in the bottom of the structures - The sizing of the wetland is based on an urbanized watershed with a low slope and an area proportionate to the project	
		Development of recreational activities and landscape: Create a place for local stakeholders to live.	- Improved health and wellness, provide passive recreation options, respect existing active recreation (shared paths, ovals, etc.) - Proposal of a space for urban cooling	/	

Objectives: The Reimagining Tarralla Creek project partners agreed on the following goals:
- Remove the pipe, with water flowing over the surface into the new waterway.
- Improve aquatic and terrestrial habitat and connectivity with greater biodiversity.
- Provide urban cooling
- Integrated Water Management (IWM) incorporated to improve water quality to keep the waterway as clean as possible.
- Create a place to live: Improve health and wellness, provide passive recreation options, respect existing active recreation (shared paths, ovals, etc.).


4.2 Dorset Road to Norton Road
4.3 Croydon Wetland
4.4 Vinter Avenue to Lusher Road
4.5 Lusher Road to Eastfield Road
4.6 Eastfield Road Options 1 and 2
Credits photos et illustrations: GHDWoodhead

4.15.7 Case study 7: Dakar, Senegal

Case of wetland restoration or creation	Work and management costs	Criteria	Positive points	Negative points	Possible application for the restoration project in Kigali
Geographic Location: Dakar, Senegal	Work: 80,6 million USD	Flood mitigation: creation of hydraulic infrastructures (rainwater collection drains and retention ponds) to reduce flooding	- 167 000 people **directly protected against flooding** - **Water table lowering** formerly humid and unhealthy low-lying areas are now able to dry out throughout the year and septic tanks can properly function - **Removal of pumping devices:** significant financial savings	- **Invasive species** is observed in the retention ponds - ponds need to be rigorously maintained - **Poor water quality** in the basins because of poor habits of population: wastewater discharges, deposits of waste oil and solid waste of all kinds in ponds and drains. - Children are exposed to danger by playing in the structures **(lack of signage regarding waterborne diseases)** - Lighting around the ponds is too poor for safety reasons - retention ponds **unused and unattractive during the dry season**	- The successful implementation of retention basins requires **rigorous and regular maintenance** in order to avoid the accumulation of waste and sediments. - The creation of these basins requires the implementation of an important population awareness campaign The **exploitation cost** will remain through the years a really **important expense** and will require permanent focus. - Because retention ponds dried up during the dry season, they represented wasted and unattractive surface and breeding ground for waterborne diseases during the wet season For all the above reasons, for the restoration project of Kigali, the Consultant **do not recommend the implementation of any kind of structures where water can stagnate.**
		Biodiversity enhancement: Not concerned by the restoration project	/	/	
Area: - 50.3 km of drains - 21 retention basins with a total capacity of 700 000 m3 - 25 km roads		Water quality improvement: Not concerned by the restoration project	/	/	
		Development of recreational activities and landscape: creation of roads and sports courses, playgrounds, public benches	- Mobility improvement - Quality of life improvement - Creation of jobs	/	
Objectives: The global objective of the project is to **reduce flooding in the city**. Besides various studies as the institutional, economic, environmental and stakeholders sensibilisation ones, the project includes the study and works of several hydraulic infrastructures. The work consisted of: - 29.3 km of closed and open primary drains - 21 km of closed and open secondary drains - 21 retention basins with a total capacity of 700 000 m3 - 25 km of drained and lighten roads, creation of pumping station - Implementation of 68 community investment projects					


Fayçal
ROUTE NATIONALE N°1
AUTOROUTE A PEAGE
BD1
BD2
COMMUNE DE HANN BEL AIR
Cité Soleil
COMMUNE DE DALIFORT FOIRAIL
SERAS
Route de la SERAS
Foirail
Areski
Route de Rufisque
BAIE DE HANN
CONSTRUCTION D'OUVRAGES PRIMAIRES DE DRAINAGE
DRAINAGE EN GRAVITAIRE DU BASSIN VERSANT DE DALIFORT
Légende
Canal primaire
Canal secondaire
Voirie pavée
Bassin aménagé
Zone protégée
0
200
400
Mètres
Mairie Dalifort en 2012 avant les travaux du PROGEP
Dalifort APRES :
Bassin BD1 / Mairie et environs assainies
Mairie
Mairie Dalifort en 2014 après les travaux du PROGEP
BASSIN D'ECRETAGE N°1 DE DALIFORT (BD1)
DEBIT ENTRANT ET SORTANT POUR UNE PLUIE DECENNALE
Projet de Gestion des Eaux Pluviales et d'Adaptation au Changement Climatique (PROGEP)
FINANCEMENT :
BD1 AMONT
BD1 AVAL
DALIFORT
DEBIT EN M³/S
DUREE EN HEURES
PLUIE DE PROJET : 120 MM
CAPACITE DU BASSIN : 20 000 M3
PROFONDEUR MOYENNE : 2,3 M
DEBIT TOTAL ENTRANT EN PROVENANCE DE LA CITE SOLEIL ET DE DALIFORT NORD OUEST (CANAUX GNP 47 et GNP 25
9,8 M3/S
DEBIT TOTAL SORTANT DU BASSIN PAR LE CANAL GNP 170
6,8 M3/S
CE BASSIN A ETE REALISE POUR VOUS, CITOYENS DE DALIFORT, DANS LE CADRE DU PROJET DE GESTION DES EAUX PLUVIALES ET D'ADAPTATION AU CHANGEMENT CLIMATIQUE (PROGEP) EXECUTE PAR L'AGENCE DE DEVELOPPEMENT MUNICIPAL (ADM).
LES OUVRAGES SONT DIMENSIONNES POUR UNE PLUIE DECENNALE, C'EST A DIRE 120 MM A DAKAR.
LA SUPERFICIE DRAINEE PAR LE RESEAU EN AMONT DU BASSIN "BD1" EST DE 35,71 HECTARES COUVRANT LA CITE SOLEIL ET LA PARTIE NORD OUEST DE DALIFORT.
PRESERVONS ENSEMBLE CES OUVRAGES

4.15.8 Case study 8: Xianyang City, China

Project: Weiliu Wetland Park by Yifang Ecoscape

Location: Xianyang City, China

Total area: 125 ha

Year: 2017

Similar problematics: the park is built on a section of Wei River's floodplain outside of Xianyang City, one of the few naturally flooded river sections remaining due to excessive urbanisation process and development of uncontrolled agricultural production on the once natural riparian areas. Constant degradation of the wild riverside landscape was found on the site and several roughly dug ditches cross the site carrying stormwater run-off (and sometimes leaked sewage) from the city into the river, causing extremely high levels of pollution.

Purifying wastewater for reuse: before any recreational and landscape activities were development, all polluted water from drainage channels that ran towards the site were directed into the local wastewater treatment plant (WWTP). The constructed wetlands were designed for treating outlet water from a WWTP and producing recycle water that meet national standards for use onsite in landscape irrigation, aquatic activities and to replenish the natural floodplain wetlands.

Lessons for the case of Kigali: the presence of several points of urban discharge carrying wastewater and rainwater found on all studied wetlands that need to be addressed before any recreational and landscape activities are developed on the sites, especially within a scenario that proposes the development of large areas of lakes and/or water ponds. If this issue is not addressed in a permanent way, the development of large open water area features risk to become a major nuisance and cause degradation of the landscape and recreational opportunities.

4.15.9 Lesson learned from the case study analysis

The analysis of case studies has highlighted important elements which need to be taken into account for Kigali wetland restoration:

- **Invasive species**: complete removal of invasive plant species is often complicated, natural (without plantation) regeneration of native plant species is only successful when there are no invasive species in the area.
- **Management of sediment** at filtering wetland is an important task to maintain wetlands' filtering functions.
- Unless there is a full separate sewerage network sorting surface runoffs and wastewater, **urban lakes shall be avoided** since stagnant water and strong accumulation of sediment and solid waste will become important nuisances and lead to rapid eutrophication of the lake (odours, mosquitos, etc.). Water depth in restored wetlands shall be kept to minimum if there is no efficient sewerage system.
- **Filtering wetland functions poorly to treat wastewater** and are more destined at filtering urban runoffs.

4.16 CONCLUSION ON BASELINE AND THE DESIRED OUTCOMES FROM THE REHABILITATION

Baseline assessment has allowed to describe the current state of each wetland and existing pressures and threats, it has helped to fine tune the rehabilitation project objectives.

When making an average of all sub-criteria of each project higher-level objectives criteria, it is evident that generally the current performance of the wetland system for these criteria is either weak or medium as shown in the following table.

As a reminder, the ranking system is as follow.

The wetland or the system performs very well		The wetland or the system performs well		The wetland or the system does not show any negative of positive performance		The wetland or the system does not perform well		The wetland or the system performs very poorly	
10	9	8	7	6	5	4	3	2	1

	Gikondo	Rwampara	Rugenge-Rwintare	Kibumba	Nyabugogo Lower
Criterion Flood mitigation average score	**6**	**4**	**7**	**4**	**4**
Gikondo Sub-Criteria 1: Water depth over road NR4	6				
Gikondo Sub-Criteria 2: Water depth over KK1 Avenue	4				
Gikondo Sub-Criteria 3: Water depth over KN14 Avenue	2				
Gikondo Sub-Criteria 4: Water depth over Muhazi	10				
Rwampara Sub-Criteria 1: Water depth over road KN 121		4			
Rwampara Sub-Criteria 2: Water depth over KK 2 Avenue		4			
Rwampara Sub-Criteria 3: Water depth over KK 31 Avenue		4			
Rwampara Sub-Criteria 4: Water depth over Avenue des Poids-Lourds NR4		4			
Rugenge-Rwintare Sub-Criteria 1: Water depth over KG 3 Avenue			10		
Rugenge-Rwintare Sub-Criteria 2: Water depth over Rugenge road			4		
Rugenge-Rwintare Sub-Criteria 3: Water depth over road KN 21			4		
Rugenge-Rwintare Sub-Criteria 4: Water depth over KN 8 Avenue			10		

Kibumba Sub-Criteria 1: Water depth over road KG 550				4	
Kibumba Sub-Criteria 2: Water depth over KG 15 Avenue				4	
Kibumba Sub-Criteria 3: Water depth over road KG 449				4	
Kibumba Sub-Criteria 4: Water depth over KG 33 Avenue				4	
Nyabugogo Lower Sub-Criteria 1: Water depth over KG 14 Avenue					4
Nyabugogo Lower Sub-Criteria 2: Water depth over Nyabugogo					4
Criterion Biodiversity enhancement average score	**3**	**2**	**3**	**3**	**4**
Sub-criteria 1: Absence of threats	2	1	2	2	2
Sub-criteria 2: Soil hydrologic conditions	5	3	6	6	6
Sub-criteria 3: Species composition	1	1	1	2	4
Sub-criteria 4: Structural diversity	1	1	2	1	1
Sub-criteria 5: Ecosystem function	4	3	4	5	6
Sub-criteria 6: External exchanges	3	3	4	4	6
Criterion Water filtration average score	**3**	**4**	**5**	**4**	**4**
Sub-criteria 1: Source of pollution inside the wetland	3	5	4	5	4
Sub-criteria 2: External sources of pollution flowing in the wetland (point source and nonpoint source)	2	5	6	3	5
Sub-criteria 3: Quality of surface water flowing in the wetland	3	4	4	4	3
Sub-criteria 4: Natural filtration function of the wetland	3	1	5	4	5
Criterion Landscape and recreational activities average score	**7**	**3**	**4**	**4**	**6**
Sub-Criteria 1: Quality of natural landscape / environment	2	3	3	2	7
Sub-Criteria 2: Quality of anthropic landscape / cultural environment	6	2	6	3	6
Sub-Criteria 3: Exposures and visual clearances / perceptions	9	2	4	3	4
Sub-Criteria 4: Occurrence and level of continuity of green routes	9	3	5	3	6

Sub-Criteria 5: Occurrence and/or proximity of recreation facilities (including educational and touristic activities)	7	4	3	9	5

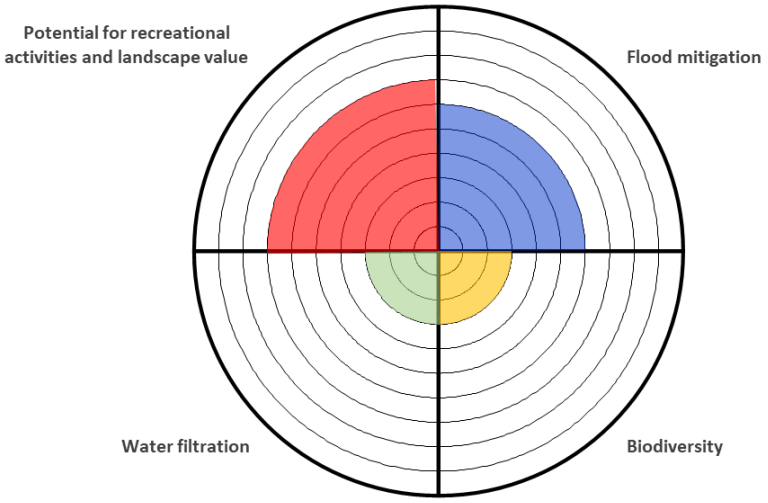


FIGURE 4-160 GIKONDO OVERALL RESULTS AT BASELINE

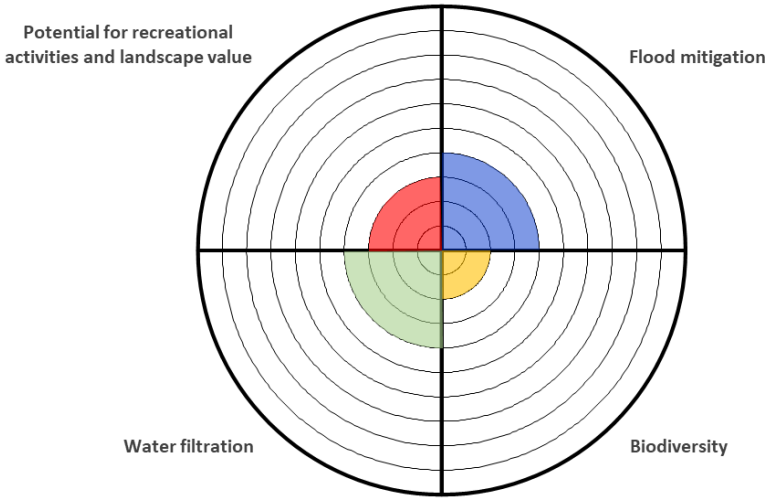


FIGURE 4-161 RWAMPARA OVERALL RESULTS AT BASELINE

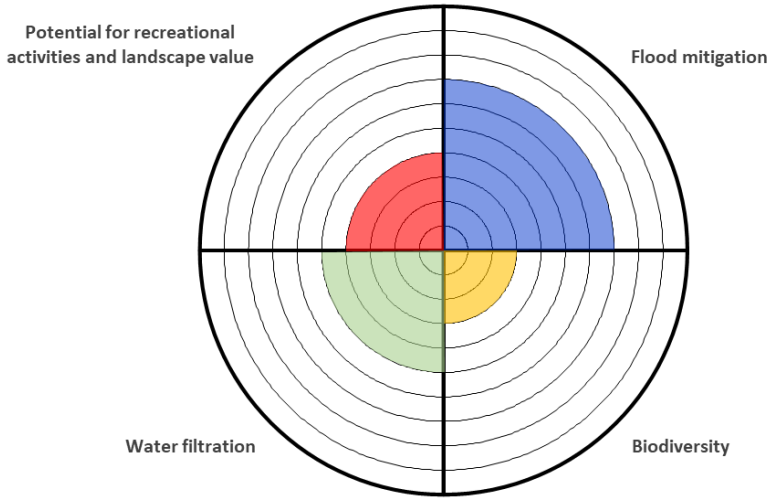


FIGURE 4-162 RUGENGE-RWINTARE OVERALL RESULTS AT BASELINE

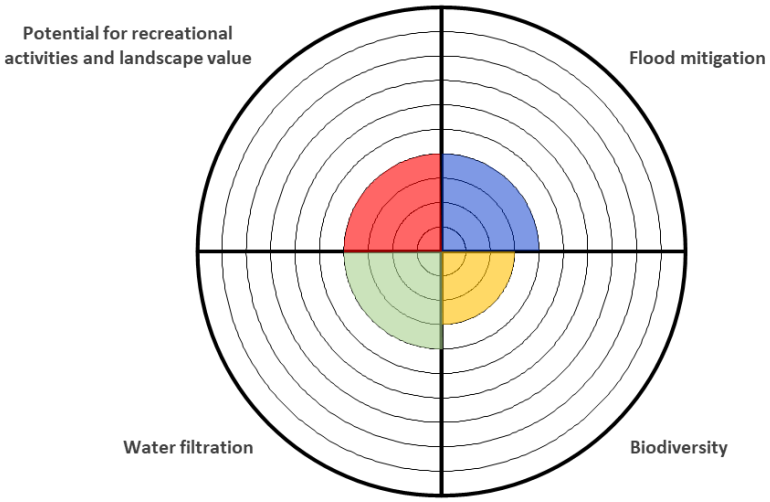


FIGURE 4-163 KIBUMBA OVERALL RESULTS AT BASELINE

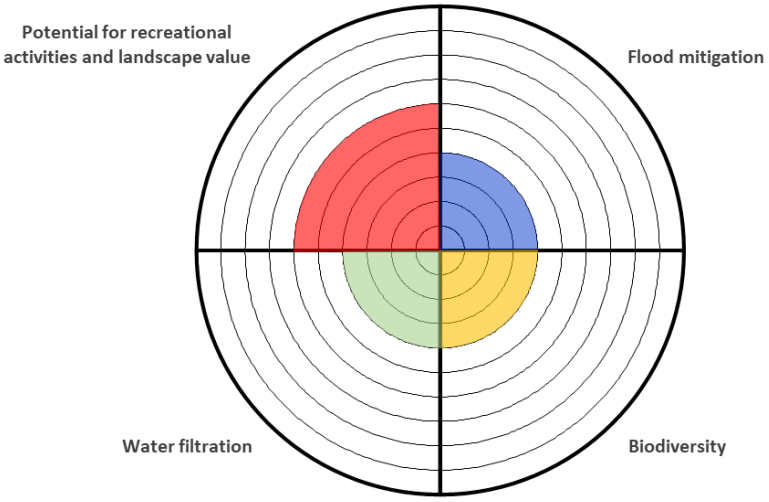


FIGURE 4-164 NYABUGOGO LOWER OVERALL RESULTS AT BASELINE

These results, informed by baseline studies as well from meetings with stakeholders, have allowed to confirm the desired outcomes for the wetlands to be rehabilitated. The rehabilitation project shall aim at:

- Improving flood control functions of the wetland to reduce the frequency and intensity of floods that affect road and infrastructure by improving flood storage and allowing rivers to re-flood riparian areas in some selected areas.
- Restore degraded wetland habitats or create new habitats in selected areas to shelter diverse plant species and biodiversity.
- Develop recreational activities and improve the wetland landscape in selected areas.
- Improving surface water filtration functions of the wetlands through the development, in selected areas, of constructed wetland and filtering wetlands to enhance water depuration.

These outcomes will be achieved by implementing nature-based solutions and ecological restoration actions as well as recreational and landscape actions.

For specifically, not all wetlands have the same potential for these outcomes. The following sections describe with more details the targets, goals and objectives and indicators as required by Principle 5 of the International Principles & Standards for the Practice of Ecological Restoration.

4.16.1 Targets

The Targets identify the native ecosystems to be restored at a site as informed by the reference model, along with any social outcomes or constraints expected of the project.

A reference state cannot be fully described for the wetlands, mainly because all wetlands were cultivated for ages. However, it was possible, thanks to botanical surveys to describe typical plant composition in healthy wetlands and a native ecosystem reference was describe (see section 4.9).

In addition, all rivers were re-profiled to flow in straight line, draining the wetlands while field evidence has shown that rivers and streams were following more pronounced meanders. Another reference state is therefore to bring back the waterbodies to their original thalwegs (riverbed) and mobility areas.

In addition to these high-level ecological targets, wetlands have specific targets:

- Gikondo: improvement of the landscape and use of the freed space for recreational activities.
- Rwampara: improvement of water retention in the wetland to reclaim wetland habitats, limit floods and filter pollutants.

- Rugenge-Rwintare: improvement of water retention in the wetland to reclaim wetland habitats, limit floods and filter pollutants.
- Kibumba: improvement of water retention in the wetland to reclaim wetland habitats, limit floods and filter pollutants.
- Nyabugogo: improvement of water retention in the wetland to reclaim wetland habitats, limit floods and filter pollutants in addition to the improvement of the landscape and recreational value of the wetland.

4.16.2 Goals, objectives and indicators

Goals are formal statements of the medium to long-term desired ecological or social condition, including the level of recovery sought. Goals must be clearly linked to targets, measurable, time-limited, and specific.

Objectives are formal statements of the interim outcomes along the trajectory of recovery. Objectives must be clearly linked to targets and goals, and be measurable, time-limited, and specific.

Goals and objectives are treated together, most indicators remain general in nature, as establishing precise indicators would need to be done at the detailed design phase.

- Gikondo:
  - Creation of an urban park in Gikondo, accessible for various activities including income generating activities.
  - End of floods affecting infrastructure such as roads.
  - Recreation of the natural profile of the river.
  - Natural treatment of stormwater at all outlets of urban drains and reduction of turbidity and water pollution for key parameters at reconnections with rivers.
  - Reduction of turbidity and water pollution for key parameters in rivers and streams.
- Rwampara:
  - Progressive replacement of unsustainable agricultural activities in accordance with the City' Master Plan and wetland habitat reclamation in more than 50% of Rwampara wetland in the downstream area.
  - End of floods affecting infrastructure such as roads.
  - Recreation of the natural profile of the river downstream.
  - Natural treatment of stormwater at all outlets of urban drains and reduction of turbidity and water pollution for key parameters at reconnections with rivers.
  - Reduction of turbidity and water pollution for key parameters in rivers and streams.
  - Minor developments (paths and trails) facilitate access to wetland-compatible recreational activities in designated areas.
  - Increase in the richness of water-dependent species of birds, amphibians and plants.
- Rugenge-Rwintare:
  - Progressive replacement of unsustainable agricultural activities in accordance with the City' Master Plan and wetland habitat reclamation in more than 80% of Rugenge-Rwintare wetland.
  - End of floods affecting infrastructure such as roads
  - Recreation of the natural profile of the river.
  - Natural treatment of stormwater at all outlets of urban drains and reduction of turbidity and water pollution for key parameters at reconnections with rivers.
  - Reduction of turbidity and water pollution for key parameters in rivers and streams.
  - Increase in the richness of water-dependent species of birds, amphibians and plants.
  - Minor developments (paths and trails) facilitate access to wetland-compatible recreational activities in designated areas.

- Kibumba:
  - Progressive replacement of unsustainable agricultural activities in accordance with the City' Master Plan and wetland habitat reclamation in more than 80% of Kibumba wetland.
  - End of floods affecting infrastructure such as roads.
  - Recreation of the natural profile of the river.
  - Natural treatment of stormwater at all outlets of urban drains and reduction of turbidity and water pollution for key parameters at reconnections with rivers.
  - Reduction of turbidity and water pollution for key parameters in rivers and streams.
  - Increase in the richness of water-dependent species of birds, amphibians and plants.
  - Minor developments (paths and trails) facilitate access to wetland-compatible recreational activities in designated areas.
- Nyabugogo:
  - Progressive replacement of unsustainable agricultural activities in accordance with the City' Master Plan and wetland habitat reclamation in more than 80% of the Nyabugogo wetland.
  - End of floods affecting infrastructure such as roads.
  - Creation of a waterfront to improve the city's landscape.
  - Recreation of the natural profile of the river downstream.
  - Natural treatment of stormwater at all outlets of urban drains and reduction of turbidity and water pollution for key parameters at reconnections with rivers.
  - Reduction of turbidity and water pollution for key parameters in rivers and streams.
  - Increase in the richness of water-dependent species of birds, amphibians and plants with an increase attractiveness for flagship bird species.
  - Reduction of coverage of the water hyacinth in the large pond in Nyabugogo.

The following table presents key indicators to be used in future monitoring programs.

TABLE 4-46 GOALS AND INDICATORS FOR MONITORING

Goals and objectives	Indicative indicators for monitoring
Minor developments (paths and trails) facilitate access to wetland-compatible recreational activities in designated areas.	Number of visitors per year in the wetland
Creation of a waterfront to improve the city's landscape at Nyabugogo.	Number of visitors per year at the waterfront
Creation of an urban park in Gikondo, accessible for various activities including income generating activities.	Number of visitors per year in the urban park Number of operating businesses in the wetland
End of floods affecting infrastructure such as roads.	Occurrence of floods affecting roads
Increase attractiveness for flagship bird species in Nyabugogo.	Identification of flagship species to be used for monitoring. Number of flagship water-bird species visiting the wetland Number of flagship water-bird species breeding in the wetland

Goals and objectives	Indicative indicators for monitoring
Increase in the richness of water-dependent species of birds, amphibians and plants.	Number of species of water dependent birds, amphibian and plants Native wetland plants cover more than 80% of the surface of wetland habitats.
Natural treatment of stormwater at all outlets of urban drains and reduction of turbidity and water pollution for key parameters at reconnections with rivers.	Reduction of pollutions at the reconnections between drains and rivers
Progressive replacement of unsustainable agricultural activities in accordance with the City' Master Plan and wetland habitat reclamation in more than 50% of Rwampara wetland in the downstream area.	Wetland habitats have reclaimed 50% of Rwampara wetland.
Progressive replacement of unsustainable agricultural activities in the horizon of 250 in accordance with the City' Master Plan and wetland habitat reclamation in more than 80% of Rugenge-Rwintare wetland.	Wetland habitats have reclaimed 80% of Rugenge-Rwintare wetland.
Progressive replacement of unsustainable agricultural activities in accordance with the City' Master Plan and wetland habitat reclamation in more than 80% of Kibumba wetland.	Wetland habitats have reclaimed 80% of Kibumba wetland.
Progressive replacement of unsustainable agricultural activities in accordance with the City' Master Plan and wetland habitat reclamation in more than 80% of the Nyabugogo wetland.	Wetland habitats have reclaimed 80% of Nyabugogo wetland.
Recreation of the natural profile of the river.	Rivers have a natural meandering shape and sufficient space for their mobility
Reduction of coverage of the water hyacinth in the large pond in Nyabugogo.	Disappearance of the water hyacinth
Reduction of turbidity and water pollution for key parameters in rivers and streams.	Reduction of 50% of the pollution load for key parameters.

5. ASSESSMENT OF WETLAND REHABILITATION – VARIANTS DEFINITION AND COMPARISON

The approach for wetland rehabilitation is based on the definition of relevant actions to achieve the goals and objectives set for each wetland according to:

- Evidence based solution: our experience allows us to propose specific actions according to the context of each wetland that respond to major issues identified.
- Sensitivity of the environment and possibility of implementation: the actions must take into account the different constraints identified during our fieldwork and the possibility of implementing the actions according to the resilience of the different stakeholders.

This approach leads to the implementation of a tailor-made action program based on the Consultant's expertise.

- A first Variant is proposed, the **Variant 1** which offers **balanced performances** between recreational, flood control, enhancement of biodiversity and water filtration. It is the variant that would allow to fulfil all goals and objectives for each wetland (see section 4.16).
- A second Variant is also proposed. **Variant 2** maximizes the use of water to create **small permanent lakes** in all wetlands, with the goal to **maximize landscape** value of the wetland.
- A third Variant is developed. **Variant 3** maximizes the use of **flood spreading** structures to improve **flood control** while reducing the need to intervene in the river and streams.

The selection of actions and variants was made through the assessment of current issues and ecological state of the wetlands and case study analysis. Based these identified issues, several actions that would solve existing issues were proposed. A total of 34 specific actions were developed.

VARIANT 1

Variant 1 is an equilibrated set of rehabilitation actions that capitalize the potential of each wetland and address all 4 higher project objectives (see chapter 4.16).

VARIANT 2

Variant 2 entails that 5 important permanent large ponds are designed: one in each wetland. Under this variant, all connections between urban drains and the lake should be disconnected to avoid any flow of dirty water into the lake.

Under Variant 2, five new actions are defined:

- **Action 29: Creation of a lake in Gikondo:** This lake was often mentioned by the CoK as a possible outcome from the restoration project. World Bank, Macfarlane (2020) has presented this lake, the "open water" area. The presentation sheet for recreation activities in presented in this section.
- **Action 30: Creation of a lake in Rwampara:** this lake was not studied in previous studies.
- **Action 31: Creation of a lake in Rugenge-Rwintare:** this central lake was proposed by Deltares (2021) to enhance the aesthetic of the wetland.
- **Action 32: Creation of a lake in Kibumba:** this lake was not studied in previous studies. The presentation sheet for recreation activities in presented in this section.
- **Action 33: Creation of a lake in Nyabugogo:** This lake, which is partly existent, but would be enlarged, was often mentioned by the CoK as a possible outcome from the restoration project. The presentation sheet for recreation activities in presented in this section.

The creation of lakes would require installing dams to create permanent open water areas, which is are important infrastructures across rivers. It would also require stabilizing edges of the wetlands to avoid erosion. Wetland plant species could colonize the tails of the reservoirs. Urban lakes are interesting landscape feature and can, under some conditions add significant value to the urban landscape.

Variant 2 would reduce some actions to smaller areas due to the space that will be occupied by the lakes. It would also not necessitate the same interventions in areas occupied by the lakes.

Under Variant 2, "Action 13: Reprofiling of the hydraulic outlets from the discharges (creation of banks with different levels) and reconnection with the river" would need to be modified at some locations to avoid connecting the outlets of urban drains to the lake to avoid collecting polluted water.

VARIANT 3

Variant 3 will optimize the diffusion of flows for improved flood control. It will rely on flood spreading structures made of gabions in rows on both side of rivers. At each location, several rows of gabions are installed which will occupy some space. This variant would avoid all interventions and modifications to rivers (no reprofiling, no filling the riverbed with aggregate, no digging of depressions). It would also not rely on earth weirs. All flood control would be guaranteed by the presence of gabions which are simpler to install and will not require important earth movement.

Under Variant 3, one new action is defined:

- **Action 34: Installation of flow spreading structures made of gabions:** At locations where floods are more severe, several lines of gabions are installed to slow down floods (reduce peak flow) and reduce soil erosion. The have the advantage to dissipate energy and provide a stable environment for wetland vegetation to grow and not be affected by destructive floods. Gabions allows for overtopping by important flows which is not always the case with earth berms, where erosion can take place and where important floods can have destructive effects. Gabions also reduce the retention times of floods because they are partly permeable but allow to spread water over a large area without creating permanent ponds, thus creating favorable conditions to sustain wetland plant species and to recharge groundwater. Their size can be adapted to local flood conditions. Gabions are also key to limit erosion along banks on the edge of wetlands. Gabions will also allow sediment to settle, thus contributing to reducing turbidity of water. Gabions are currently installed at several location along the rivers that flows in the wetland, there is therefore significant return of experience on this method. Depending on soil condition, gabion mattress can be installed for more stability.

Variant 3 would no longer require several interventions in the rivers or the need to create artificial depressions, as row of gabions would fill flood control functions that would have been fulfilled by the following actions:

- Action 1: Raising the water level of the river in order to limit the lowering of the groundwater and to favour flooding of the river on the riparian areas.
- Action 7: Re-profiling of the river with the creation of meanders and banks with different levels.
- Action 8: Filling of the old minor bed of the watercourse.
- Action 18: Creation of a depression disconnected from the river which will be fed by flood water and the groundwater.
- Action 19: Diversification of natural habitats typical of wetlands through the creation of a mosaic of depressions.
- Action 21: Natural weirs in cascade to limit floods (located at urban drains).
- Action 26: Creation of a delta before the confluence of the Nyabugogo River and its right bank tributary (Rwenzagoro River).

In addition, the presence of gabions would sometimes not allow to implement this action due to the space occupied by the rows of gabions:

- Action 14: Differentiated management according to natural habitats.

5.1 COMPREHENSIVE LIST AND DESCRIPTION OF ACTIONS

Action 1: Raising the water level in the outfalls or the river. The hydraulic outfalls affected by this action are relatively deep (about 2m). They were built to drain plots for agricultural purposes. The purpose of raising the water level is to limit the drainage of the wetland (lowering the water table). In addition, this action reduces overflow from the outfalls into the wetland during rainy periods. These overflows also limit the acceleration of water evacuation downstream of the wetland. This increase in water level can be achieved by recharging the minor bed with aggregates of different diameters.

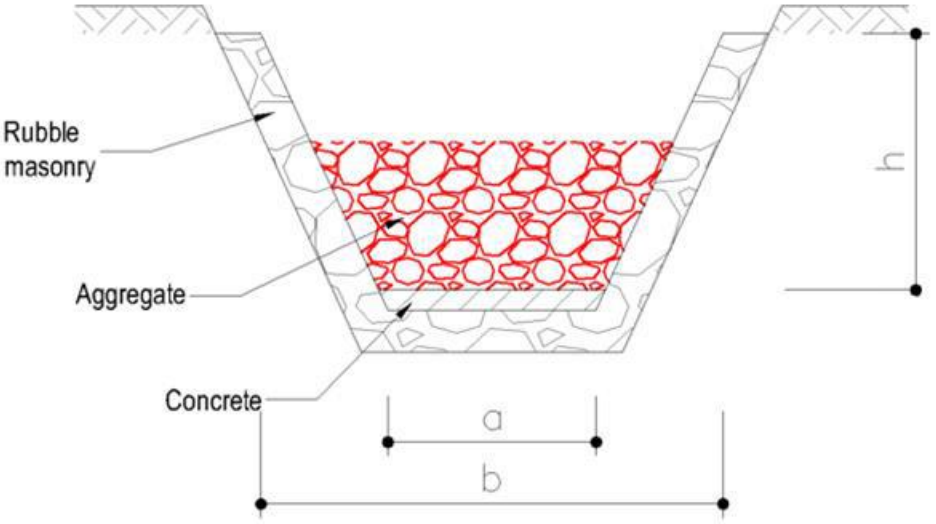
Concerning the riverbed, this action allows to obtain a raising of the water line in favour of the aquatic environment of the river and the nearby wetlands. Indeed, it allows the watering of the annexed wetlands and

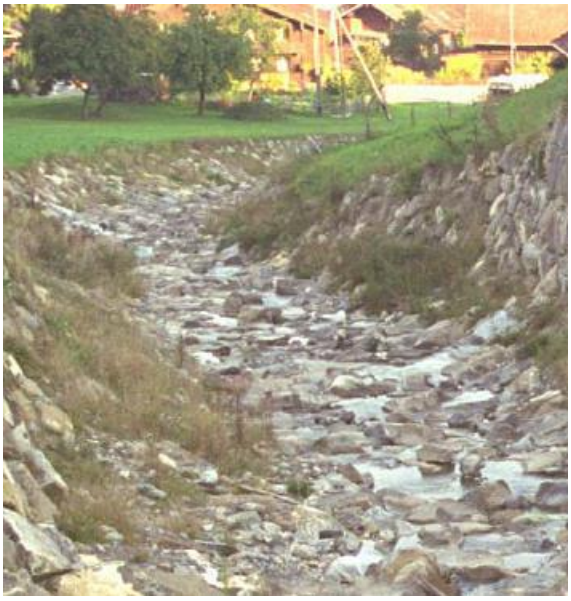
the raising of the water table. In addition to the water resource or natural heritage, the landscape can be a motivation for this type of action (giving back to the river some of its current size and appearance).

Raising the water level, with materials of different diameters, has several positive consequences:

- Decreased river depth;
- Increase in the speed of the water;
- Decrease of the temperature;
- Increase in water oxygenation.

The result is an improvement in the living conditions of aquatic species linked to running water.

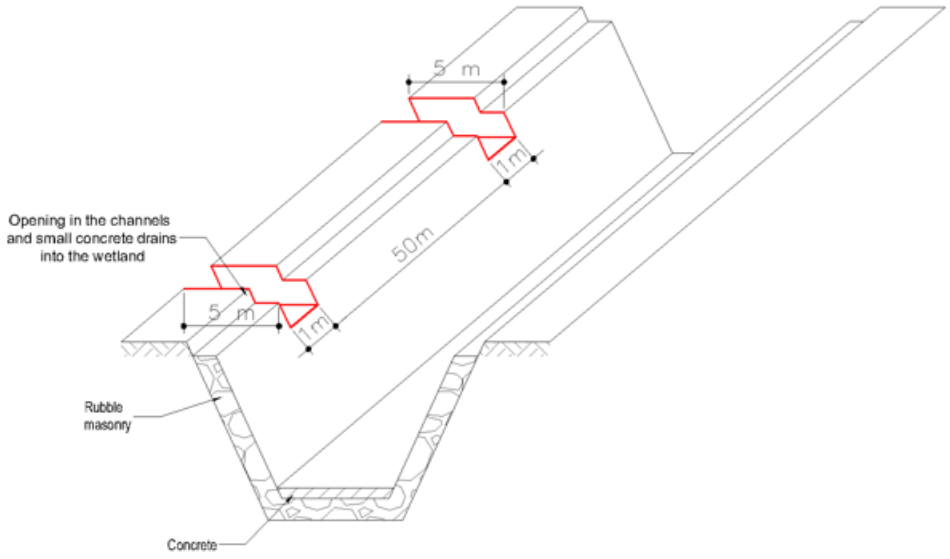






Action 2: Creation of overflows on the two concrete canals to ensure overflow of water into the wetland during rainfall. The current channelling of the peripheral hydraulic outfalls contributes to limiting the supply of water to the wetland during small rains (current rains). Indeed, during rainy episodes, the water is directly directed downstream of the wetland without transiting through it. In this case, the wetland no longer plays its role as a buffer in case of rain and as a "natural filter" to treat runoff. These overflows will be positioned every 50m. They will be sized so that the water level overflows towards the wetland for a weekly rainfall. ***After discussion with stakeholders in the finalization of the Study, it was decided that these concrete canals be destroyed and entirely removed*.**







Action 3: Creation of buffer zones (filtering wetlands) at the right of the overflows to ensure the treatment of the polluted water before overflowing into the wetland and then the river. The buffer wetland (elongated depression) concerns a development in which the mechanisms of abatement of suspended solids and other pollutants are favoured. In addition, the diversity of the bank facies, the result of an adapted hydraulic dimensioning and supplemented by ecological engineering, guarantees the specific richness of the vegetated zone. This wetland buffer is the site of several biological and physical phenomena that contribute to the degradation of certain pollutants: sedimentation, photolysis, phytoremediation, biodegradation, etc. These buffer zones will be positioned just downstream of the hydraulic outfalls. Once filled, they will overflow into the wetland or the river. Within the proposed development, there will be different habitats favourable to biodiversity (nesting, breeding, resting and feeding). In addition to its role as a sediment trap before water overflow to the wetland or the river, the capacity of assimilation of pollutants by plants and the biodegradation mechanisms are optimized at the rhizosphere level. In this compartment, the water height will be lower than 0.50m. These buffer zones, which will be effective if the urban waters only discharge stormwater, will thus buffer runoff, protect and nourish the wetland.



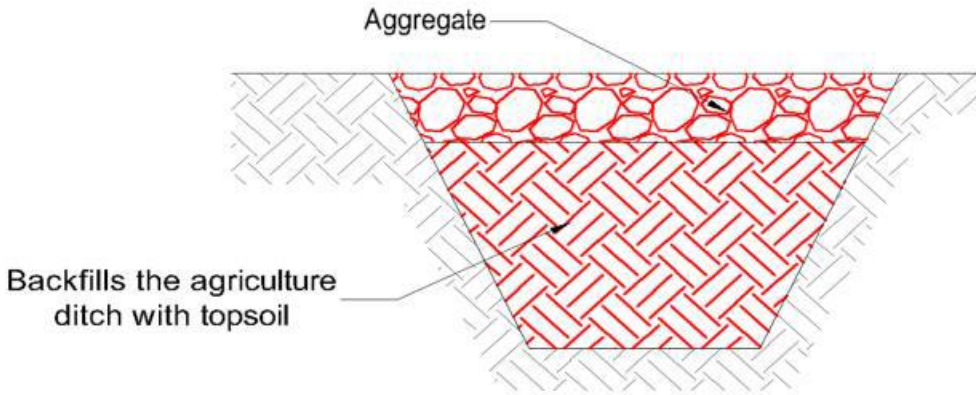
Action 4: Removal of existing backfills. The purpose of removing the embankments is to restore a portion of the floodplain that has been consumed by urbanization and agricultural activity. It will be a question of stripping the totality of the embankment until the natural ground and restore the capacity of storage of water in the event of period of floods. This action will allow to limit the peak flows downstream which generate major dysfunctions (overflow, saturation of the network, erosion...). The stripped fill will be exported out of the wetland.





Action 5: Blocking of surface drains (agriculture ditch) to limit the lowering of the groundwater and increase the residence time of the water in the wetland. This action will allow the removal of surface drains (ditches) and underground drains (farm drains) that contribute to the lowering of the water table and the rapid drying of the soil. They have been installed to facilitate the development of intensive agriculture by strongly impacting the hydraulic dynamics of the wetland and its waterlogging. The surface drains will be filled with topsoil free of any invasive plant species. Subsurface drains will be cut/obstructed by a subsoiler or excavator.





Action 6: Planting of native plant species adapted to the wetland environment (based on the plant species surveyed in the existing natural area in the centre of the wetland). Key focus is water filtration (domestic wastewater is rejected in this area). In the restored area, the planting of native plant species typical of wetlands will create habitats favourable to biodiversity (nesting, reproduction, resting and feeding areas) and increase the specific richness of this area by welcoming species that will find favourable conditions for their development and maintenance. Indeed, the current occupation of the grounds (agriculture, embankments...) are not favourable to shelter typical wildlife of wetlands. These plantations of helophytes (prairie cover or reed beds) also have the advantage of optimizing the soil/root interface with the micro-organisms. Thus, the capacity of assimilation of the pollutants by the plants and the mechanisms of biodegradation are favoured at the level of the rhizosphere. The choice of plant species was defined following the analysis of botanical expertise carried out on the study sites and previous studies (SMEC, NEMUS, REMA...). Some species were chosen according to the purification capacities of the plants but their auto

ecological characteristics were a priority in the decision. The local origin of the plants is a necessity during the realization of the action from an ecological and economic perspective:

- Ecological, because the plants present on a given territory necessarily have the appropriate genetic material adapted to the local conditions;

- Economic, because it would bring benefits to local suppliers.

Considering that the work will be carried out over several years, the reduction of revegetation costs is possible by proposing non-vegetated sectors (pilot sectors) and vegetated sectors during the first phase of the work. A botanical follow-up of these sectors will make it possible to evaluate the development of the plants and to check the colonization of invasive plant species. If the non-vegetated sectors present an interesting ecological trajectory, the vegetation proposals for the other work sectors can be adapted in order to reduce the amount of plants or seeds required and reduce the design costs.



Action 7: Re-profiling of the river with the creation of meanders and banks with different levels. The meandering of certain rivers is a natural way to dissipate their excess energy by lengthening their course and reducing their slope. These meanders are called "free", as opposed to the enclosed meanders imposed by the relief. The action of re-meandering within the framework of this action consists in artificially recreating this natural functioning, altered by past interventions. The purpose of such an intervention is multiple since it aims:

- To mitigate the impacts linked to the incision of the minor bed (lowering of the water table, lowering of the surface area of the flooded zones, acceleration of the flows...);

- To slow down the dynamics of water allowing to reduce the flood wave downstream;

- To lengthen the line of the watercourse and thus to multiply the contacts between ground and water (ecotone), possible places of purification;

- To find a diversity of natural habitats for animal species which is much more important in meandering streams than in straight streams. The work of the banks in different levels (height defined according to the flows of reference floods) will also allow to support this diversification.

The approach will successively focus on:

- A historical analysis of the evolution of the meanders before the works, based on old maps (cadastral in particular), or aerial photographs (if available). Based on field visits, the river has been recalibrated to facilitate the evacuation of water;

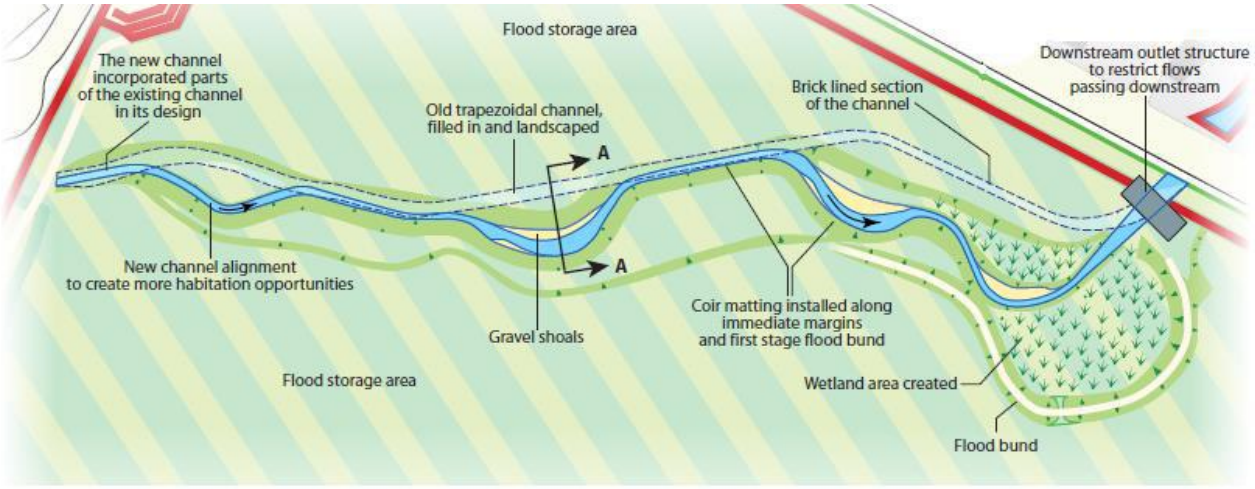
- A characterization of the type of meanders, an estimation of their speed and direction of movement before the works;

- An analysis of the impact of the works on the functioning of the river and in particular the value of the incision, because the watercourse does not have any more necessarily today the same capacity to meander as in the past;

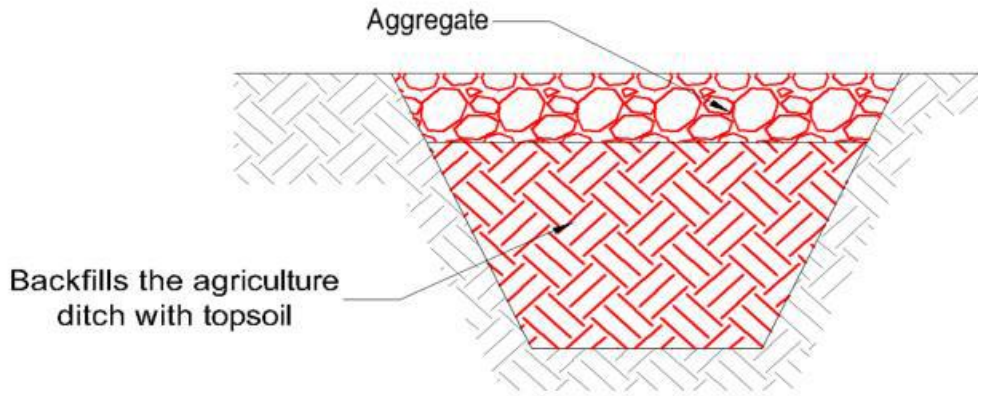
- An analysis of the specific power of the river, in order to determine its capacity of self-adjustment.

It is a question of taking into account the capacity of the watercourse to find its initial course and to estimate the speed of movement.





Action 8: Filling of the old minor bed of the watercourse. During the reprofiling of the watercourse, the old minor bed, not used by the future watercourse, will be filled with topsoil free of invasive plant species. The objective is to recover a space favourable for the planting of wetland plant species and the development of natural habitats (herbaceous to arboreal).



Action 9: Planting the banks with native plant species according to the water level and their tolerance for wetness. The choice of plants will be made according to the degree of humidity linked to the water level of

the watercourse. For the same reasons as the plantings carried out within the buffer wetlands, these plantings will have for objectives to improve the ecological and bio-geochemical functionalities of the watercourse.

Action 10-G: Development of an Eco-valley (in Gikondo) that proposes two interconnected thematic areas: the Active Valley and the Creative Valley. The development proposes a model where nature meets urban life in harmonic co-existence. The aim is to bring together nature, active lifestyle, and to celebrate local food and craftsmanship (referring to the former industrial uses of the area). The development of both areas will be associated to economic activities to ensure sustainability of investments.

The aim is to celebrate local culture and to propose urban activities while promoting an active lifestyle as well as the protection of natural habitats. The eco valley proposes to create a recreational natural playscape in which food, culture, wetland preservation and sport infrastructures are operative and intertwined.

As a general strategy it is recommended to improve both visual permeability and accessibility of the wetland as well as improving connection with main existing axis within adjacent urban areas (see landscape plan).

Activities in the area can include:

- A visitor centre, constructed from sustainable materials, located at the entrance to the wetlands proving information on wetlands habitats and their preservation to increase awareness and attract the public

- Observation decks for watching wildlife and photography can be installed near ponds and riverside

- Sports grounds (football, volleyball, basketball)

- Outdoor gym circuits

- Active play areas for children

- Economic activities: bike rental kiosks, food kiosks, events areas, crafts and souvenirs kiosks, renting of sports grounds

- Food courts/snack areas

- Landscaped areas (with benches, greenery, water ponds, etc)

- Cultural events amphitheatre

- Relaxing areas

- Creation of various natural habitats (meadows, woodland, etc.) to improve the landscape quality of the site and make it more attractive to biodiversity and visitors.

After discussion with stakeholders in the finalization of the Study, it was decided that soil compaction would be limited to 4% of the surface of wetlands. Therefore, permanent infrastructure (such as Food courts/snack, Cultural events amphitheatre, playground and sport fields) areas would be limited in the wetlands.

Action 11: Riprap at the outlet of urban discharges. The approach consists in implementing boulders (rounded rip rap) of different diameters at the outlets of urban drains. The objectives are to:

- Break the incoming flow;

- Limit the erosive power of water in case of heavy rainfall;

- Improve the diffusion of water towards the wetland and other hydraulic outlets;

- Participate in the aeration of runoff.





Action 12: Constructed wetland will act as buffer zones at urban discharges, sized for qualitative and quantitative water management (sizing according to the catchment area and water quality). The design of wetland buffers, sized for the qualitative and quantitative treatment of urban runoffs (without wastewater input), is based on the characteristics of the upstream watershed (surface area, slope, land use, networks, water quality, etc.). The concept of wetland buffers, explained below, is the same for each site but its sizing must be specific to the characteristics of the contributing watershed. More than a global hypothesis for the elimination of certain pollutants present in water, this buffer wetland links the molecules to be treated with the treatment bed of the wetland (photodegradation, adsorption, removal by plants and biodegradation). The objective of this development is to improve the quality of the discharges to the natural wetland. It is a question of creating a buffer space that integrates into the landscape of the natural wetland and also offers a support for biodiversity.

The concept of a buffer wetland is composed of habitats typical of wetlands. This specificity allows to favour the mechanisms of elimination of pollutants and the colonization of fauna/flora species that are adapted to these spaces. The diversity of habitats (amphibious communities, aquatic vegetation, magnocariçaie, reedbeds, etc.) increases the specific richness of the buffer zone by welcoming species that will find favourable conditions for their development and maintenance.

Thus, within the zone itself, the plant associations allow the nesting, reproduction and feeding of wetland fauna. The selection of local species is based on the purification capacities of the plants, but their auto ecological characteristics are given priority in the decision tree. The selection of the flora of a buffer zone is also conditioned by the characteristics of the urban water, which must not be polluted by untreated wastewater.

The buffer wetland will have a succession of compartments, within which the water flows by gravity. These different structures have specific but often complementary functionalities: a compartment dominated by a reed bed, a compartment dominated by a shallow grass pool and a compartment composed of meanders:

- Compartment dominated by a reed bed. By promoting the total coverage of the compartment by reeds/carex and by lengthening the hydraulic path as much as possible through the implementation of dikes (= groynes), the soil/root interface with the associated microorganism procession is improved. The groynes are embankment shapes that obstruct the flow downstream of the over depth zones (micro-depression for a preferential decantation of the suspended matter).

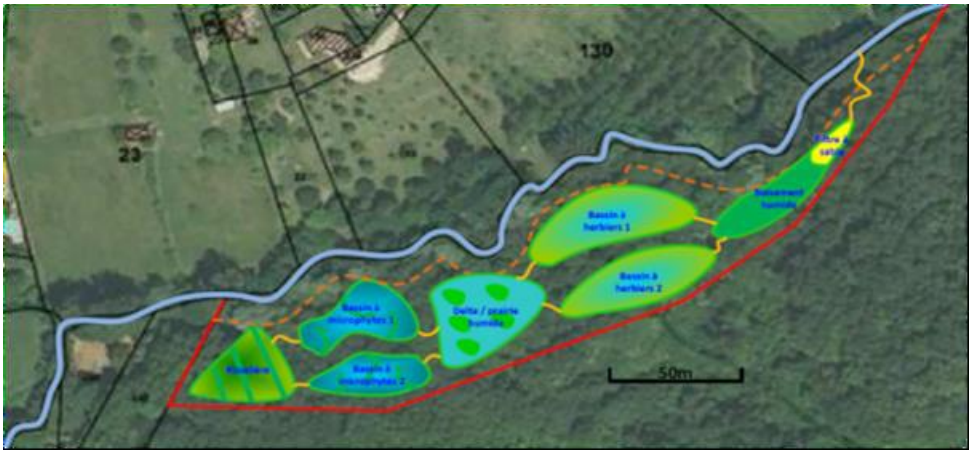
In addition to its role as a sediment trap before the water overflows to the grassy compartment, the assimilation capacity of the pollutants by the plants and the biodegradation mechanisms are optimized in the rhizosphere. In this compartment, the water height will be less than 10cm.

- Compartment dominated by a seagrass pond. With a water height favourable to the photolysis of certain pollutants, these compartments are positioned in parallel line allowing to reduce the incoming flows and to carry out phases of rest (improvement of the exploitation at the time of the setting with dry of one of the two compartments). Their elongated shape (ratio width/length of about 1:3), with an opposite water inlet/outlet, also have the objective of increasing the sedimentation of plant particles coming from the upstream compartments. The increase in temperature and the accumulation and production of plant organic matter lead to microbial metabolic activities ensuring the biodegradation of certain pollutants in aerobic and anaerobic phases.

Within this water level, the water height will be lower than 1.30m. In the seagrass pond, "shallows" will be set up to increase the settling of fine particles.

- Compartment composed of meanders. The linearity of the compartments, the width (about 7m), the plant density and the low flow speed (about mm/s) contribute to the adsorption of certain molecules with the colloidal matter (organic or mineral) and then their settling. The contact between the vegetated banks/sediments and the water column is privileged here as well as the biodegradation phenomena at the level of the rhizosphere in aerobic condition.

The water will then be discharged downstream to the receiving environment or natural wetland.

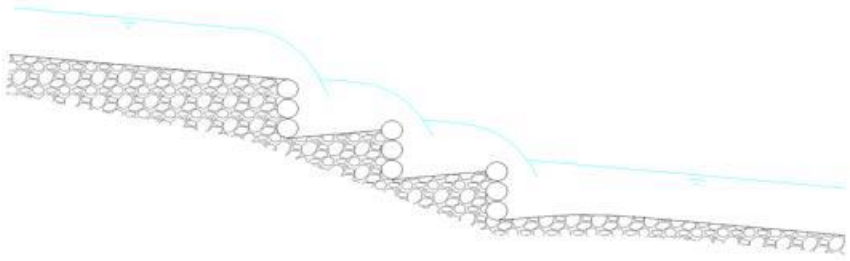


Action 13: Reprofiling of the hydraulic outlets from the discharges (creation of banks with different levels) and reconnection with the river. It is a question of reprofiling the hydraulic outfalls with banks in different levels to recover a dynamic flow. This reprofiling of the minor bed will allow to create:

- A low waterbed and a bed during periods of heavy rainfall;

- Different lentic and lotic flow facies;

- Vegetated banks participating in the purification of water and the diversification of natural habitats favourable to biodiversity.





Action 14: Differentiated management according to natural habitats. A management and maintenance plan is intended to ensure the effectiveness, efficiency, and sustainability of wetland habitats over a defined period of time. This management plan, which may evolve according to the results of monitoring, will notably comply with the following principles:

- Mowing will be mechanized or manual, late and in a dry period to facilitate access, promote reseeding and limit impacts on wildlife. They will be carried out at a minimum height of 10cm, so as to push the fauna towards the refuge zones of the non-mowed sectors and the speed of the self-propelled mowing machines will be moderate to leave time for the insects and reptiles to move. An alternative, extensive grazing, could be implemented subject to a density of the herd adapted to the bearing capacity of the soil and the quality of the habitats.

- Mowing residues are systematically exported to limit soil eutrophication and the development of nitrophilic vegetation;

- Chemical weeding and the use of phytosanitary products is prohibited;

An annual botanical monitoring will be set up to identify the development and evolution of the plant formations and thus to adapt the objectives and maintenance methods of the management plan. The final objective is to perpetuate the hygrophilous formations best adapted to the wetland.

Action 15: Clearance over a large width to facilitate the overflow of the river during flood periods. This action consists in lowering the edges of the watercourse to recreate a flood expansion zone. Indeed, in the case of highly anthropized sites, it is interesting to create an artificial major bed by excavating the ground along the river in order to lower the water line in flood, and even to ensure a certain retention of water. This type of operation will be accompanied by the creation of wetlands. The maintenance and restoration of flooding of the major beds is favourable to all the functions of the river hydrosystem:

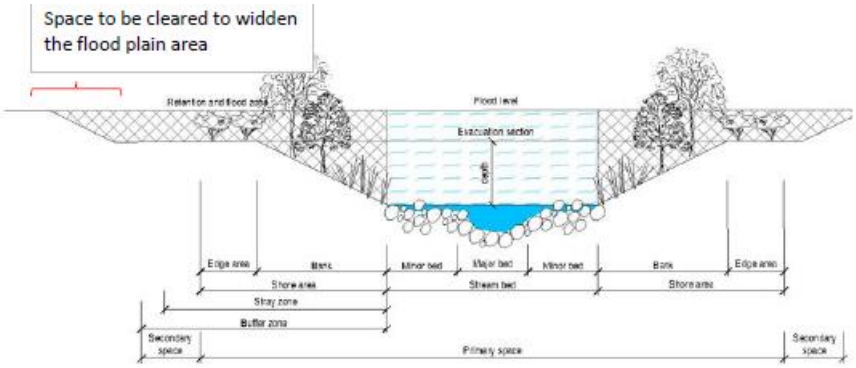
- Flood expansion (lowering of water lines, cushioning), contributing to the protection of riparian habitats;

- Natural heritage, often very rich in floodable areas;

- Water purification;

- Recharge of water tables.

The precise objectives (extent and frequency of the desired floods) and the operations to be carried out will be established with the help of a hydraulic model.



Action 16: Ground levelling and vegetation to create an urban green space (recreational area) that can be flooded in times of high water. This action consists in levelling the land, currently in industrial wasteland, to facilitate the realization of planting and landscaping. It includes the removal of macro-remediation (rubble, concrete blocks...) without carrying out an exhaustive soil decontamination.

Action 17: was removed in the course of the study.

Action 18: Creation of a depression disconnected from the river which will be fed by flood water and the groundwater. This action consists in creating a shallow river arm (about 1m) disconnected from the main river. This development will be fed by rainwater and the water table during rainy episodes. In periods of low water, it can be dry. The advantages of this depression are that the arm is long-lasting, has a strong ecological interest for biodiversity (variable water level according to the seasons) and plays a role of protection against pollution:

- The reclamation project must be studied in order to optimize the ecological and landscape quality of the environment;

- The "project elevation" (longitudinal profile) must be determined on the basis of a good knowledge of the level of the river and the water table (and its variations);

- The depth of excavation must allow for the sustainability of the operation and the development of various plant communities;

- The slopes of the banks must be as low as possible;

- The arm/depression can be materialized by multiple pools;

- The recreation will not be uniform and systematic.

Action 19: Diversification of natural habitats typical of wetlands through the creation of a mosaic of depressions. These depressions will have banks with different levels depending on the water level. These depressions will have banks with different levels depending on the water level. These depressions will have banks with different levels depending on the water level. It is a matter of proposing the creation of different natural habitats typical of wetlands (herbaceous to arboreal) according to the cross-section of the depression, the "waterline" slopes and the degree of hydromorphy of the soils. The planted species will be indigenous and adapted to wetlands.

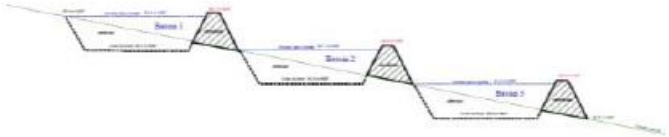
Action 20: Stream protection zone with a vegetated riparian buffer. A buffer strip of at least 25 m in width will limit the transfer of pollutants and/or sediments to the watercourse via runoff from agricultural plots. This width will be adapted according to the watershed intercepted by the buffer strip. This buffer strip, which will also have the advantage of serving as an ecological corridor for the migration of animal species, can be made up of grassy strips, permanent grasslands, fallow land, hedges, woods. The plant species planted should be indigenous and adapted to the soil typology.

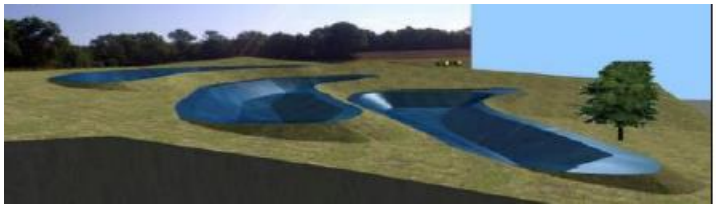
Action 21: Natural weirs in cascade to limit floods. This action consists of the creation of multiple water retention areas cascading along the flow axis of the hydraulic outfalls (located at urban drains). The upstream water compartment will overflow to the downstream water compartment. These compartments will be in the form of ponds with water surfaces of less than 500m². The objectives of these facilities will be to

- Retain runoff water (removal of suspended solids and other pollutants);

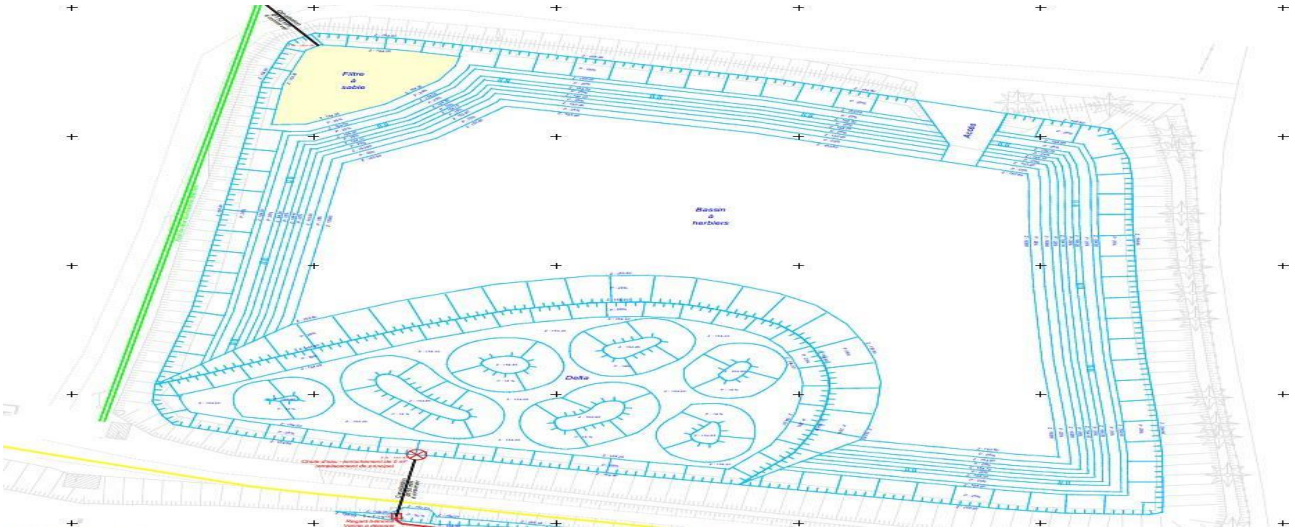
- To buffer water during flood periods;

- To create spaces of biodiversity interesting for the wild fauna, in particular the amphibians.





Action 22: Modification of the banks of aquaculture ponds by creating levels according to the water level. To implement this action, clay and topsoil will be required to reshape the banks of the water bodies for aquaculture. As a result, the water surface will be reduced from the existing state. The work will be carried out by creating landings/risers on which plants can be planted. The coast of these landings will be fixed according to the water level and the height of water that we wish to have at each landing/riser. These civil engineering arrangements will allow the creation of different landings/risers that will present a variable hydromorphy according to their proximity to the water level. Thus, this variation in water level will allow for a diversity of natural habitats favourable to biodiversity and the creation of habitats not currently existing in the wetland.





Action 23: Diversification of natural habitats to make these water bodies more ecologically attractive. At each level of the banks of the water bodies, banks will be planted with plant species that are adapted to the aquatic and wetland environment. The purpose of these plantings will be to diversify the natural habitats (progressive humidity facies from the water level to the top of the banks) and to create favourable supports for the feeding, reproduction and nesting of numerous animal species. As for action 6 "Planting of local plant species adapted to the wetland environment", the choice of plant species was defined following the analysis of botanical expertise carried out on the study sites and previous studies (SMEC, NEMUS, REMA...).

Action 24: Protection and conservation of typical wetland habitats. The objective of this action is to implement:

- Devices to protect the most biologically sensitive natural habitats (privileged reproduction area of animal species, quality plant station...): fences, wooden barriers, environmental regulatory zoning prohibiting all developments/works without authorization by the state services...

- Ecological monitoring measures in order to follow the ecological trajectory of the protected natural habitats and to adapt the management measures.

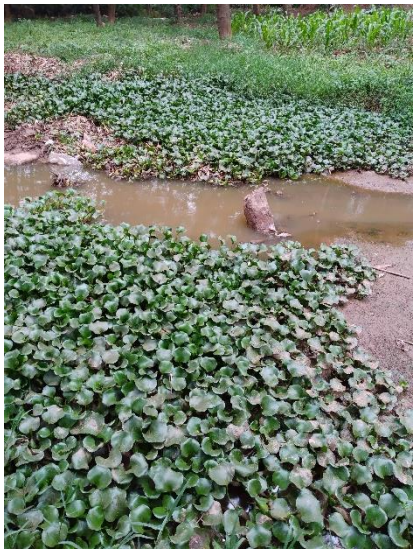
Action 25: Diversion of the river into the original flow (thalweg bottom) with potential to upgrade the existing wetland (with good potential), restoring and meandering the old channel to create a small delta). The objective of the action is to reposition the watercourse, via earthworks, in the initial minor bed so that it is reconnected to the wetlands. This repositioning will also allow to feed the wetlands and avoid their drying up in the short/medium term. During periods of heavy rainfall, the stream will be able to overflow into the adjacent wetlands, thereby enhancing their hydraulic and biogeochemical functions. This old diversion of the watercourse had probably for objectives to clean up the parcel to facilitate its exploitation for agriculture. This work will have to be based on the analysis of the old aerial photographs and the topographic surveys in order to reposition ideally the watercourse.

Action 26: Creation of a delta before the confluence of the Nyabugogo River and its right bank tributary (Rwenzagoro River). This action is the result of the actions carried out above. The topographic configuration of the valley at this confluence and the developments projected in the actions will create an area that will be flooded more regularly during current rainfall. The ecological, hydraulic and biogeochemical functionalities of this area will thus be reinforced. According to the topographic surveys and hydraulic modelling, a cribbing of about 0.10m could be done to accentuate this delta aspect at the confluence. This height will have to be refined in order to ensure a quick draining of the soil after rainy episodes.

The creation of the delta corresponds to a slight stripping of the soil (less than 0.50 meters deep) to increase the frequency of flooding and inundation of this downstream part of the Nyabugogo wetland. This stripping will be associated with the creation of different branches of the main watercourse that will allow the delta to be irrigated during periods of heavy rainfall. This delta will therefore have different degrees of humidity, thus contributing to the creation of a diversity of natural habitats typical of wetlands. Unlike a dike or a dam, the delta is not intended to block runoff but to distribute it more evenly across the valley floor.

In the short/medium term, sedimentation in the arms and the delta will be possible, but the sediment can be remobilized and exported downstream during exceptional floods. Thus, the delta is not intended to retain sediment from the watershed like a dike or dam. It presents less risk of sedimentation and accumulation of sediments than these civil engineering structures.

Action 27: Management to limit the expansion of water hyacinth and increase of the size of the existing lake. The aim is to remove the water hyacinth, increase the depth of the lake to limit the colonization of this invasive plant and improve navigability in the lake. Removed water hyacinth would need to be burnt in a designated area to avoid spreading the plant in other habitats. Excavating the contour of the lake would help to limit future colonization of the plant and improve recreational activities. Currently, the lake has a size of about 3 ha. With the removal of water hyacinth and excavation, the lake would have a size of about 7.5 ha. The depth of excavation would be about 1 meter in the additional area (4.5 ha). A significant recovery would also be achieved by solving current water quality issues.





Action 28: Creation of a circuit of pedestrian/cycling routes. In Gikondo, the routes can follow existing alignments of disused roads of former industrial area. For other wetlands paths can follow existing paths created by current uses.

The created network should provide universal access to the wetland at several points and should connect to existing identified links and green corridors in adjacent urban areas (indicated by the main arrows on the presentation sheets/plans).

It is recommended that all pedestrian paths are flat and equipped with benches every 500 meters so that the entire site is easily accessible for all. Light poles should also be installed to ensure safety.

Various natural habitats (meadows, woodland, etc.) can be created along paths to improve the quality of the landscape and make the site more attractive to biodiversity and visitors.

The current pedestrian bridge would be maintained during priority 1 actions and upgraded during priority 2 actions

Bridges can be installed at strategic crossings to provide a wide access to the wetlands and create spatial continuity. Bridges should be designed to be accessible to all.







Action 29: Creation of a lake in Gikondo: This lake was often mentioned by the CoK as a possible outcome from the restoration project. World Bank, Macfarlane (2020) has presented this lake, the "open water" area.



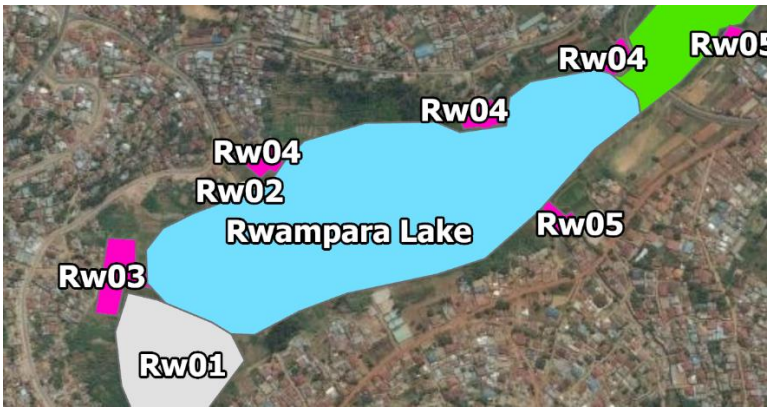
According to the hydrologic and hydraulic calculation, the characteristics of the lake are the following.

Creation of a lake in Gikondo	Average surface of the lake in ha	38
Characteristics of the dam	H - Height in m	16
	L – Approximative length in m	370
	Maximal overflow to ensure annual renewal of the lake (m3/s)	0.21
	% of annual average flow	88%

The following graphic shows the water level (in m) of the lake during 2 consecutive years.



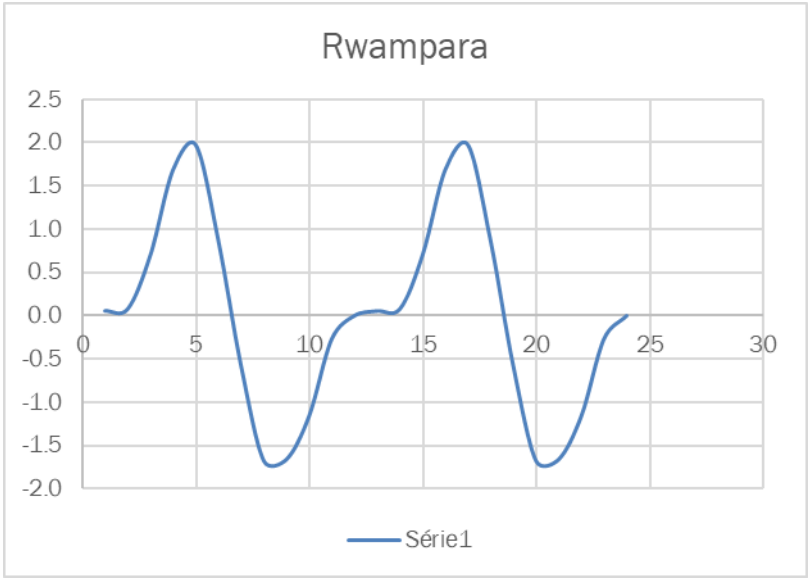
Action 30: Creation of a lake in Rwampara: this lake was not studied in previous studies.



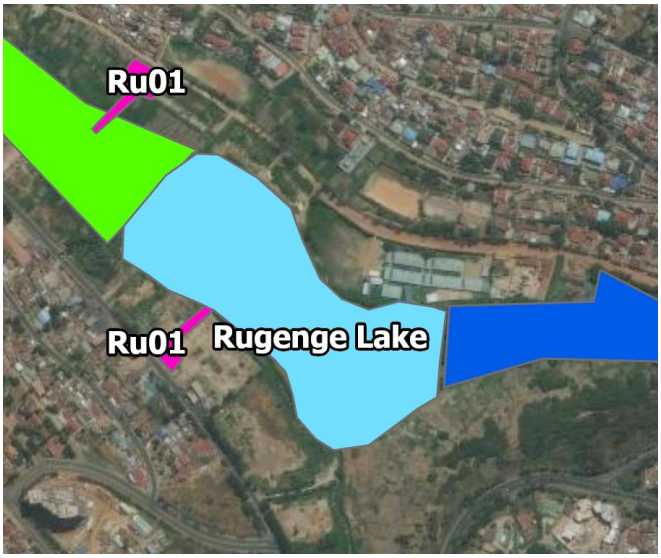
According to the hydrologic and hydraulic calculation, the characteristics of the lake are the following.

Creation of a lake in Rwampara	Average surface of the lake in ha	18
Characteristics of the dam	H - Height in m	10
	L – Approximative length in m	215
	Maximal overflow to ensure annual renewal of the lake (m3/s)	0.19
	% of annual average flow	92%

The following graphic shows the water level (in m) of the lake during 2 consecutive years.



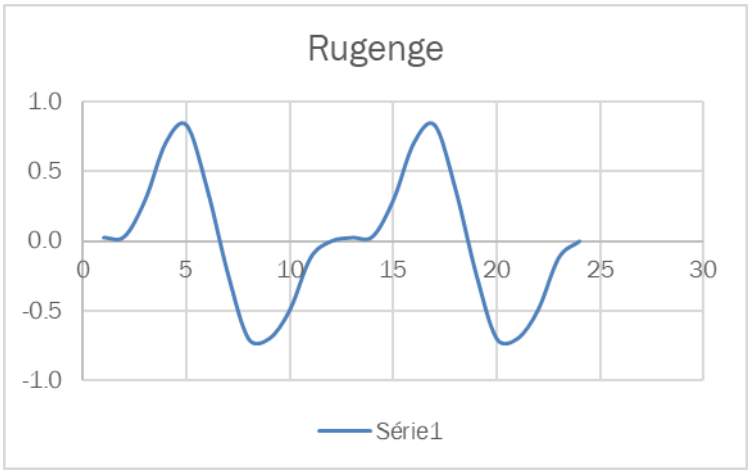
Action 31: Creation of a lake in Rugenge-Rwintare: this central lake was proposed by Deltares (2021) to enhance the aesthetic of the wetland.



According to the hydrologic and hydraulic calculation, the characteristics of the lake are the following.

Creation of a lake in Rugenge	Average surface of the lake in ha	10
Characteristics of the dam	H - Height in m	3
	L – Approximative length in m	250
	Maximal overflow to ensure annual renewal of the lake (m3/s)	0.05
Very low!	% of annual average flow	12%

The following graphic shows the water level (in m) of the lake during 2 consecutive years.



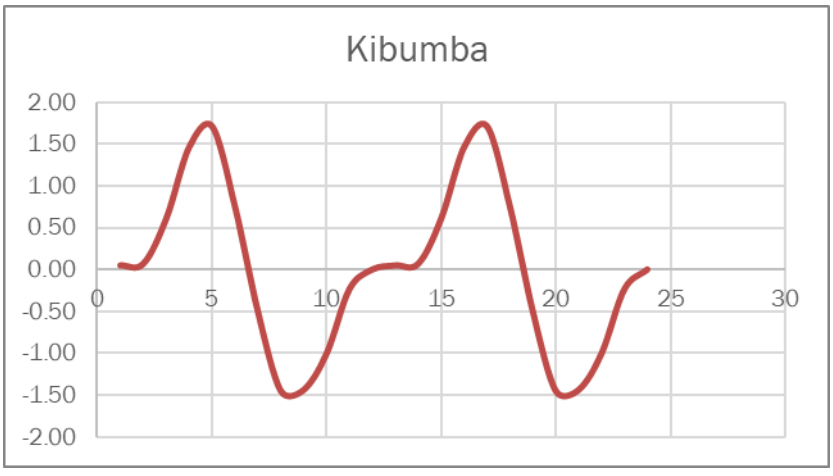
Action 32: Creation of a lake in Kibumba: this lake was not studied in previous studies.



According to the hydrologic and hydraulic calculation, the characteristics of the lake are the following.

Creation of a lake in Kibumba	Average surface of the lake in ha	19
Characteristics of the dam	H - Height in m	7
	L – Approximative length in m	220
	Maximal overflow to ensure annual renewal of the lake (m3/s)	0.13
	% of annual average flow	90%

The following graphic shows the water level (in m) of the lake during 2 consecutive years.



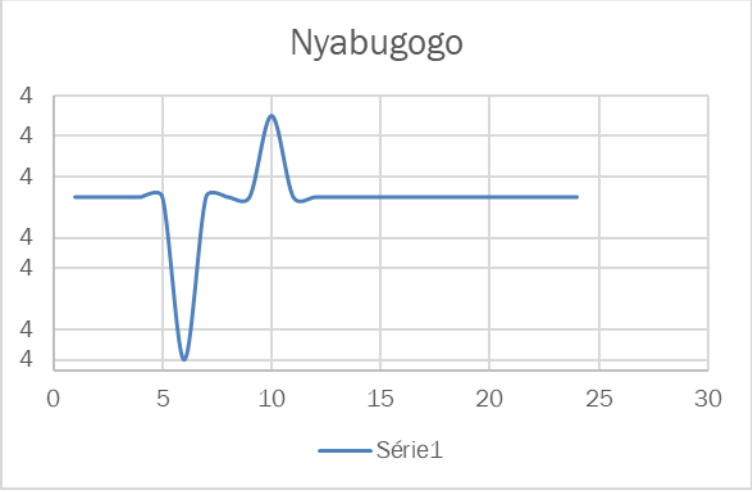
Action 33: Creation of a lake in Nyabugogo: This lake, which is partly existent, but would be enlarged, was often mentioned by the CoK as a possible outcome from the restoration project.



According to the hydrologic and hydraulic calculation, the characteristics of the lake are the following.

Creation of a lake in Nyabugogo	Average surface of the lake in ha	33
Characteristics of the dam	H - Height in m	4
	L – Approximative length in m	250
	Maximal overflow to ensure annual renewal of the lake (m3/s)	19.7
	% of annual average flow	97%

The following graphic shows the water level (in m) of the lake during 2 consecutive years.



Action 34: Installation of flow spreading structures made of gabions: At locations where floods are more severe, several lines of gabions are installed to slow down floods (reduce peak flow) and reduce soil erosion. The have the advantage to dissipate energy and provide a stable environment for wetland vegetation to grow and not be affected by destructive floods. Gabions allows for overtopping by important flows which is not always the case with earth berms, where erosion can take place and where important floods can have destructive effects. Gabions also reduce the retention times of floods because they are partly permeable but allow to spread water over a large area without creating permanent ponds, thus creating favorable conditions to sustain wetland plant species and to recharge groundwater. Their size can be adapted to local flood conditions. Gabions are also key to limit erosion along banks on the edge of wetlands. Gabions will also allow sediment to settle, thus contributing to reducing turbidity of water. Gabions are currently installed at several location along the rivers that flows in the wetland, there is therefore significant return of experience on this method. Depending on soil condition, gabion mattress can be installed for more stability.







5.2 GIKONDO

A. SPECIFIC WETLAND REHABILITATION GOALS

Goals and objectives for Gikondo are presented at section 4.16:

- Creation of an urban park in Gikondo, accessible for various activities including income generating activities.
- End of floods affecting infrastructure such as roads.
- Recreation of the natural profile of the river.
- Natural treatment of stormwater at all outlets of urban drains and reduction of turbidity and water pollution for key parameters at reconnections with rivers.
- Reduction of turbidity and water pollution for key parameters in rivers and streams.

B. SPECIFIC ACTIONS

Based on Gikondo wetland rehabilitation goals, the baseline assessment, secondary data from other previous studies and the results of multiple criteria combined with the consultant international experience in the project with similar context, the consultant selected best actions to be developed in Gikondo and presented them in three different variants.

The maps show the three variants and the associated recreational activities that are proposed.

Each area is identified with a code (G19, G20, etc.) that refers to a specific action and location.

The use of colors in the boxes allows to easily find the correspondent location.

Yellow boxes	Refer to modification of existing concrete canals
Green boxes	Refer to removal of agricultural activities and blocking of agricultural drains and removal of backfills along watercourses
Blue boxes	Refer to modification of watercourses (river profiling)
Orange boxes	Refer to recreational and/or landscape development
Purple boxes	Refer to constructed wetlands at the outlet of urban drains (buffer zones)

The following tables is a presentation of key restoration treatment prescriptions for Variant 1, 2, and 3. These are presented as Actions.

TABLE 5-1 ALL ACTIONS FOR GIKONDO

Location	Comprehensive list of actions	Variant 1	Variant 2	Variant 3
	Southern branch			
G01 G02	Action 1: Raising the water level in the outfalls or the river.	Present	Present	Present
	Action 2: Creation of overflows on the two concrete canals to ensure overflow of water into the wetland during rainfall.	Present	Present	Present
	Action 3: Creation of buffer zones (filtering wetlands) at the right of the overflows to ensure the treatment of the polluted water before overflowing into the wetland and then the river.	Present	Present	Present
G03 G04 G05	Action 4: Removal of existing backfills.	Present	Present	Present
	Action 5: Blocking of surface drains (agriculture ditch) to limit the lowering of the groundwater and increase the residence time of the water in the wetland.	Present	Present	Present
	Action 6: Planting of native plant species adapted to the wetland environment (based on the plant species surveyed in the existing natural area in the center of the wetland).	Present	Present	Present
	Action 34: Installation of flow spreading structures made of gabions	Not part of Variant 1	Not part of Variant 2	New to Variant 3
G06	Action 1: Raising the water level of the river in order to limit the lowering of the groundwater and to favour flooding of the river on the riparian areas.	Present	Present	Not part of Variant 3
	Action 7: Re-profiling of the river with the creation of meanders and banks with different levels.	Present	Present	Not part of Variant 3
	Action 8: Filling of the old minor bed of the watercourse.	Present	Present	Not part of Variant 3
	Action 9: Planting the banks with native plant species according to the water level and their tolerance for wetness.	Present	Present	Present

Location	Comprehensive list of actions	Variant 1	Variant 2	Variant 3
	Action 20: Stream protection zone with a vegetated riparian buffer.	Present	Present	Present
G07	See common action for the Gikondo eco-valley (G21, G20, G19, G18, G07)	Present	At G07, actions remain the same	At G07, actions remain the same
Northern Branch				
G08	Action 11: Riprap at the outlet of urban discharges.	Present	Present	Present
	Action 12: Constructed wetland will act as buffer zones at urban discharges, sized for qualitative and quantitative water management (sizing according to the catchment area and water quality).	Present	Present	Present
	Action 13: Reprofiling of the hydraulic outlets from the discharges (creation of banks with different levels) and reconnection with the river.	Present	Present	Present
G9	Action 1: Raising the water level of the river in order to limit the lowering of the groundwater and to favour flooding of the river on the riparian areas.	Present	Present	Not part of Variant 3
	Action 7: Re-profiling of the river with the creation of meanders and banks with different levels.	Present	Present	Not part of Variant 3
	Action 8: Filling of the old minor bed of the watercourse.	Present	Present	Not part of Variant 3
	Action 9: Planting the banks with local plant species according to the water level and tolerance to wetness.	Present	Present	Present
	Action 20: Stream protection zone with a vegetated riparian buffer.	Present	Present	Present
G10 G11 G12	Action 5: Blocking of surface drains (agriculture ditches) to limit the lowering of the groundwater and increase the residence time of the water in the wetland.	Present	Present	Present

Location	Comprehensive list of actions	Variant 1	Variant 2	Variant 3
	Action 6: Planting of native plant species adapted to the wetland environment (based on the plant species found in the existing natural area in the center of the wetland).	Present	Present	Present
	Action 34: Installation of flow spreading structures made of gabions	Not part of Variant 1	Not part of Variant 2	New to Variant 3
G13 G14	Action 5: Blocking of surface drains	Present	Present	Present
	Action 14: Differentiated management according to natural habitats.	Present	Present	Not part of Variant 3
Main branch				
G15	Action 1: Raising the water level of the river in order to limit the lowering of the groundwater and to favour the flooding of the river on the riparian plots.	Present	Not part of Variant 2	Not part of Variant 3
	Action 7: Re-profiling of the Rugenge river with the creation of meanders and banks with different levels.	Present	Not part of Variant 2	Not part of Variant 3
	Action 8: Filling of the old minor bed of the watercourse.	Present	Not part of Variant 2	Not part of Variant 3
	Action 9: Planting the banks with local plant species according to the water level and tolerance to wetness.	Present	Not part of Variant 2	Present
	Action 15: Clearance over a large width to facilitate the overflow of the river during flood periods.	Present	Not part of Variant 2	Present
	Action 20: Stream protection zone with a vegetated riparian buffer.	Present	Not part of Variant 2	Present
	Action 29: Creation of a lake in Gikondo	Not part of Variant 1	New to Variant 2	Not part of Variant 3

Location	Comprehensive list of actions	Variant 1	Variant 2	Variant 3
	Action 34: Installation of flow spreading structures made of gabions.	Not part of Variant 1	Not part of Variant 2	New to Variant 3
G16 G17	Action 11: Riprap at the outlet of urban discharges.	Present	Present	Present
	Action 12: Constructed wetland will act as buffer zones at urban discharges, sized for qualitative and quantitative water management (sizing according to the catchment area and water quality).	Present	Present	Present
	Action 13: Reprofiling of the hydraulic outlets from the discharges (creation of banks with different levels) and reconnection with the river.	Present	Modified to avoid connecting the outlets of urban drains to the lake (to avoid collecting polluted water)	Present
G18 G19 G20 G21	Action 16: Ground levelling and vegetation to create an urban green space (recreational area) that can be flooded in times of high water.	Present	Present	Present
	Action 10-G: Development of an Eco-valley	Present	Modified, as the size of recreational activities would be reduced due to the presence of the lake	Modified, as the size of recreational activities would be reduced due to the presence flow spreading structures made of gabions.

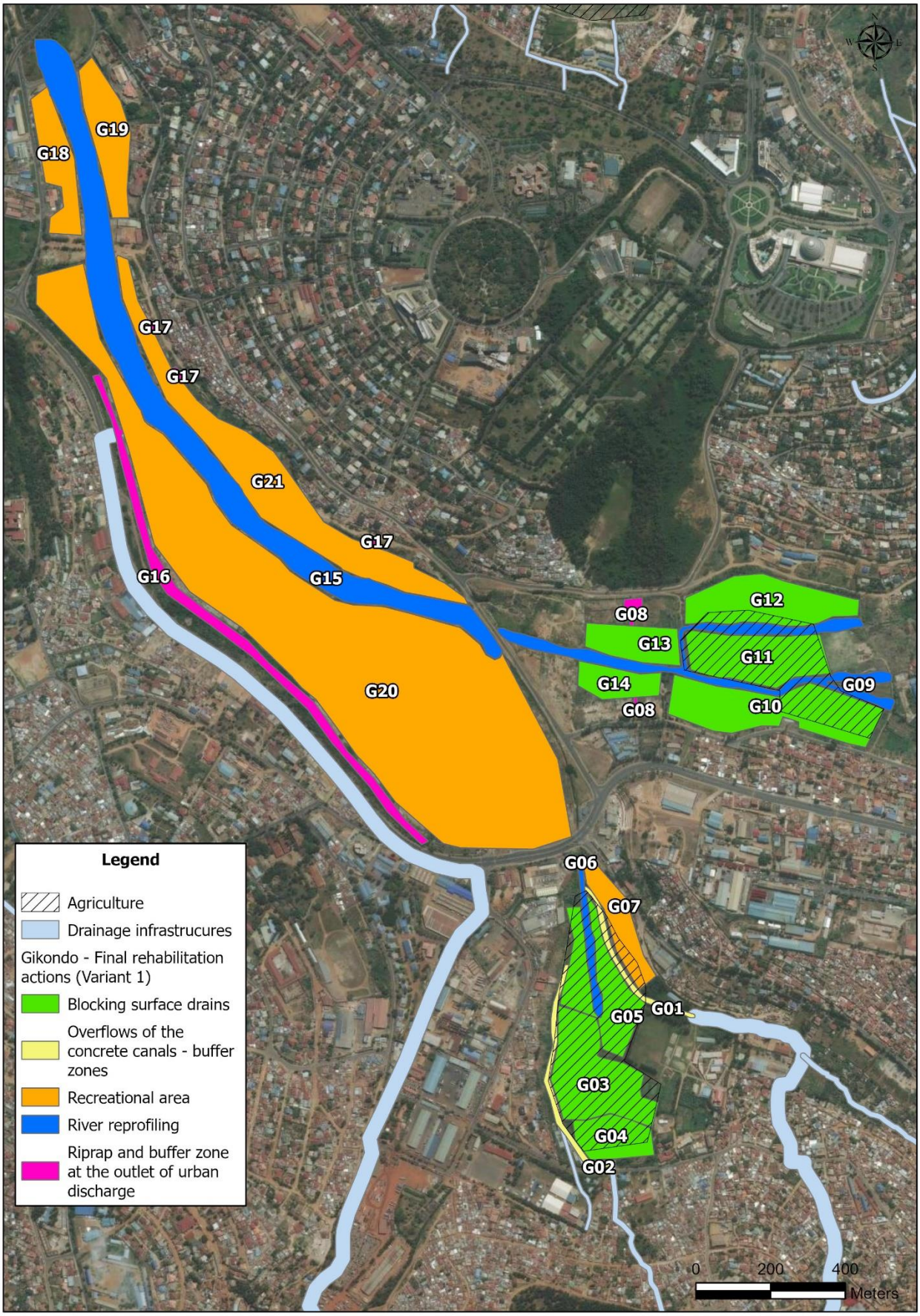


FIGURE 5-1 ACTIONS IN VARIANT 1 GIKONDO

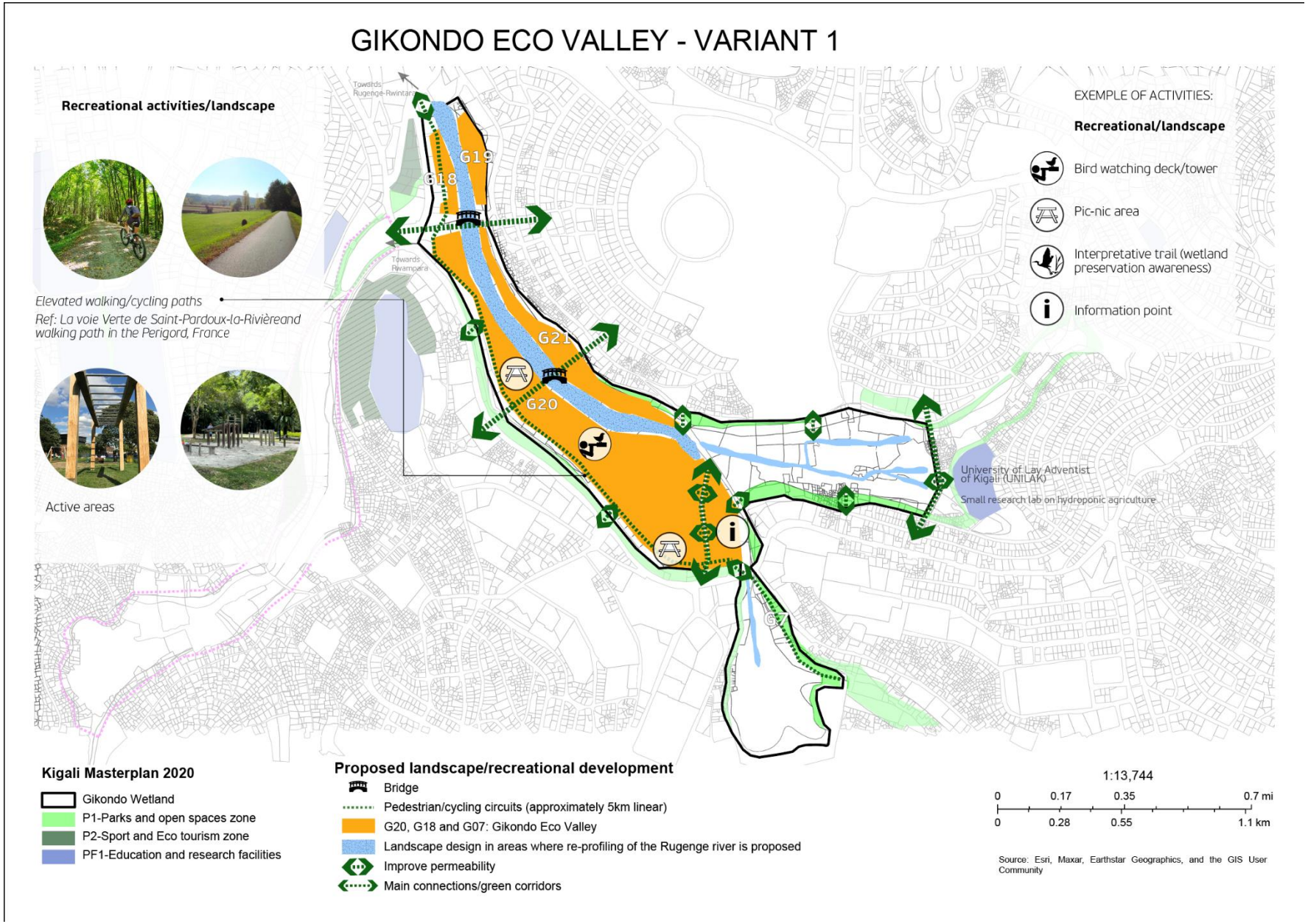


FIGURE 5-2 GIKONDO ECO VALLEY UNDER VARIANT 1

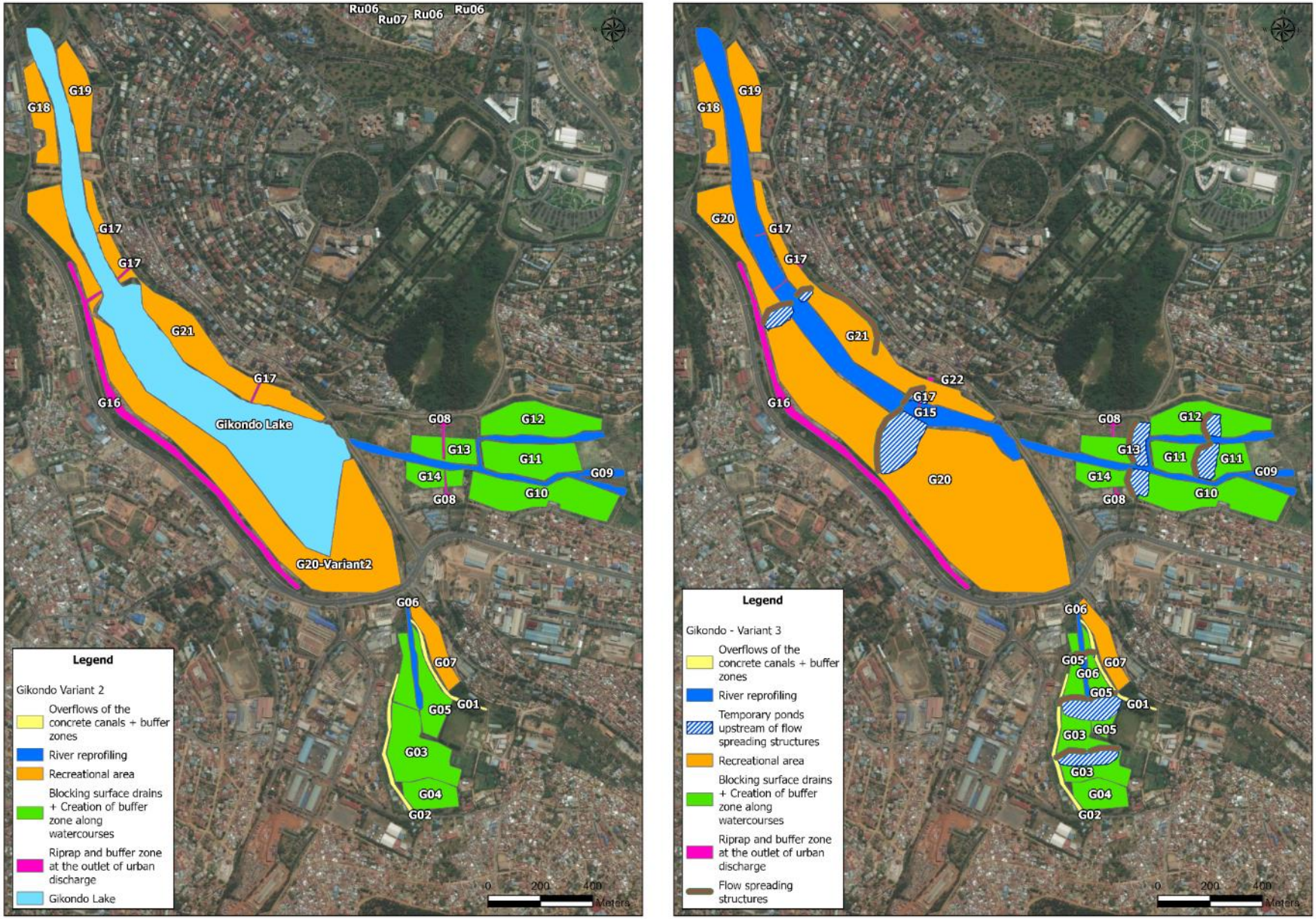


FIGURE 5-3 ACTIONS IN GIKONDO VARIANT 2 (LEFT) AND VARIANT 3 (RIGHT)

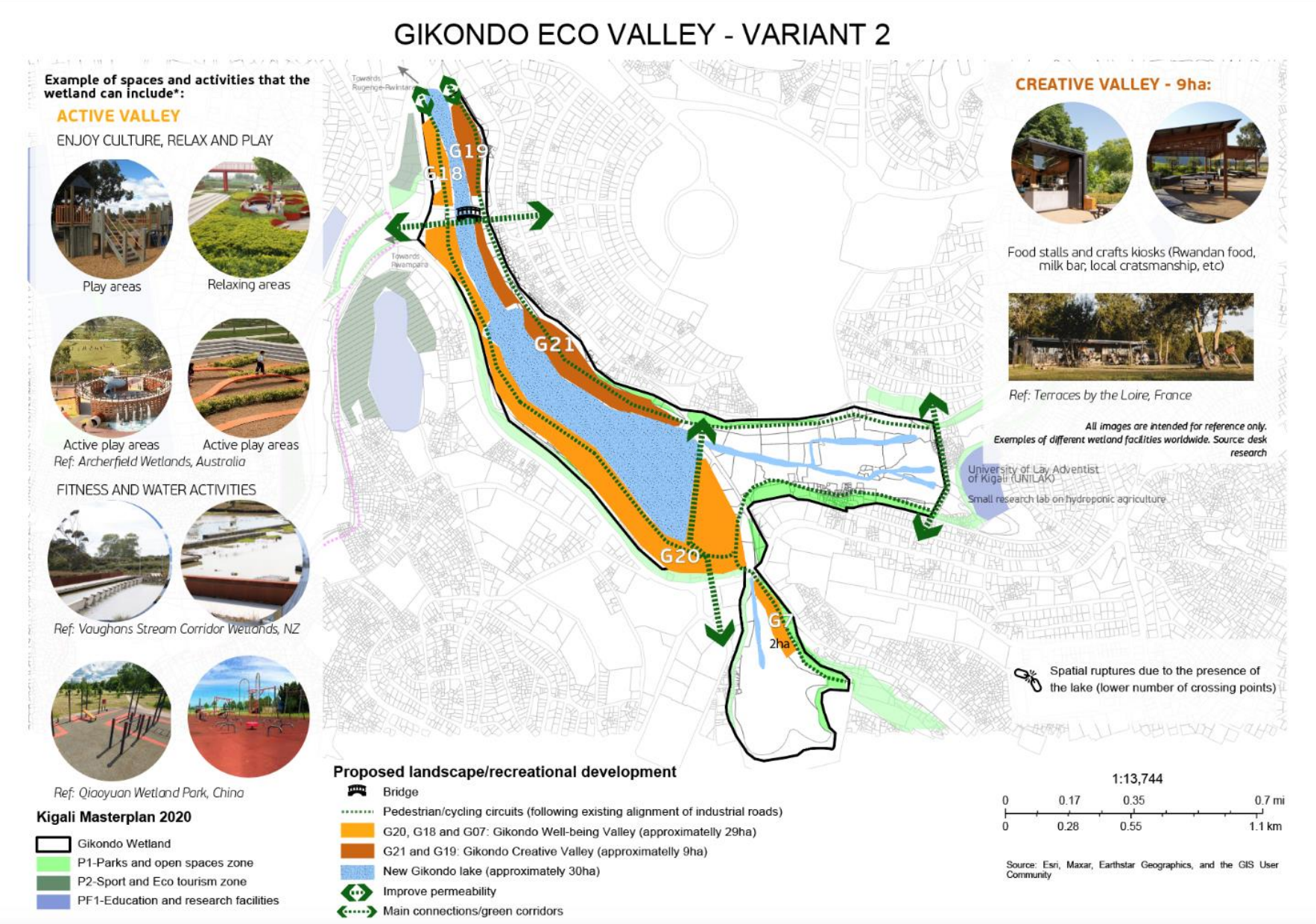


FIGURE 5-4 GIKONDO ECO VALLEY UNDER VARIANT 2

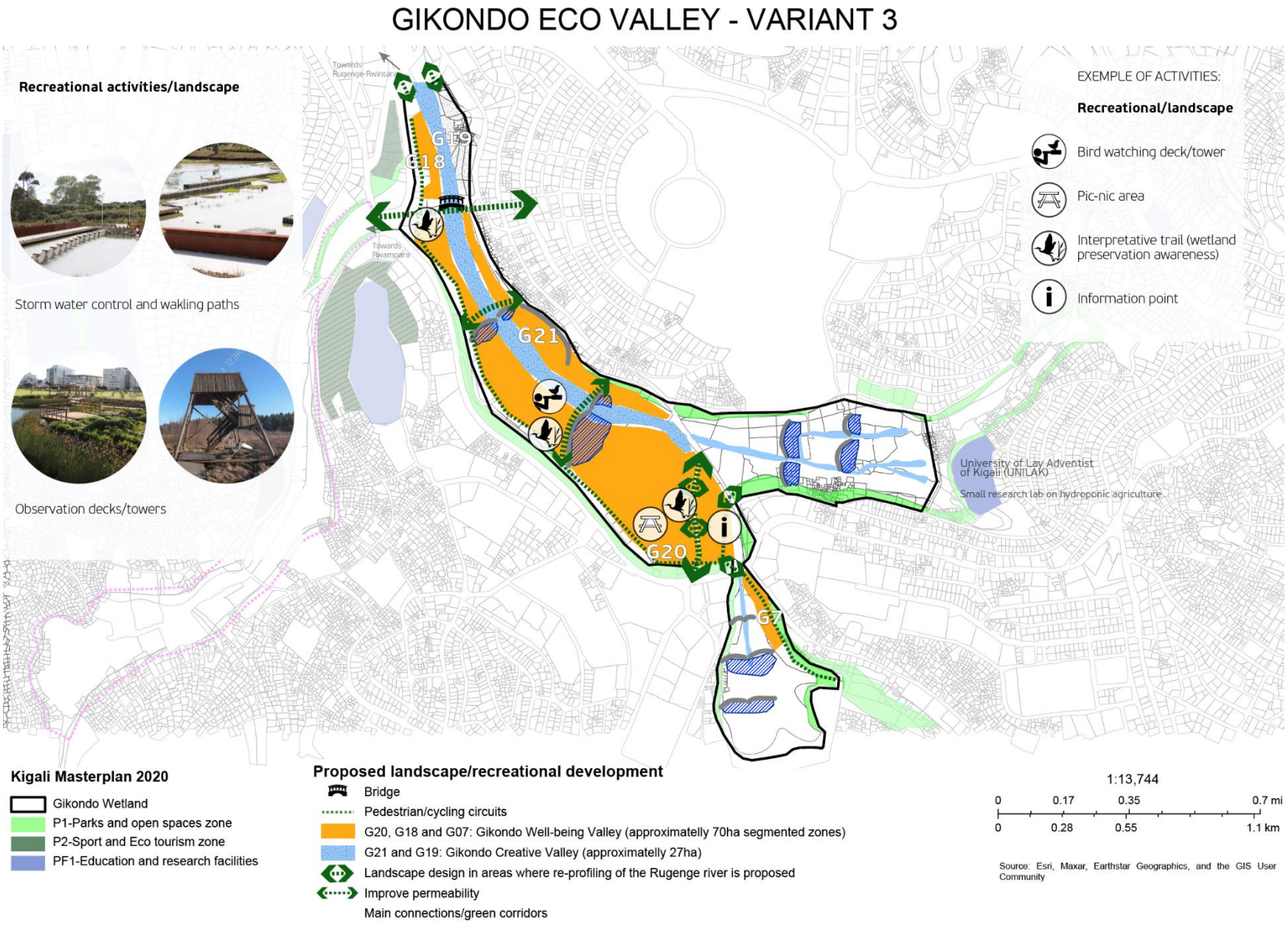


FIGURE 5-5 GIKONDO ECO VALLEY UNDER VARIANT 3

5.3 RWAMPARA

A. SPECIFIC WETLAND REHABILITATION GOALS

Goals and objectives for Kibumba are presented at section 4.16:

- Progressive replacement of unsustainable agricultural activities in accordance with the City' Master Plan and wetland habitat reclamation in more than 50% of Rwampara wetland in the downstream area.
- End of floods affecting infrastructure such as roads.
- Recreation of the natural profile of the river downstream.
- Natural treatment of stormwater at all outlets of urban drains and reduction of turbidity and water pollution for key parameters at reconnections with rivers.
- Reduction of turbidity and water pollution for key parameters in rivers and streams.
- Minor developments (paths and trails) facilitate access to wetland-compatible recreational activities in designated areas.
- Increase in the richness of water-dependent species of birds, amphibians and plants.

B. SPECIFIC ACTIONS

The following maps show the three variants and the associated recreational activities that are proposed.

Each area is identified with a code (Rw01, Rw02, etc.) that refers to a specific action and location. Downstream of Rw06, the presence of hard infrastructure for flood mitigation such as gabions along the river does not allow to propose additional actions.

The use of colors in the boxes allows to easily find the correspondent location.

Grey boxes	Refer to areas that have important constraint due to the local topography, actions will be limited to the downstream part
Yellow boxes	Refer to modification of existing concrete canals
Green boxes	Refer to removal of agricultural activities and blocking of agricultural drains and removal of backfills along watercourses
Purple boxes	Refer to constructed wetlands at the outlet of urban drains (buffer zones)

The following tables is a presentation of key restoration treatment prescriptions for Variant 1, 2, and 3. These are presented as Actions.

TABLE 5-2 ALL ACTIONS FOR RWAMPARA

Sector	Comprehensive list of actions	Variant 1	Variant 2	Variant 3
Rw01	Action 1: Raising the water level in the outfalls or the river.	Present	Present	Not part of Variant 3

Sector	Comprehensive list of actions	Variant 1	Variant 2	Variant 3
	Action 7: On the downstream part of the area, reprofiling of the Rwampara River with the creation of meanders and banks with different levels.	Present	Present	Not part of Variant 3
	Action 8: Filling of the old minor bed of the watercourse.	Present	Present	Not part of Variant 3
	Action 9: Planting the banks with native plant species according to the water level and tolerance to wetness.	Present	Present	Present
	Action 11: Riprap at the outlet of urban discharges.	Present	Present	Present
	Action 12: Creation of buffer zones at urban discharges, sized for qualitative and quantitative water management (sizing according to the catchment area and water quality).	Present	Present	Present
	Action 20: Stream protection zone with a vegetated riparian buffer.	Present	Present	Present
Rw02	Action 1: Raising the water level in the outfalls or the river.	Present	Not part of Variant 2	Not part of Variant 3
	Action 2: Creation of overflows on the concrete canal to ensure overflow of water into the wetland during rainfall.	Present	Not part of Variant 2	Present
	Action 3: Creation of buffer zones at the right of the overflows to ensure the treatment of the water before overflowing into the wetland and then the river.	Present	Not part of Variant 2	Present
Rw03 Rw04 Rw04 Rw05	Action 11: Riprap at the outlet of urban discharges.	Present	Present	Present
	Action 12: Constructed wetland will act as buffer zones at urban discharges, sized for qualitative and quantitative water management (sizing according to the catchment area and water quality).	Present	Present	Present
	Action 13 : Reprofiling of the hydraulic outlets from the discharges (creation of banks with different levels) and reconnection with the Rwampara River.	Present	Modified to avoid	Present

Sector	Comprehensive list of actions	Variant 1	Variant 2	Variant 3
			connecting the outlets of urban drains to the lake (to avoid collecting polluted water)	
Rw06	Action 5: Blocking of surface drains to limit the lowering of the groundwater and increase the residence time of the water in the wetland.	Present	Not part of Variant 2	Present
	Action 6: Planting of local plant species adapted to the wetland environment.	Present	Present	Present
	Action 7 : Reprofiling of the Rwampara River with the creation of meanders and banks with different levels.	Present	Not part of Variant 2	Not part of Variant 3
	Action 8 : Filling of the old minor bed of the watercourse.	Present	Not part of Variant 2	Not part of Variant 3
	Action 9 : Planting the banks with local plant species according to the water level.	Present	Present	Present
	Action 18: Creation of a depression disconnected from the Rwampara river which will be fed by flood water and the groundwater.	Present	Not part of Variant 2	Not part of Variant 3
	Action 19: Diversification of natural habitats typical of wetlands through the creation of a mosaic of depressions.	Present	Not part of Variant 2	Not part of Variant 3
	Action 20: Stream protection zone with a vegetated riparian buffer.	Present	Not part of Variant 2	Present
	Action 30: Creation of a lake in Rwampara	Not part of Variant 1	New to Variant 2	Not part of Variant 3
	Action 34: Installation of flow spreading structures made of gabions	Not part of Variant 1	Not part of Variant 2	New to Variant 3

Sector	Comprehensive list of actions	Variant 1	Variant 2	Variant 3
Rw06 See presentation sheets	Action 28: Creation of a circuit of pedestrian/cycling routes	Present	Present	Modified, as the size of recreational activities would be reduced due to the presence of flow spreading structures made of gabions.

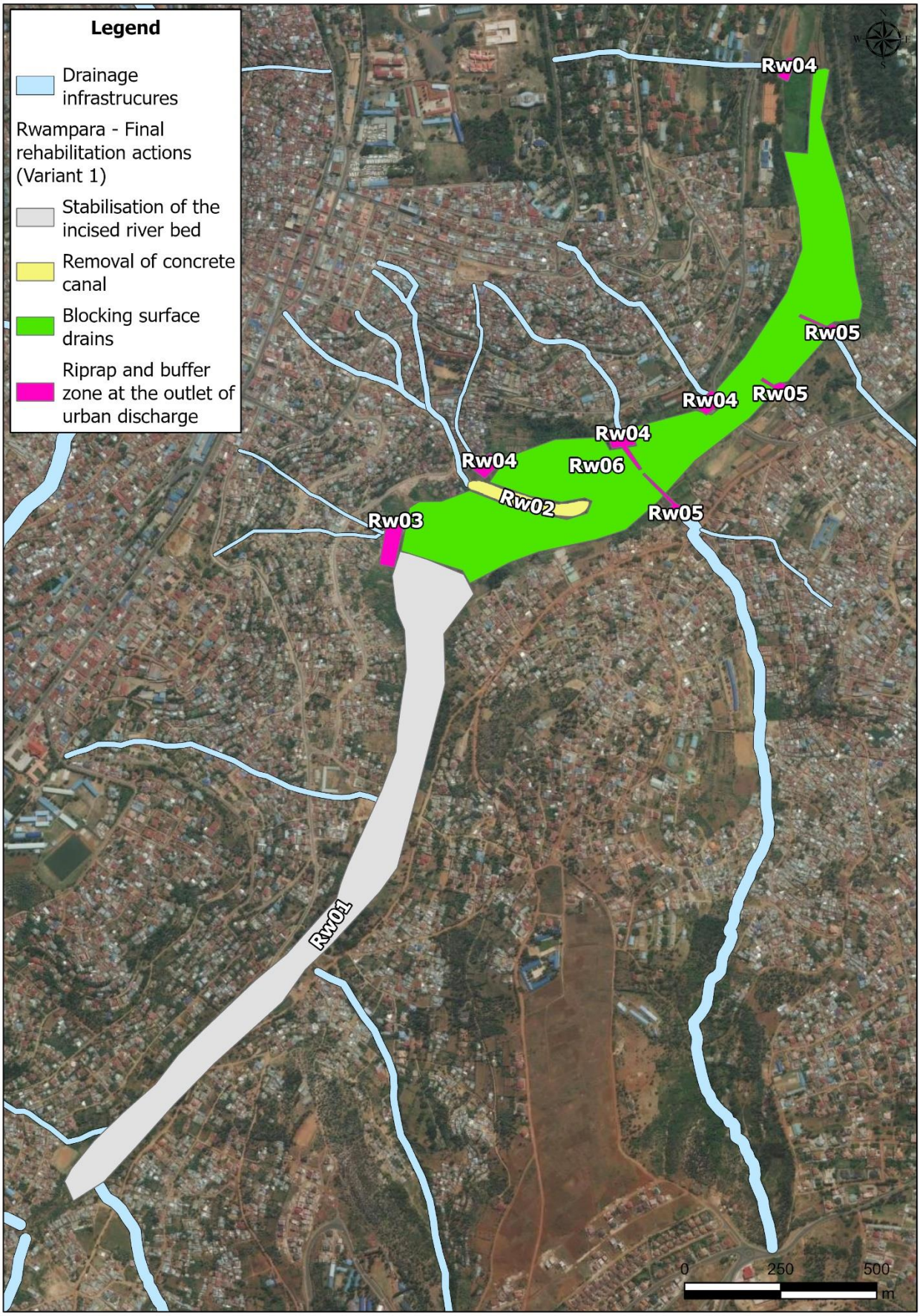


FIGURE 5-6 ACTIONS IN VARIANT 1 RWAMPARA

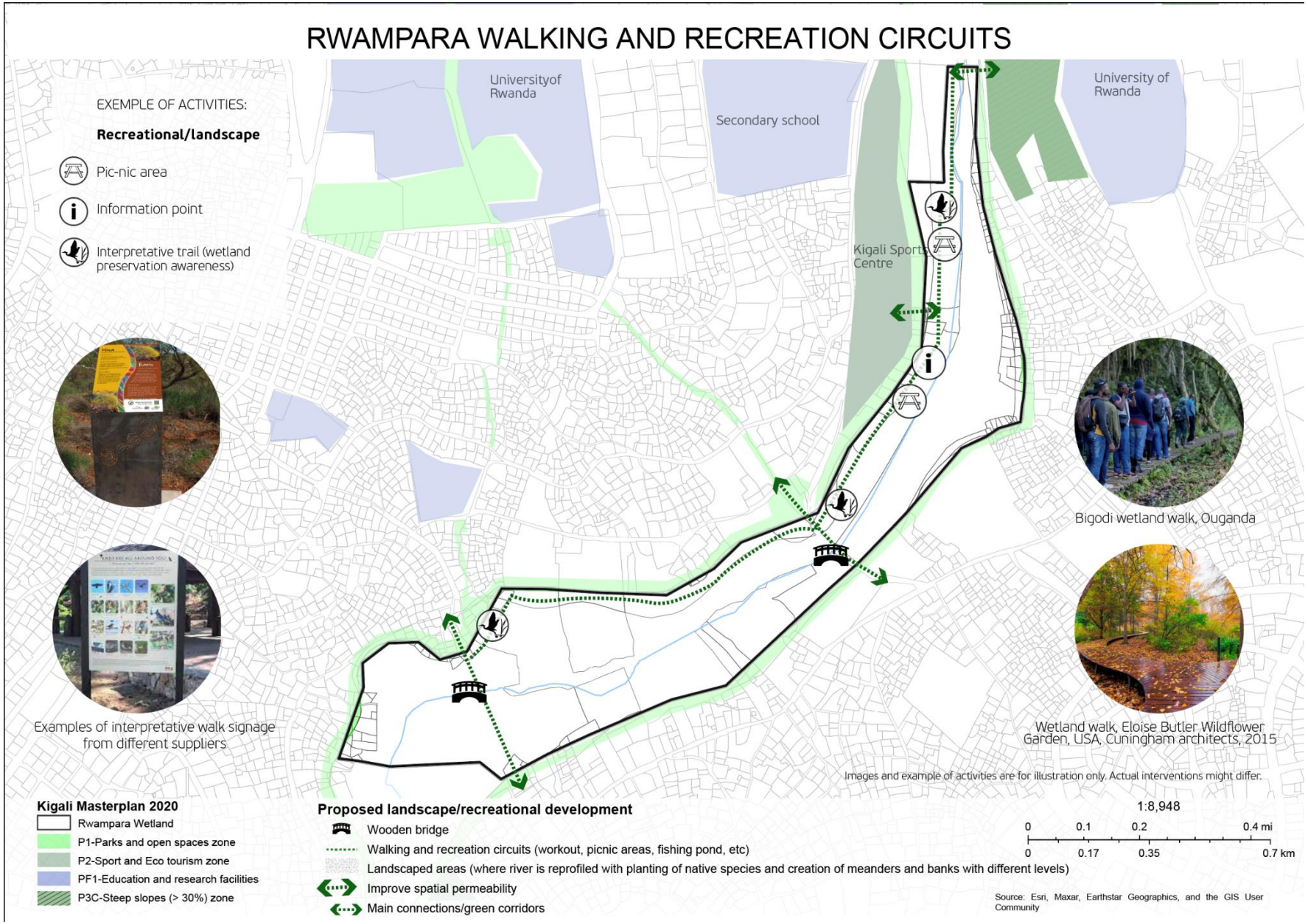


FIGURE 5-7 RWAMPARA WALKING AND RECREATION CIRCUITS UNDER VARIANTS 1, 2 AND 3

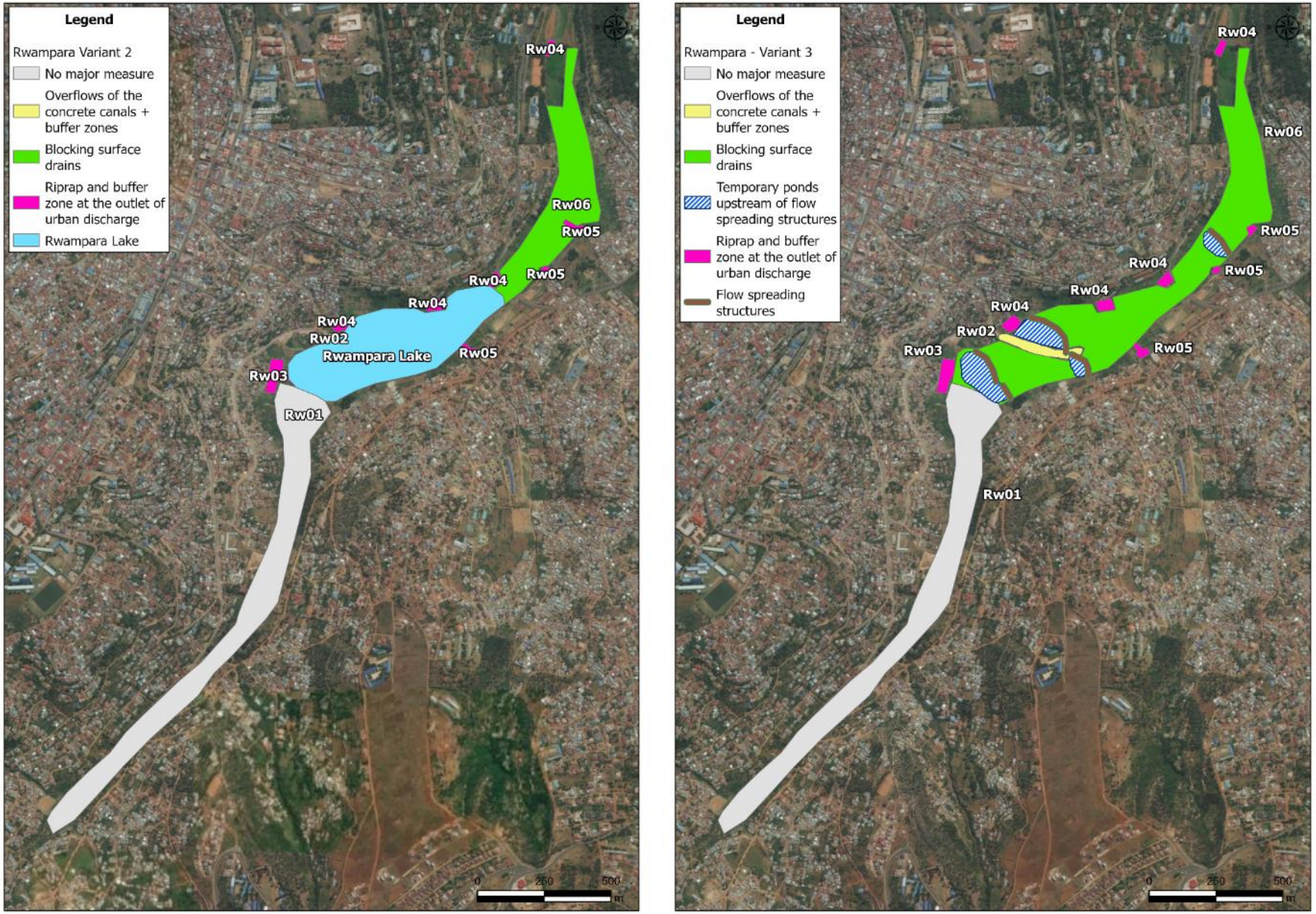


FIGURE 5-8 ACTIONS IN RWAMPARA VARIANT 2 (LEFT) AND VARIANT 3 (RIGHT)

5.4 RUGENGE-RWINTARE

A. SPECIFIC WETLAND REHABILITATION GOALS

Goals and objectives for Rugenge-Rwintare are presented at section 4.16:

- Progressive replacement of unsustainable agricultural activities in accordance with the City' Master Plan and wetland habitat reclamation in more than 80% of Rugenge-Rwintare wetland.
- End of floods affecting infrastructure such as roads
- Recreation of the natural profile of the river.
- Natural treatment of stormwater at all outlets of urban drains and reduction of turbidity and water pollution for key parameters at reconnections with rivers.
- Reduction of turbidity and water pollution for key parameters in rivers and streams.
- Increase in the richness of water-dependent species of birds, amphibians and plants.
- Minor developments (paths and trails) facilitate access to wetland-compatible recreational activities in designated areas.

B. SPECIFIC ACTIONS

The following maps show the three variants and the associated recreational activities that are proposed.

Each area is identified with a code (Ru01, Ru02, etc.) that refers to a specific action and location.

The use of colors in the boxes allows to easily find the correspondent location.

Green boxes	Refer to removal of agricultural activities and blocking of agricultural drains and removal of backfills along watercourses
Blue boxes	Refer to modification of watercourses (river reprofiling)
Orange boxes	Refer to recreational and/or landscape development
Purple boxes	Refer to constructed wetlands at the outlet of urban drains (buffer zones)

The following tables is a presentation of key restoration treatment prescriptions for Variant 1, 2, and 3. These are presented as Actions.

TABLE 5-3 ALL ACTIONS FOR RUGENGE-RWINTARE

Location	Comprehensive list of actions	Variant 1	Variant 2	Variant 3
Ru01	Action 11: Riprap at the outlet of urban discharges.	Present	Present	Present
	Action 12: Constructed wetland will act as buffer zones at urban discharges, sized for qualitative and quantitative water management (sizing according to the catchment area and water quality).	Present	Present	Present
	Action 13: Reprofiling of the hydraulic outlets from the discharges (creation of banks with different levels) and reconnection with the river.	Present	Modified to avoid connecting the outlets of urban drains to the lake (to avoid collecting polluted water)	Present
Ru02	Action 5: Blocking of surface drains to limit the lowering of the groundwater and increase the residence time of the water in the wetland.	Present	Present	Present
	Action 6: Planting of native plant species adapted to the wetland environment (based on the plant species found in the existing natural area in the center of the wetland).	Present	Present	Present
	Action 18: Creation of a depression disconnected from the river which will be fed by flood water and the groundwater.	Present	Present	Not part of Variant 3
	Action 19: Diversification of natural habitats typical of wetlands through the creation of a mosaic of depressions.	Present	Present	Not part of Variant 3
	Action 34: Installation of flow spreading structures made of gabions.	Not part of Variant 1	Not part of Variant 2	New to Variant 3
Ru03	Action 5: Blocking of surface drains to limit the lowering of the groundwater and increase the residence time of the water in the wetland.	Present	Not part of Variant 2	Present
	Action 7: Reprofiling of the river with the creation of meanders and banks with different levels.	Present	Not part of Variant 2	Not part of Variant 3

Location	Comprehensive list of actions	Variant 1	Variant 2	Variant 3
	Action 8: Filling of the old minor bed of the watercourse.	Present	Not part of Variant 2	Not part of Variant 3
	Action 9: Planting the banks with local plant species according to the water level.	Present	Present	Present
	Action 20: Stream protection zone with a vegetated riparian buffer.	Present	Not part of Variant 2	Present
	Action 34: Installation of flow spreading structures made of gabions	Not part of Variant 1	Not part of Variant 2	New to Variant 3
	Action 31: Creation of a lake in Rugenge-Rwintare (common to Ru03 and Ru04)	Not part of Variant 1	New to Variant 2	Not part of Variant 3
Ru04	Action 5: Blocking of surface drains to limit the lowering of the groundwater and increase the residence time of the water in the wetland.	Present	Present	Present
	Action 7: Reprofiling of the river with the creation of meanders and banks with different levels.	Present	Not part of Variant 2	Not part of Variant 3
	Action 8: Filling of the old minor bed of the watercourse.	Present	Not part of Variant 2	Not part of Variant 3
	Action 9: Planting the banks with local plant species according to the water level.	Present	Present	Present
	Action 20: Stream protection zone with a vegetated riparian buffer.	Present	Not part of Variant 2	Present
	Action 34: Installation of flow spreading structures made of gabions	Not part of Variant 1	Not part of Variant 2	New to Variant 3
Ru05	Action 1: Raising the water level in the outfalls or the river.	Present	Present	Not part of Variant 3
	Action 7: Reprofiling of the river with the creation of meanders and banks with different levels.	Present	Present	Not part of Variant 3

Location	Comprehensive list of actions	Variant 1	Variant 2	Variant 3
	Action 8: Filling of the old minor bed of the watercourse.	Present	Present	Not part of Variant 3
	Action 9: Planting the banks with local plant species according to the water level (based on the plant species found in the existing natural area in the center of the wetland at Ru04).	Present	Present	Present
Ru06	Action 11: Riprap at the outlet of urban discharges.	Present	Present	Present
	Action 12: Constructed wetland will act as buffer zones at urban discharges, sized for qualitative and quantitative water management (sizing according to the catchment area and water quality).	Present	Present	Present
	Action 13: Reprofiling of the hydraulic outlets from the discharges (creation of banks with different levels) and reconnection with the river.	Present	Present	Present
Ru07	Action 5: Blocking of surface drains to limit the lowering of the groundwater and increase the residence time of the water in the wetland.	Present	Present	Present
	Action 6: Planting of local plant species adapted to the wetland environment (based on the plant species found in the existing natural area in the center of the wetland).	Present	Present	Present
	Action 21: Natural weirs in cascade to limit floods (located at urban drains).	Present	Present	Not part of Variant 3
	Action 34: Installation of flow spreading structures made of gabions	Not part of Variant 1	Not part of Variant 2	New to Variant 3
See presentation sheets	Action 28: Creation of a circuit of pedestrian/cycling routes	Present	Present	Modified, as the size of recreational activities would be reduced due to the presence of flow spreading structures

Location	Comprehensive list of actions	Variant 1	Variant 2	Variant 3
				made of gabions.

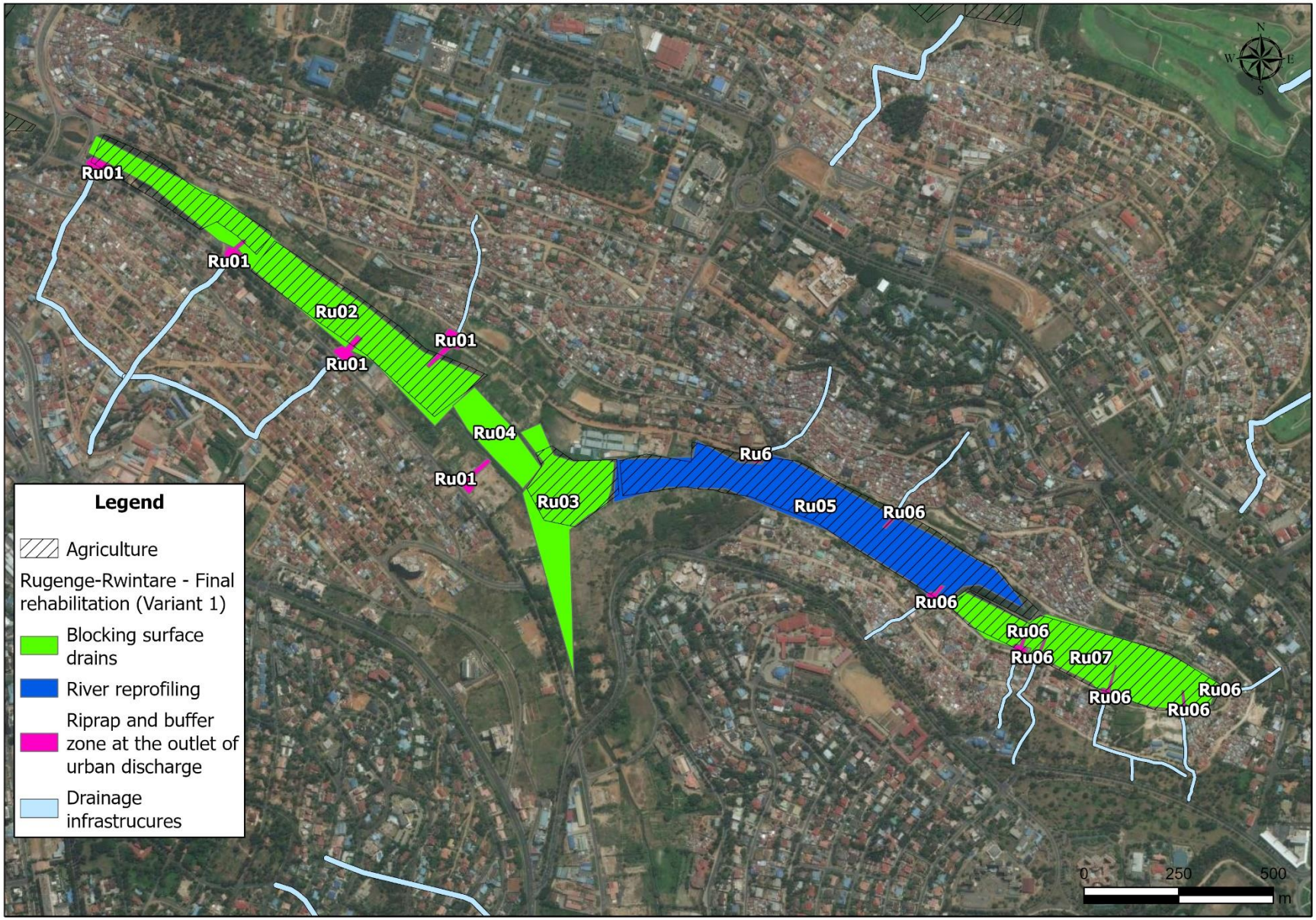


FIGURE 5-9 ACTIONS IN VARIANT 1 RUGENGE-RWINTARE

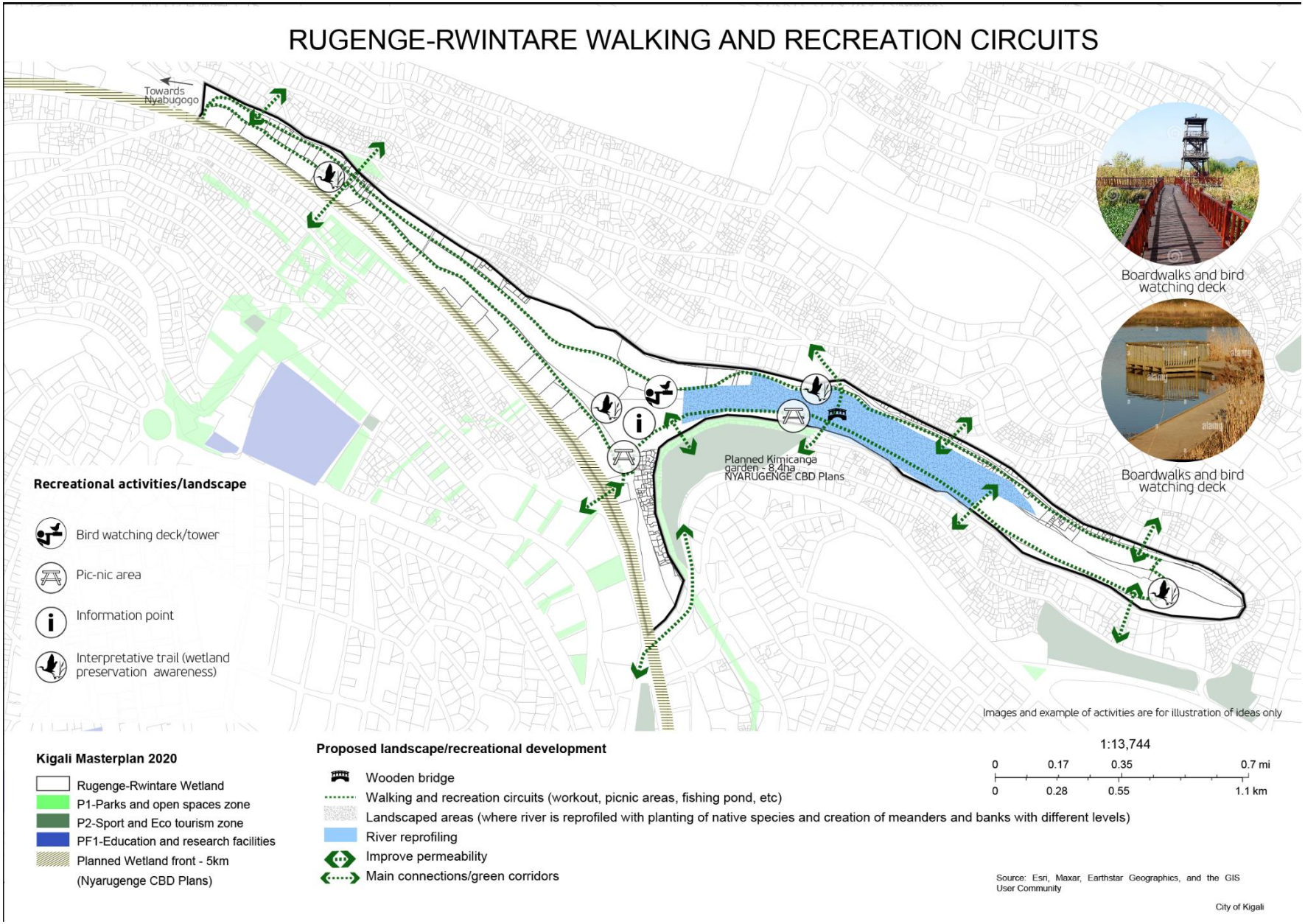


FIGURE 5-10 RUGENGE-RWINTARE WALKING AND RECREATION CIRCUITS UNDER VARIANTS 1, 2 AND 3

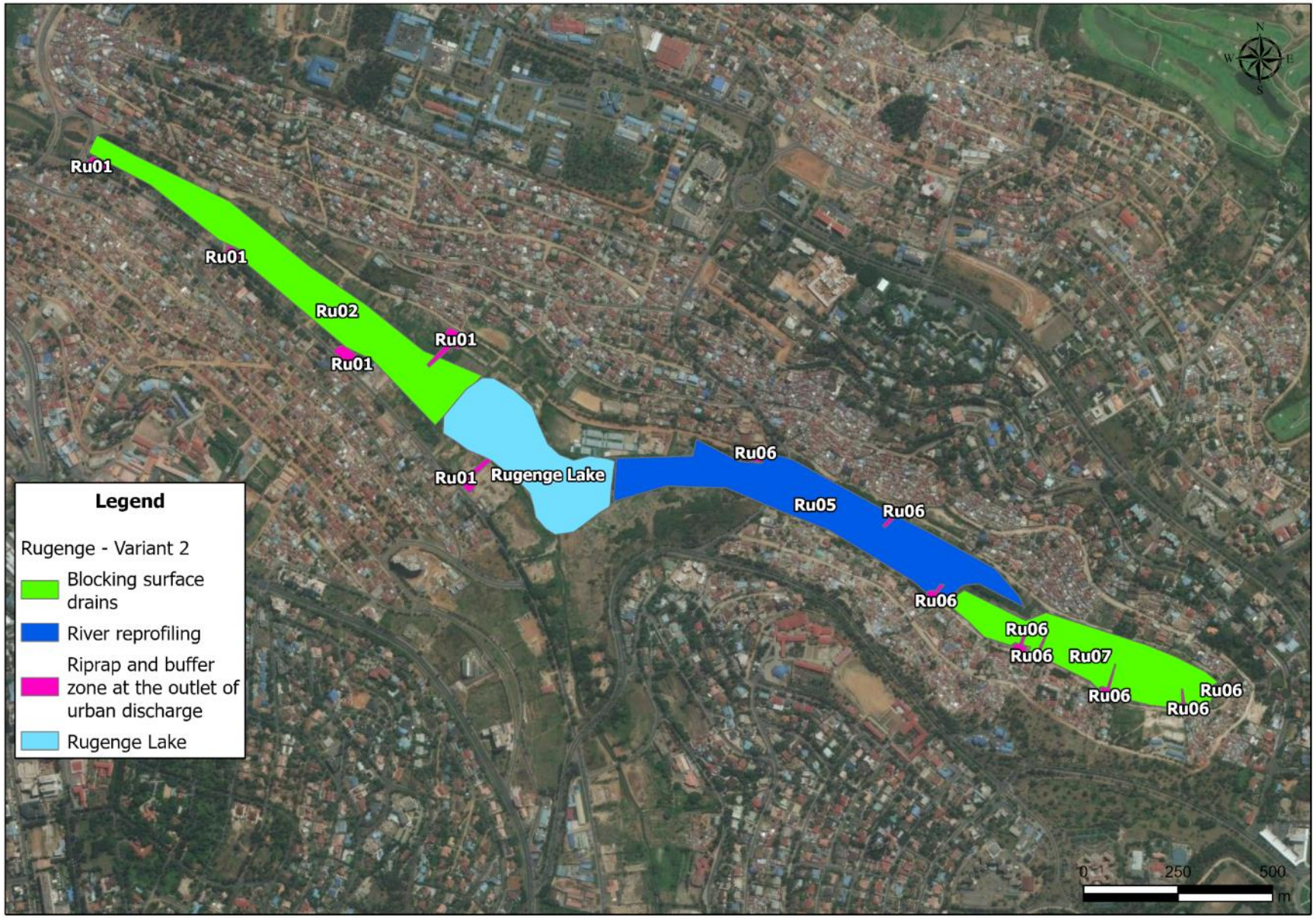


FIGURE 5-11 ACTIONS IN RUGENGE RWINTARE VARIANT 2

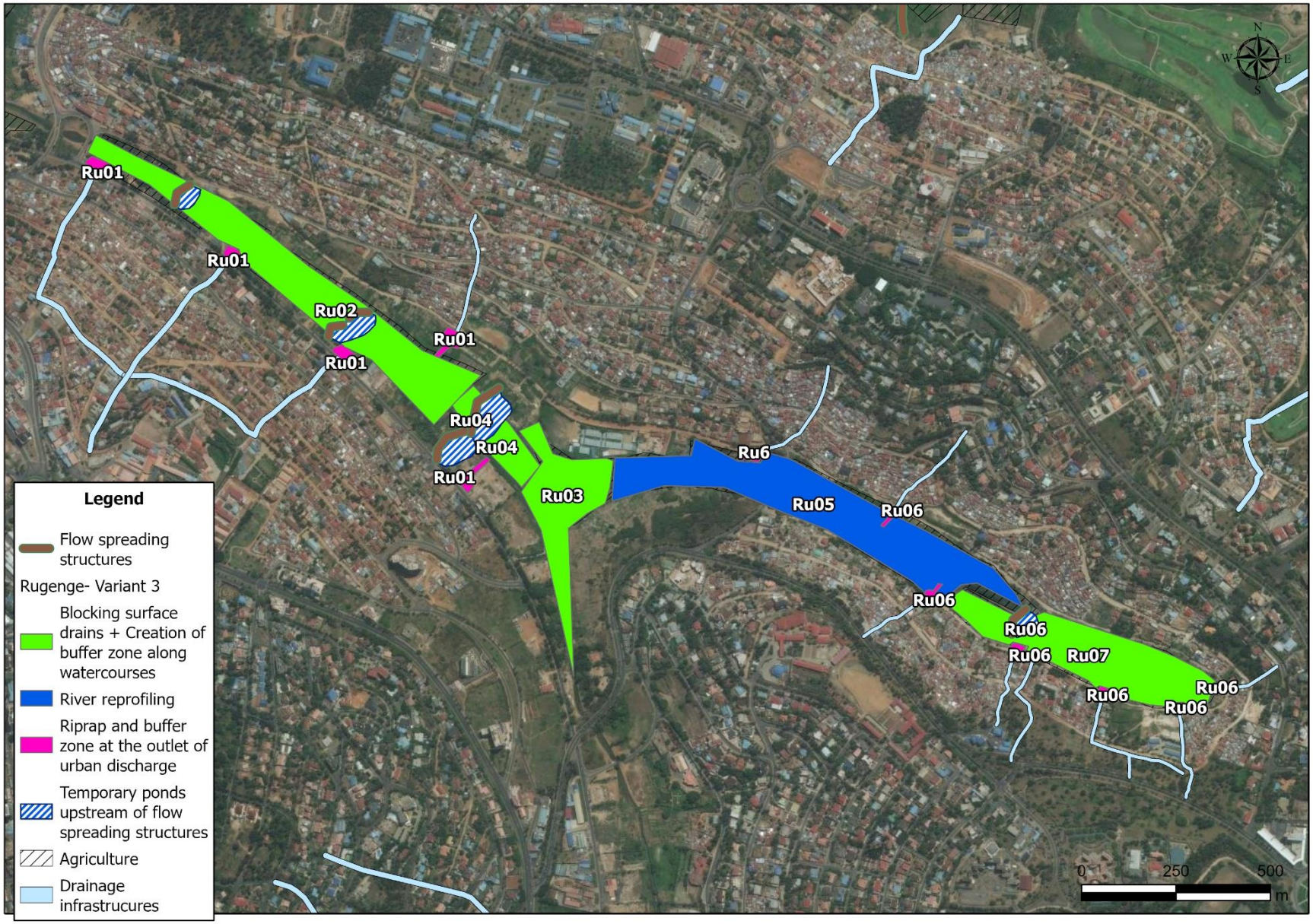


FIGURE 5-12 ACTIONS IN RUGENGE RWINTARE VARIANT 3

5.5 KIBUMBA

A. SPECIFIC WETLAND REHABILITATION GOALS

Goals and objectives for Kibumba are presented at section 4.16:

- Progressive replacement of unsustainable agricultural activities in accordance with the City' Master Plan and wetland habitat reclamation in more than 80% of Kibumba wetland.
- End of floods affecting infrastructure such as roads.
- Recreation of the natural profile of the river.
- Natural treatment of stormwater at all outlets of urban drains and reduction of turbidity and water pollution for key parameters at reconnections with rivers.
- Reduction of turbidity and water pollution for key parameters in rivers and streams.
- Increase in the richness of water-dependent species of birds, amphibians and plants.
- Minor developments (paths and trails) facilitate access to wetland-compatible recreational activities in designated areas.

B. SPECIFIC ACTIONS

The following maps show the three variants and the associated recreational activities that are proposed.

Each area is identified with a code (K09, K10, etc.) that refers to a specific action and location.

The use of colors in the boxes allows to easily find the correspondent location.

Green boxes	Refer to removal of agricultural activities and blocking of agricultural drains and removal of backfills along watercourses
Light blue box	Refers to modification of fishponds
Blue boxes	Refer to modification of watercourses (river reprofiling)
Orange boxes	Refer to recreational and/or landscape development
Purple boxes	Refer to constructed wetlands at the outlet of urban drains (buffer zones)

The following tables is a presentation of key restoration treatment prescriptions for Variant 1, 2, and 3. These are presented as Actions.

TABLE 5-4 ALL ACTIONS FOR KIBUMBA

Location	Comprehensive list of actions	Variant 1	Variant 2	Variant 3
K01	Action 5: Blocking of surface drains to limit the lowering of the groundwater and increase the residence time of the water in the wetland.	Present	Present	Present
	Action 6: Planting of native plant species adapted to the wetland environment (based on the plant species found in the existing natural area in the southeast of the wetland).	Present	Present	Present
	Action 18: Creation of a depression disconnected from the river which will be fed by flood water and the groundwater.	Present	Present	Not part of Variant 3
	Action 19: Diversification of natural habitats typical of wetlands through the creation of a mosaic of depressions.	Present	Present	Not part of Variant 3
	Action 34: Installation of flow spreading structures made of gabions	Not part of Variant 1	Not part of Variant 2	New to Variant 3
K02	Action 22: Modify the banks of aquaculture ponds by creating levels according to the water level.	Present	Present	Present
	Action 23: Diversification of natural habitats to make these water bodies more ecologically attractive.	Present	Present	Present
K03	Action 1: Raising the water level in the outfalls or the river.	Present	Not part of Variant 2	Not part of Variant 3
	Action 5: Blocking of surface drains to limit the lowering of the groundwater and increase the residence time of the water in the wetland.	Present	Not part of Variant 2	Present
	Action 6: Planting of local plant species adapted to the wetland environment (based on the plant species found in the existing natural area in the southeast of the wetland).	Present	Present	Present
	Action 7: Reprofiling of the Rugenge River with the creation of meanders and banks with different levels.	Present	Not part of Variant 2	Not part of Variant 3

Location	Comprehensive list of actions	Variant 1	Variant 2	Variant 3
	Action 8: Filling of the old minor bed of the watercourse.	Present	Not part of Variant 2	Not part of Variant 3
	Action 9: Planting the banks with native plant species according to the water level and tolerance to wetness.	Present	Not part of Variant 2	Present
	Action 20: Stream protection zone with a vegetated riparian buffer.	Present	Not part of Variant 2	Present
	Action 32: Creation of a lake in Kibumba	Not part of Variant 1	New to Variant 2	Not part of Variant 3
	Action 34: Installation of flow spreading structures made of gabions	Not part of Variant 1	Not part of Variant 2	New to Variant 3
K04	Action 5: Blocking of surface drains to limit the lowering of the groundwater and increase the residence time of the water in the wetland.	Present	Present	Present
	Action 6: Planting of native plant species adapted to the wetland environment (based on the plant species found in the existing natural area in the center of the wetland).	Present	Present	Present
	Action 21: Natural weirs in cascade to limit floods.	Present	Present	Not part of Variant 3
	Action 34: Installation of flow spreading structures made of gabions	Not part of Variant 1	Not part of Variant 2	New to Variant 3
K05	Action 5: Blocking of surface drains.	Present	Present	Present
	Action 14: Differentiated management according to natural habitats.	Present	Present	Present
	Action 24: Protection and conservation of typical wetland habitats.	Present	Present	Present
K06	Action 6: Planting of native plant species adapted to the wetland environment (based on the plant species found in the existing natural area in the southeast of the wetland).	Present	Present	Present

Location	Comprehensive list of actions	Variant 1	Variant 2	Variant 3
	Action 7: Reprofiling of the river with the creation of meanders and banks with different levels.	Present	Present	Not part of Variant 3
	Action 8: Filling of the old minor bed of the watercourse.	Present	Present	Not part of Variant 3
	Action 9: Planting the banks with local plant species according to the water level.	Present	Present	Present
	Action 20: Stream protection zone with a vegetated riparian buffer.	Present	Present	Present
	Action 25: Diversion of the river into the original flow (thalweg bottom) with potential to upgrade the existing wetland (with good potential), restoring and meandering the old channel to create a small delta).	Present	Present	Present
	Action 34: Installation of flow spreading structures made of gabions.	Not part of Variant 1	Not part of Variant 2	New to Variant 3
K07	Action 5: Blocking of surface drains to limit the lowering of the groundwater and increase the residence time of the water in the wetland.	Present	Present	Present
	Action 6: Planting of local plant species adapted to the wetland environment (based on the plant species found in the existing natural area in the southeast of the wetland).	Present	Present	Present
	Action 7: Reprofiling of the river with the creation of meanders and banks with different levels.	Present	Present	Not part of Variant 3
	Action 8: Filling of the old minor bed of the watercourse.	Present	Present	Not part of Variant 3
	Action 9: Planting the banks with local plant species according to the water level.	Present	Present	Present
	Action 20: Stream protection zone with a vegetated riparian buffer.	Present	Present	Present

Location	Comprehensive list of actions	Variant 1	Variant 2	Variant 3
	Action 25: Diversion of the river into its original flow (thalweg bottom) with potential to upgrade the existing wetland (with good potential), restoring and meandering the old channel to create a small delta.	Present	Present	Not part of Variant 3
	Action 34: Installation of flow spreading structures made of gabions.	Not part of Variant 1	Not part of Variant 2	New to Variant 3
K08	Action 11: Riprap at the outlet of urban discharges.	Present	Present	Present
	Action 12: Constructed wetland will act as buffer zones at urban discharges, sized for qualitative and quantitative water management (sizing according to the catchment area and water quality).	Present	Present	Present
	Action 13: Reprofiling of the hydraulic outlets from the discharges (creation of banks with different levels) and reconnection with the river.	Present	Present	Present
K09	Action 11: Riprap at the outlet of urban discharges.	Present	Present	Present
	Action 12: Constructed wetland will act as buffer zones at urban discharges, sized for qualitative and quantitative water management (sizing according to the catchment area and water quality).	Present	Present	Present
	Action 13: Reprofiling of the hydraulic outlets from the discharges (creation of banks with different levels) and reconnection with the river.	Present	Modified to avoid connecting the outlets of urban to the lake (to divert polluted water away from the lake)	Present
See presentation sheets	Action 28: Creation of a circuit of pedestrian/cycling routes	Present	Action 28 would be modified to accommodate a lake, recreational activities would	Action 28 is modified, as the size of recreational activities would be reduced due to the presence of flow spreading

Location	Comprehensive list of actions	Variant 1	Variant 2	Variant 3
			be reduced to dry areas	structures made of gabions.

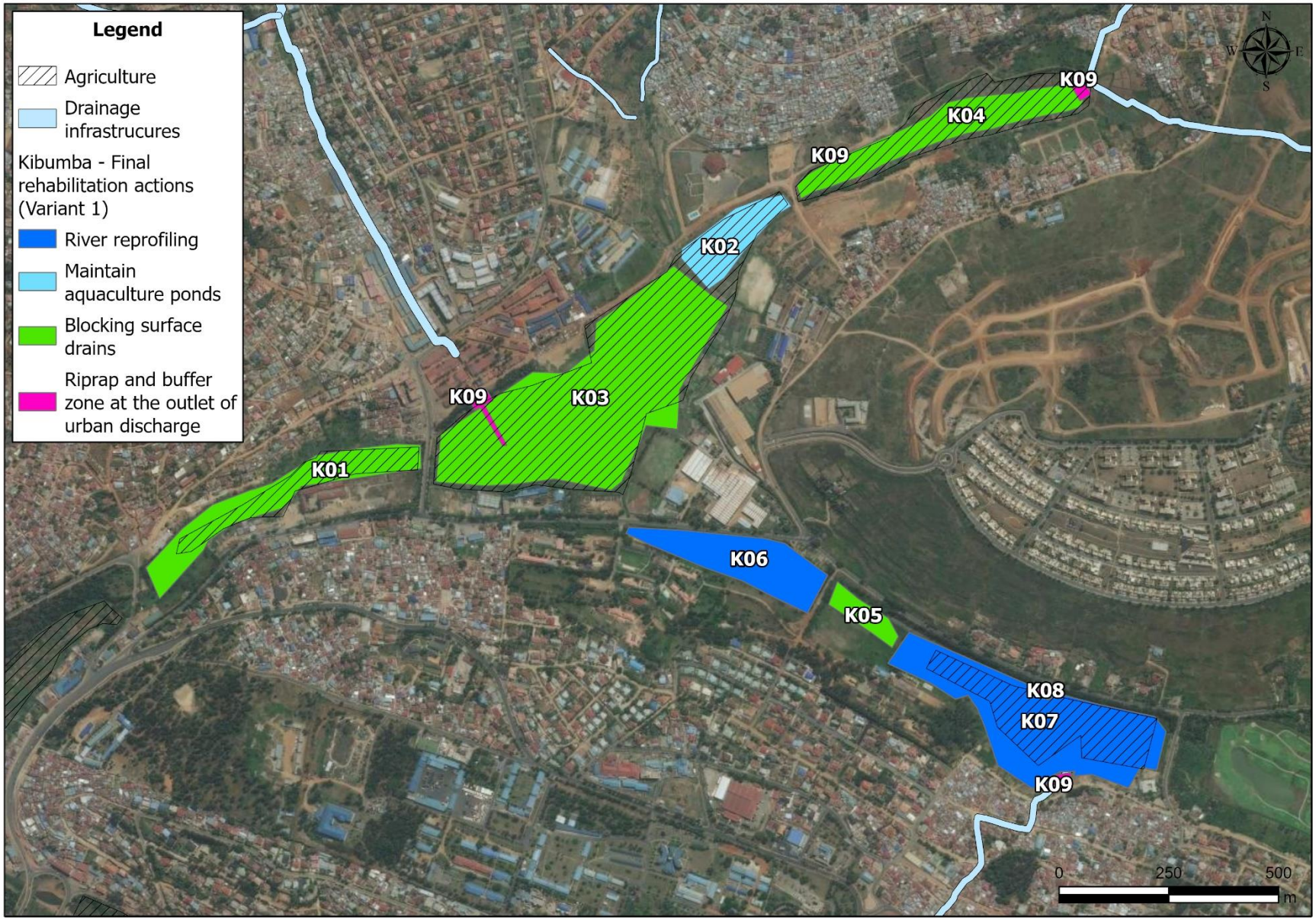


FIGURE 5-13 ACTIONS IN VARIANT 1 KIBUMBA

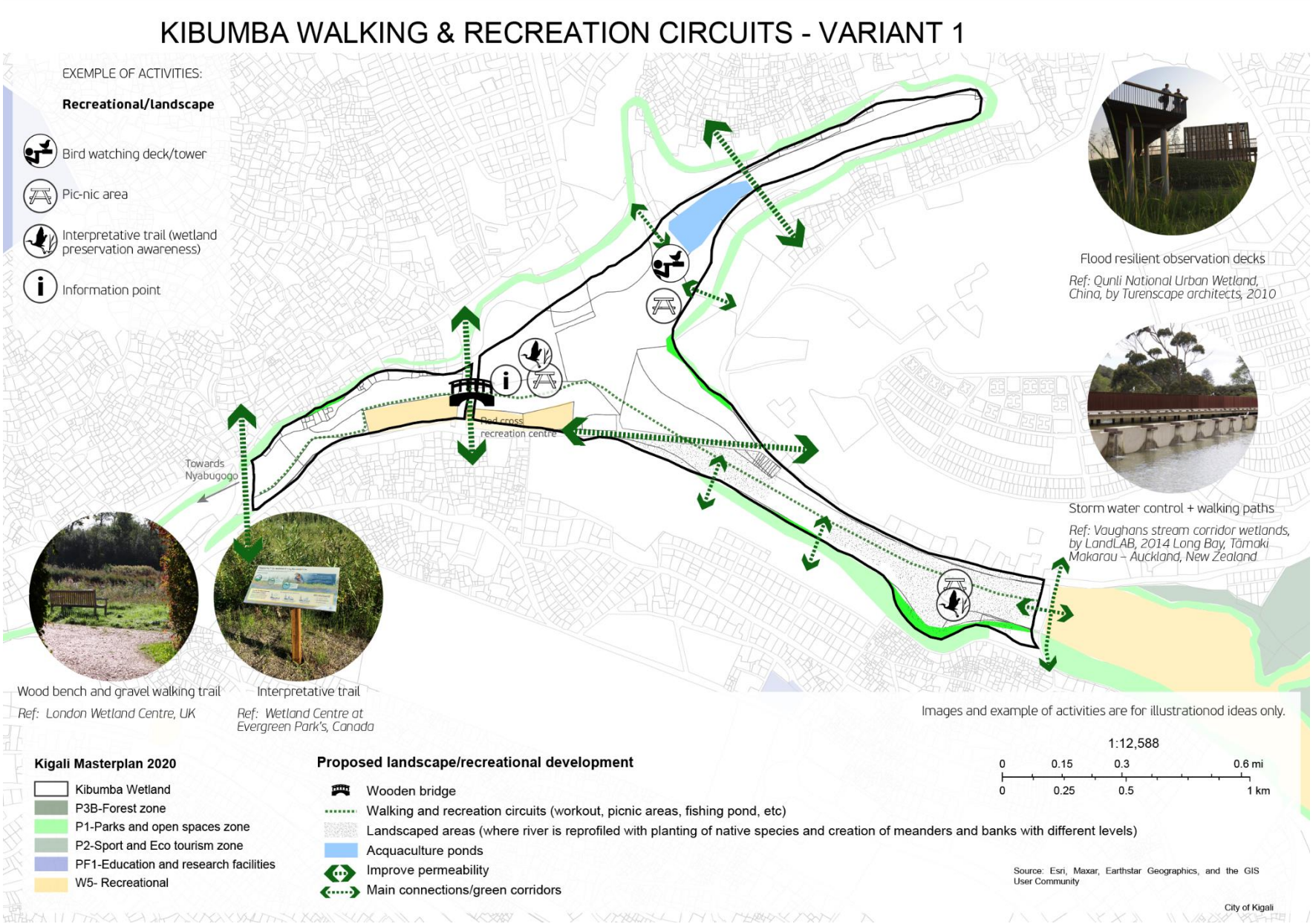


FIGURE 5-14 KIBUMBA WALKING AND RECREATION CIRCUITS UNDER VARIANT 1

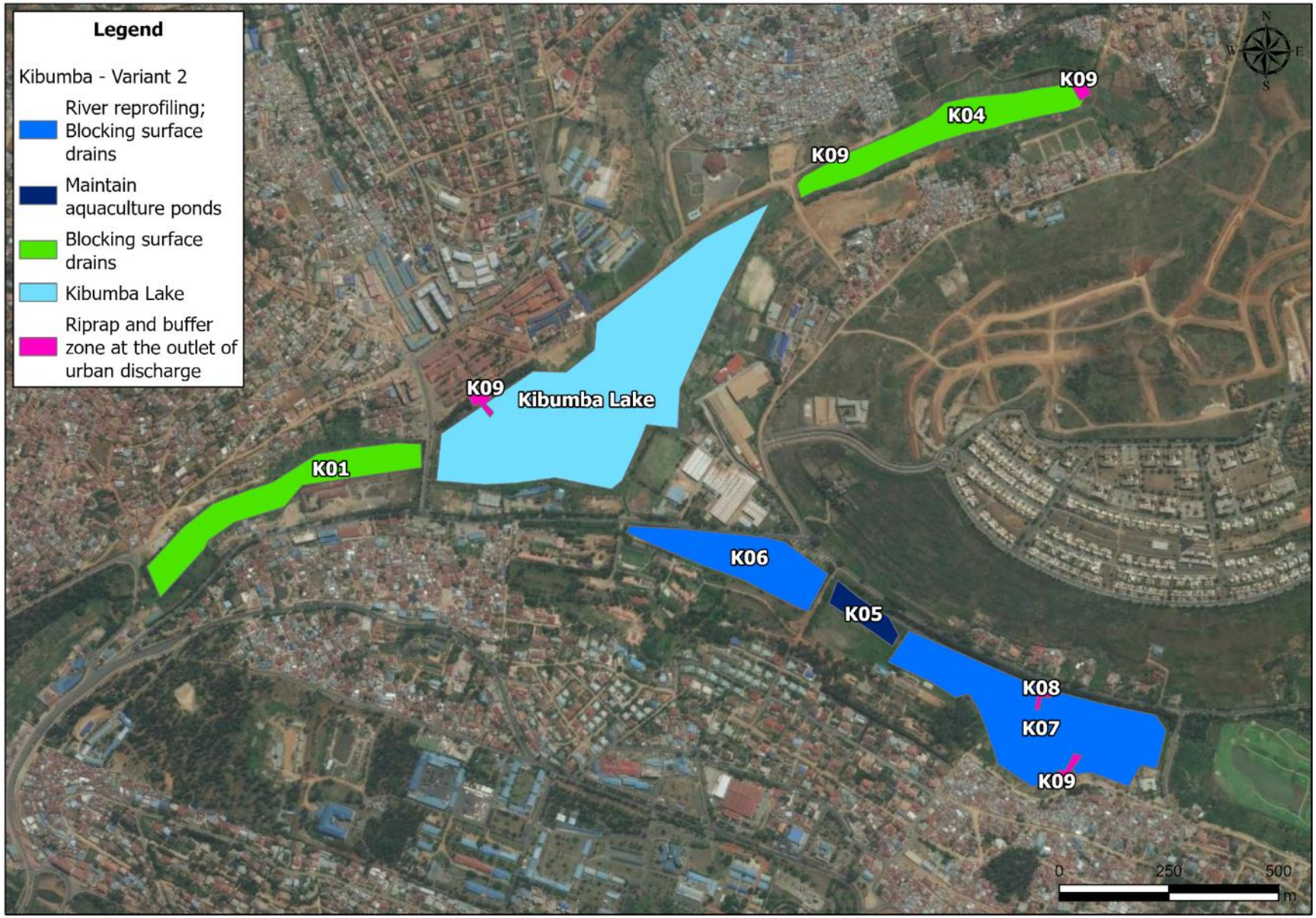


FIGURE 5-15 ACTIONS IN KIBUMBA VARIANT 2

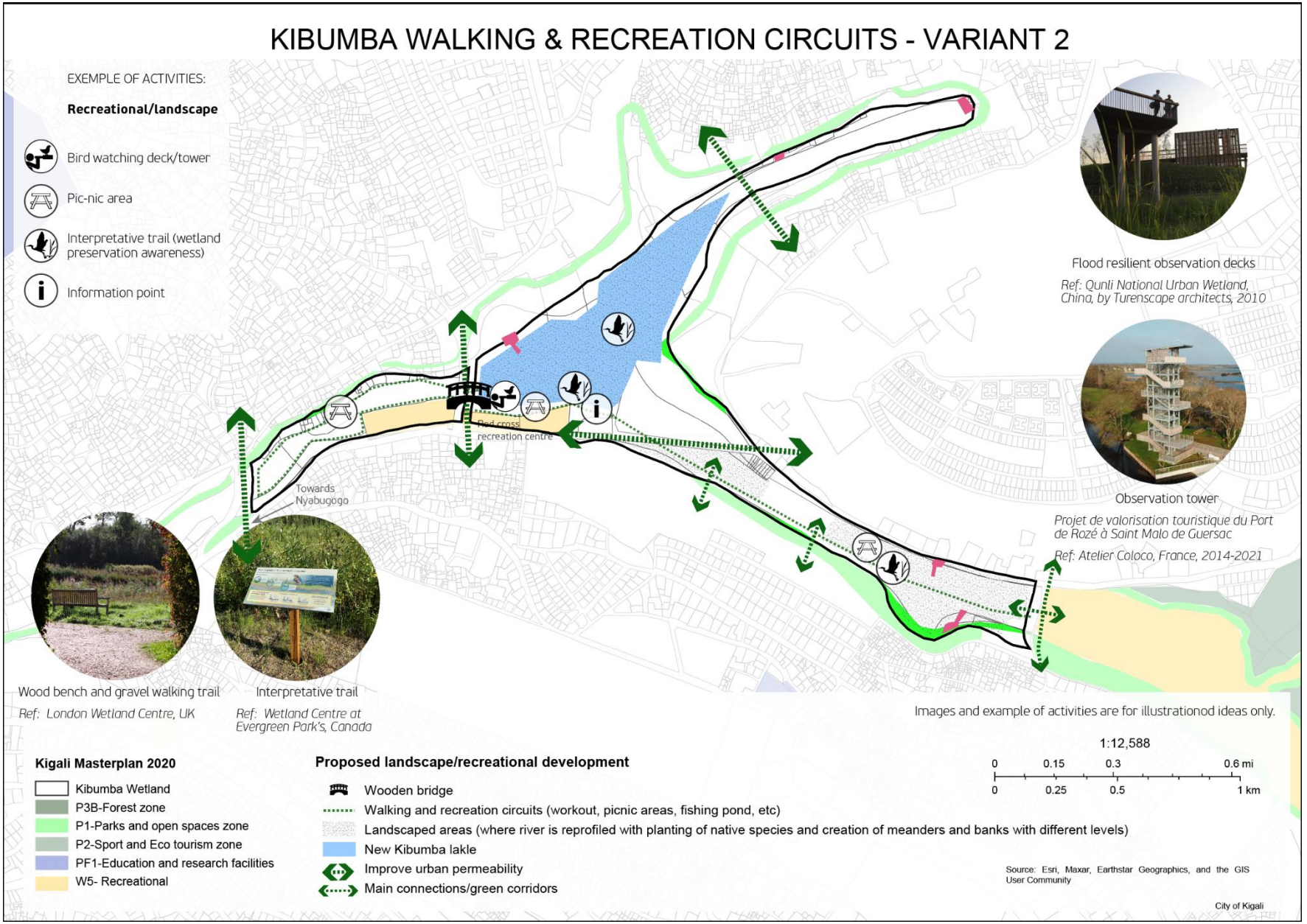


FIGURE 5-16 KIBUMBA WALKING AND RECREATION CIRCUITS UNDER VARIANT 2

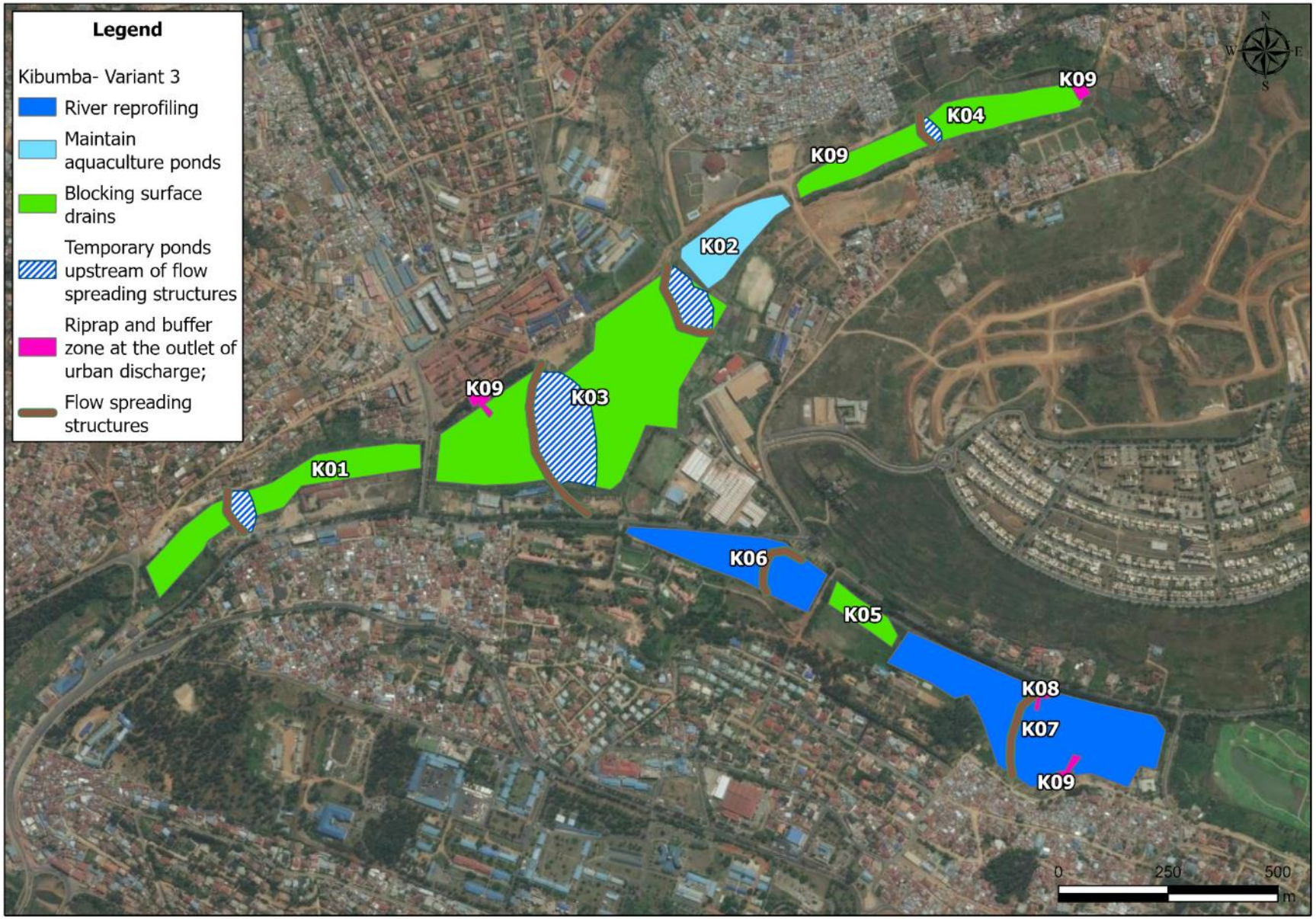


FIGURE 5-17 ACTIONS IN KIBUMBA VARIANT 3

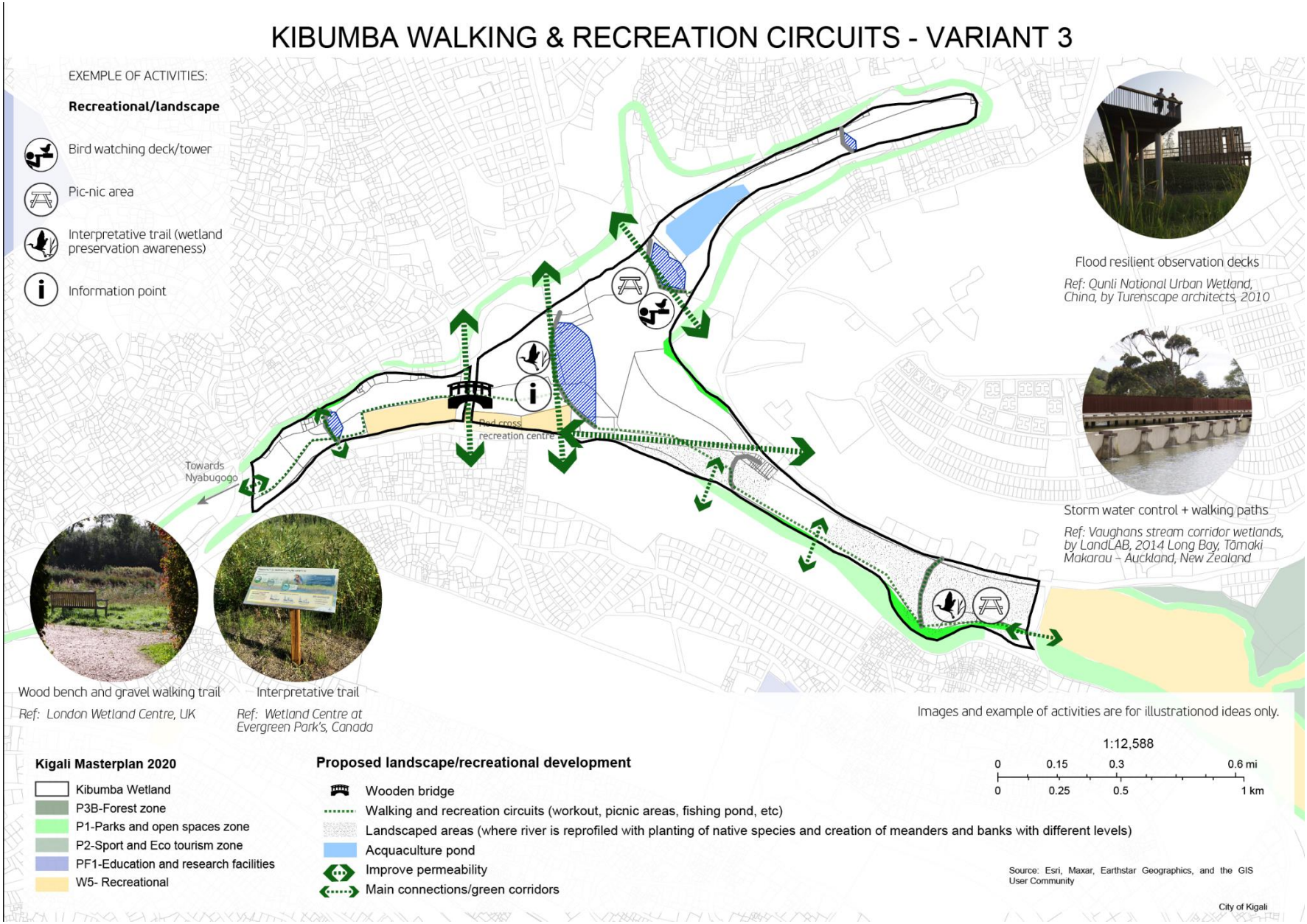


FIGURE 5-18 KIBUMBA WALKING AND RECREATION CIRCUITS UNDER VARIANT 3

5.6 NYABUGOGO LOWER

A. SPECIFIC WETLAND REHABILITATION GOALS

Goals and objectives for Nyabugogo Lower are presented at section 4.16:

- Progressive replacement of unsustainable agricultural activities in accordance with the City' Master Plan and wetland habitat reclamation in more than 80% of the Nyabugogo wetland.
- End of floods affecting infrastructure such as roads.
- Creation of a waterfront to improve the city's landscape.
- Recreation of the natural profile of the river downstream.
- Natural treatment of stormwater at all outlets of urban drains and reduction of turbidity and water pollution for key parameters at reconnections with rivers.
- Reduction of turbidity and water pollution for key parameters in rivers and streams.
- Increase in the richness of water-dependent species of birds, amphibians and plants with an increase attractiveness for flagship bird species.
- Reduction of coverage of the water hyacinth in the large pond in Nyabugogo.

B. SPECIFIC ACTIONS

The following maps shows the three variants and the associated recreational activities that are proposed.

Each area is identified with a code (N02, N03, etc.) that refers to a specific action and location.

The use of colors in the boxes allows to easily find the correspondent location.

Green boxes	Refer to removal of agricultural activities and blocking of agricultural drains and removal of backfills along watercourses
Blue boxes	Refer to modification of watercourses (river reprofiling)
Orange boxes	Refer to recreational and/or landscape development
Purple boxes	Refer to constructed wetlands at the outlet of urban drains (buffer zones)

The following tables is a presentation of key restoration treatment prescriptions for Variant 1, 2, and 3. These are presented as Actions.

TABLE 5-5 ALL ACTIONS FOR NYABUGOGO

Location	Comprehensive list of actions	Variant 1	Variant 2	Variant 3
N01 N02 N03	Action 11: Riprap at the outlet of urban discharges.	Present	Present	Present
	Action 12: Constructed wetland will act as buffer zones at urban discharges, sized for qualitative and quantitative water management (sizing according to the catchment area and water quality).	Present	Present	Present
	Action 13: Reprofiling of the hydraulic outlets from the discharges (creation of banks with different levels) and reconnection with the Nyabugogo River and its natural channels.	Present	Present	Present
N04	Action 1: Raising the water level of the river in order to limit the lowering of the groundwater and to favour the flooding of the river on the riparian plots.	Present	Not part of Variant 2	Not part of Variant 3
	Action 7: Reprofiling of the Nyabugogo River with the creation of meanders and banks with different levels.	Present	Not part of Variant 2	Not part of Variant 3
	Action 8: Filling of the old minor bed of the watercourse.	Present	Not part of Variant 2	Not part of Variant 3
	Action 9: Planting the banks with native plant species according to the water level and tolerance to wetness.	Present	Not part of Variant 2	Present
	Action 20: Stream protection zone with a vegetated riparian buffer.	Present	Not part of Variant 2	Present
	Action 26: Creation of a delta before the confluence of the Nyabugogo River and its right bank tributary (Rwenzagoro River).	Present	Not part of Variant 2	Not part of Variant 3
	Action 33: Creation of a lake in Nyabugogo	Not part of Variant 1	New to Variant 2	Not part of Variant 3
	Action 34: Installation of flow spreading structures made of gabions.	Not part of Variant 1	Not part of Variant 2	New to Variant 3
	Action 27: Management to limit the expansion of water hyacinth and increase of the size of the existing lake.	Present	Present	Present

Location	Comprehensive list of actions	Variant 1	Variant 2	Variant 3
N05	Action 10-N: Development of Nyabugogo Wetland Centre.	Present	Modified to adapt to the presence of a lake	Modified as the size of recreational activities would be reduced due to the presence of flow spreading structures made of gabions.
N06	Action 5: Blocking of surface drains (agriculture ditches) to limit the lowering of the groundwater and increase the residence time of the water in the wetland.	Present	Present	Present
	Action 6: Planting of local plant species adapted to the wetland environment (based on the plant species found in the existing natural area in the center of the wetland Papyrus).	Present	Present	Present
	Action 18: Creation of a depression disconnected from the river which will be fed by flood water and the groundwater.	Present	Present	Not part of Variant 3
	Action 19: Diversification of natural habitats typical of wetlands through the creation of a mosaic of depressions.	Present	Present	Present
	Action 34: Installation of flow spreading structures made of gabions.	Not part of Variant 1	Not part of Variant 2	New to Variant 3
N07	Action 5: Blocking of surface drains to limit the lowering of the groundwater and increase the residence time of the water in the wetland.	Present	Present	Present

Location	Comprehensive list of actions	Variant 1	Variant 2	Variant 3
	Action 6: Planting of native plant species adapted to the wetland environment (based on the plant species found in the existing natural area in the center of the wetland such as Papyrus).	Present	Present	Present
	Action 15: Clearance over a large along the river width to facilitate the overflow of the river during flood periods.	Present	Present	Present
	Action 34: Installation of flow spreading structures made of gabions.	Not part of Variant 1	Not part of Variant 2	New to Variant 3
N08 N09	Action 5: Blocking of surface drains (if any).	Present	Present	Present
	Action 14: Differentiated management according to natural habitats.	Present	Present	Present
	Action 24: Protection and conservation of typical wetland habitats.	Present	Present	Present
N11	Action 28: Creation of a circuit of pedestrian/cycling routes	Present	Action 28 would be modified to accommodate a lake, recreational activities would be reduced to dry areas	Action 28 is modified, as the size of recreational activities would be reduced due to the presence of flow spreading structures made of gabions.

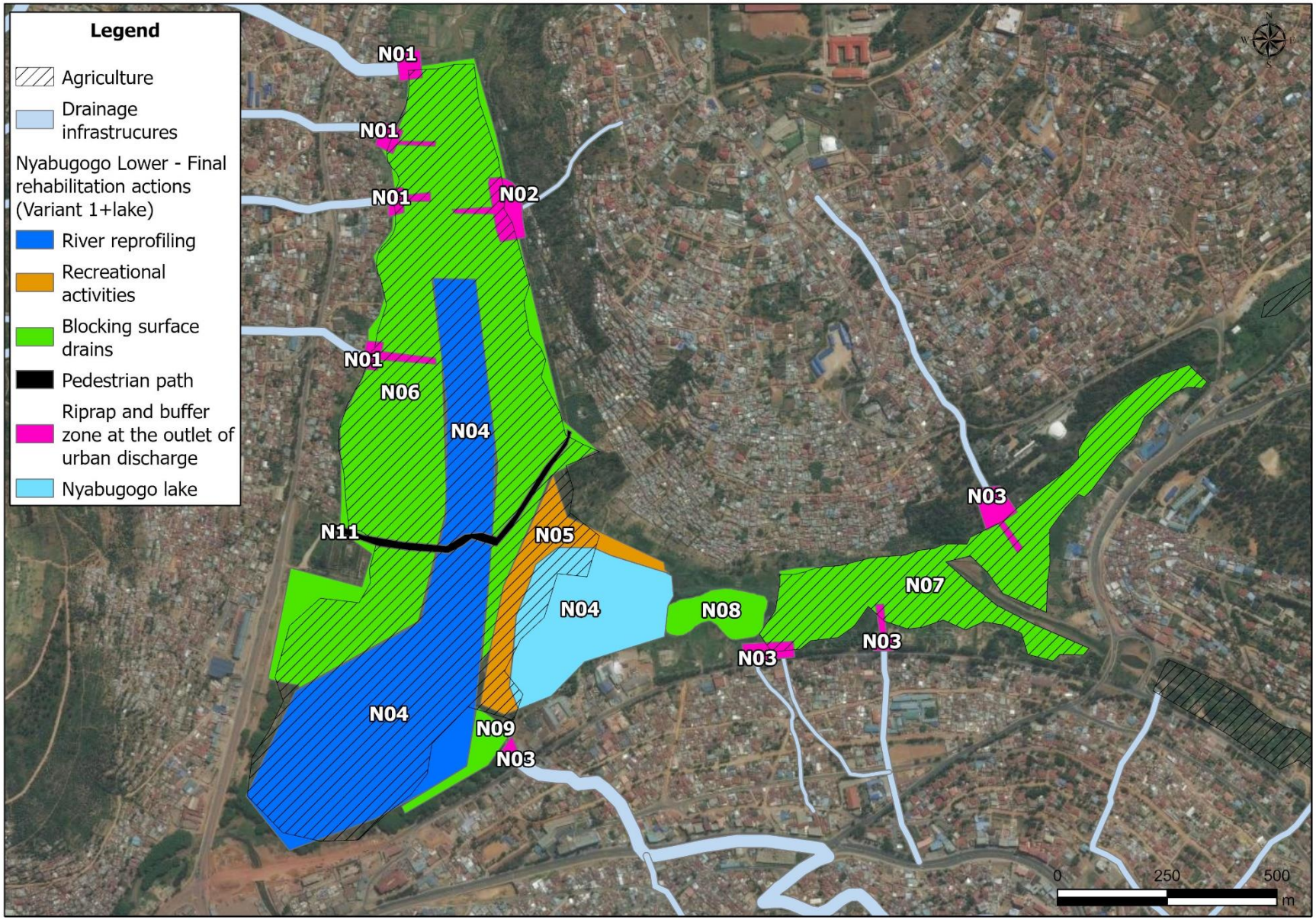


FIGURE 5-19 ACTIONS IN VARIANT 1 NYABUGOGO

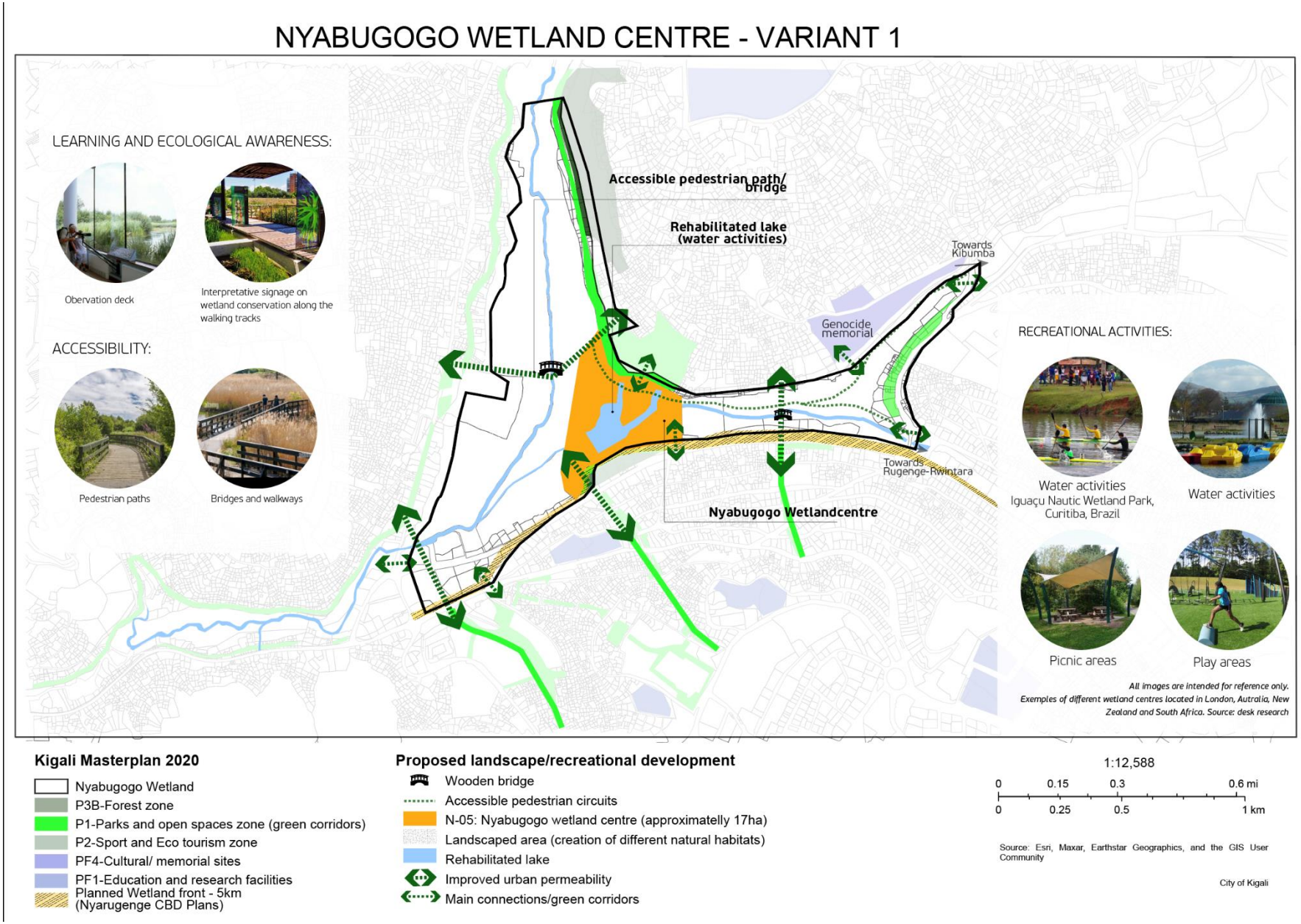


FIGURE 5-20 NYABUGOGO WETLAND CENTER UNDER VARIANT 1

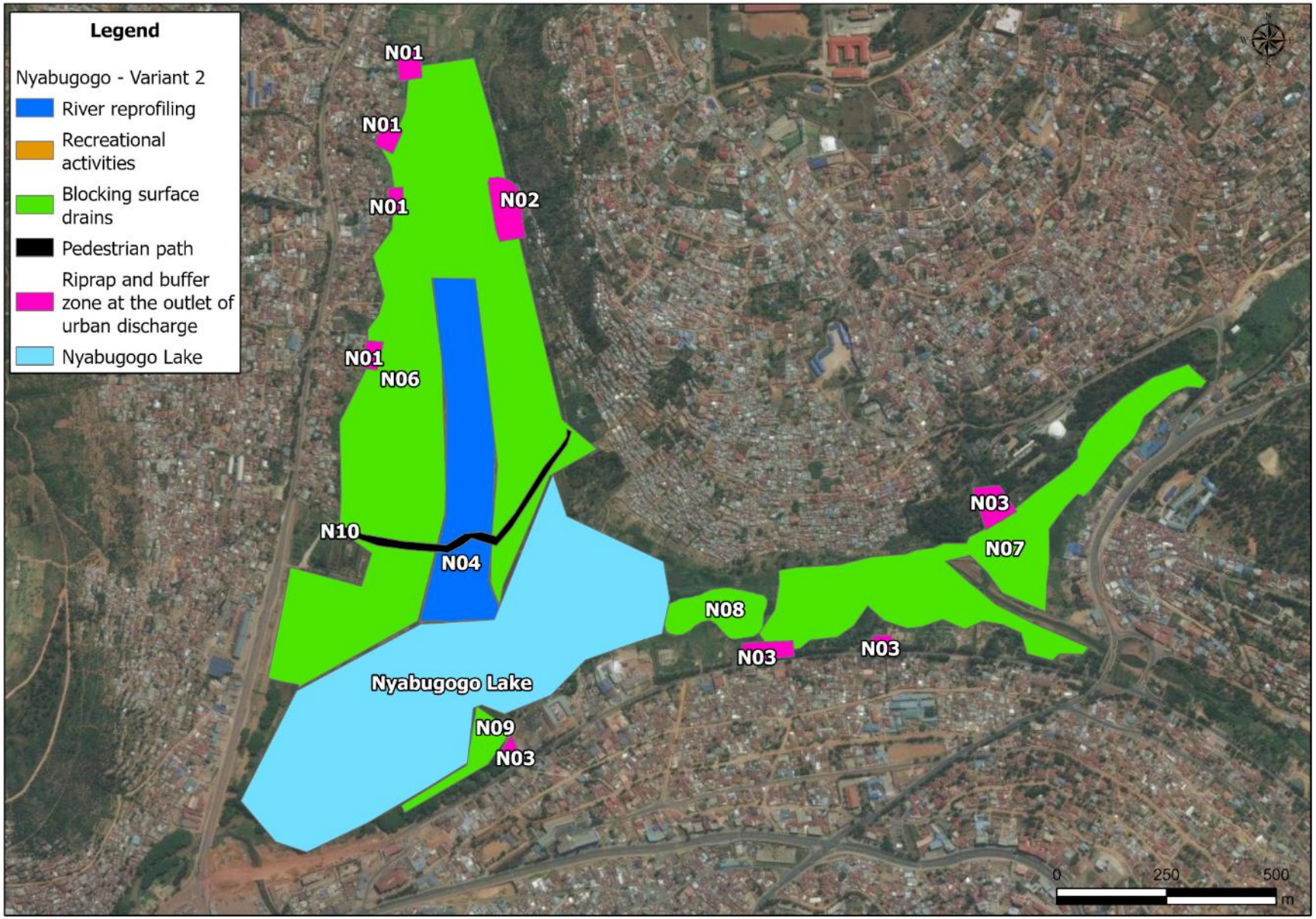


FIGURE 5-21 ACTIONS IN NYABUGOGO VARIANT 2

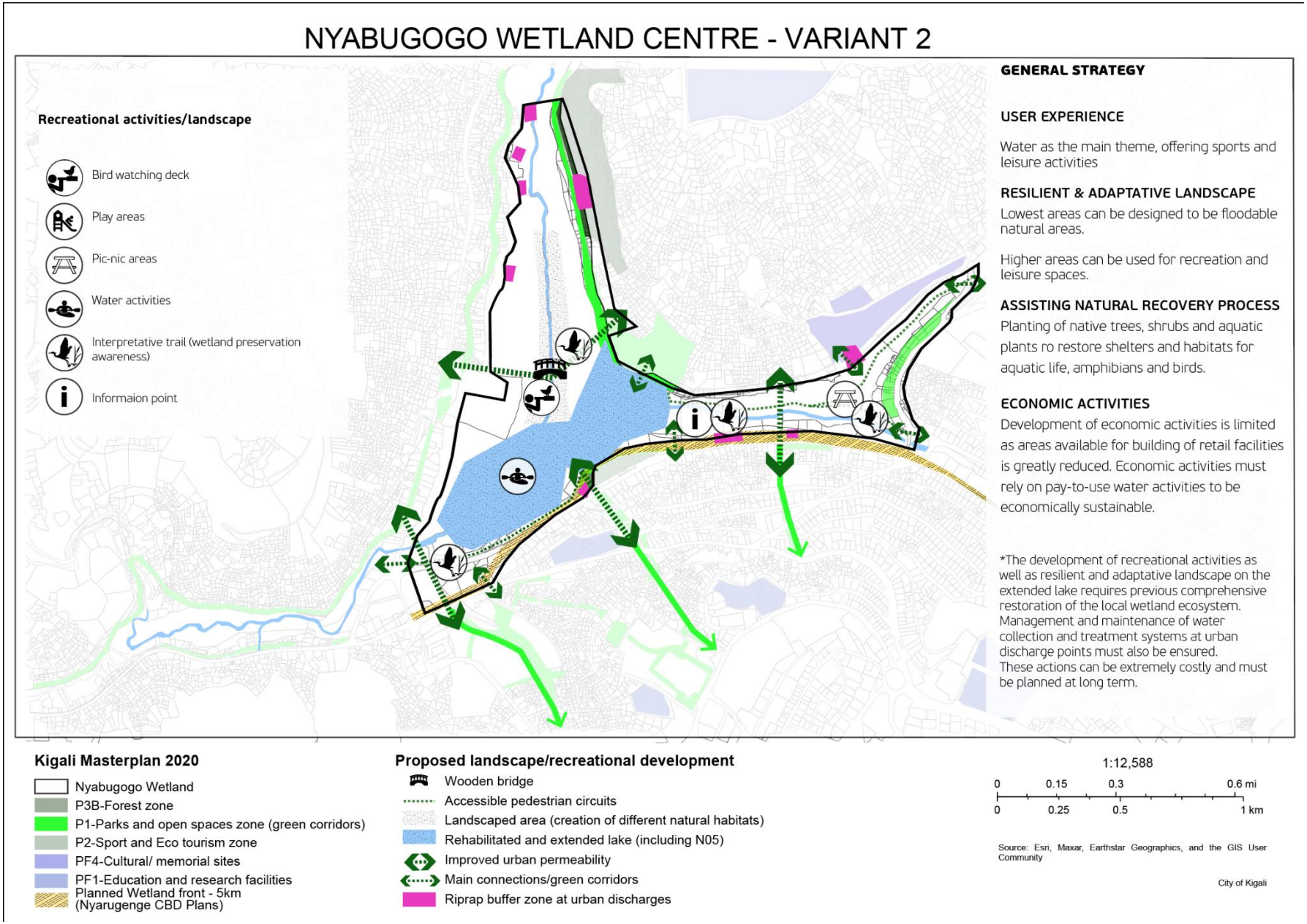


FIGURE 5-22 NYABUGOGO WETLAND CENTER UNDER VARIANT 2

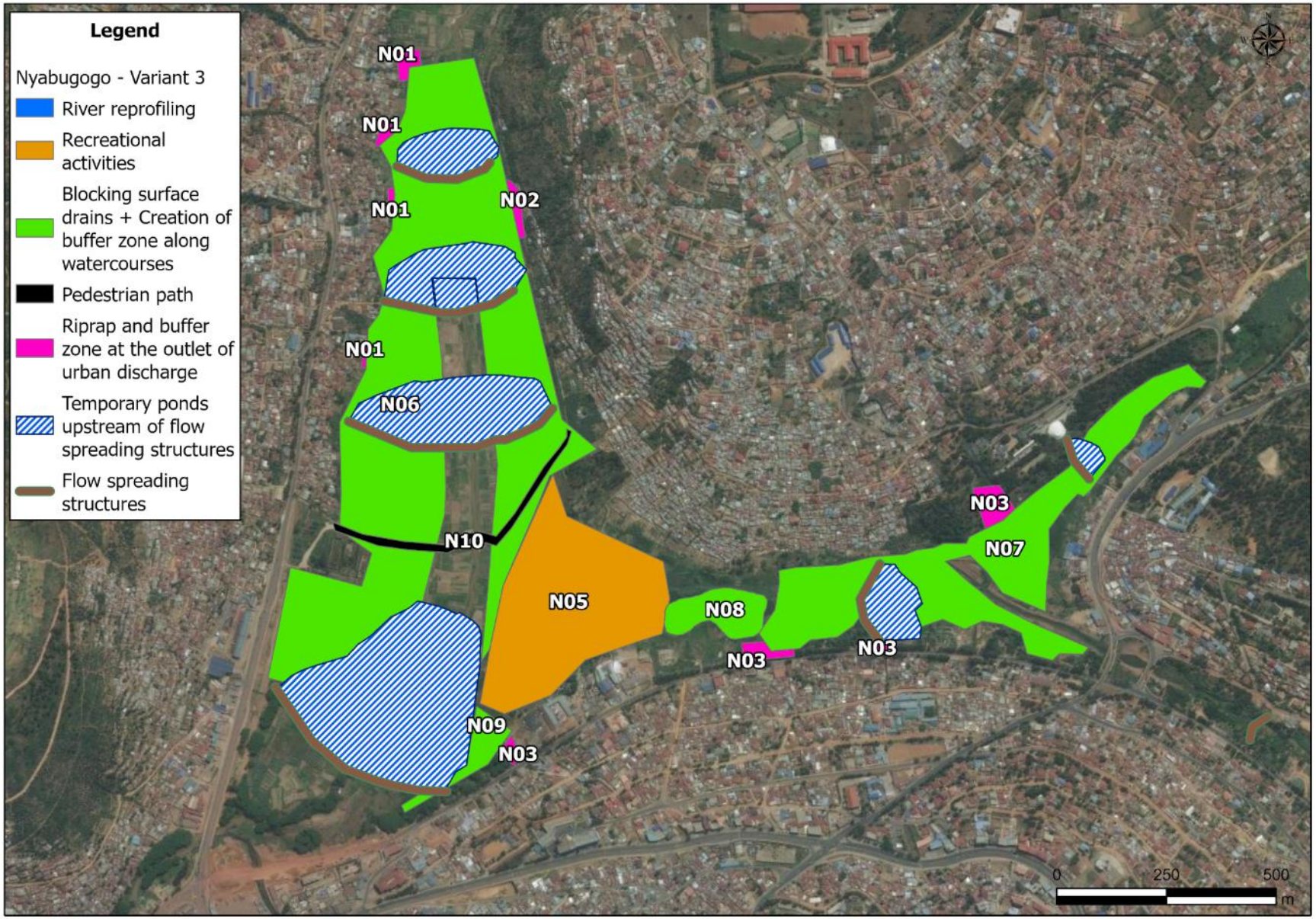


FIGURE 5-23 ACTIONS IN NYABUGOGO VARIANT 3

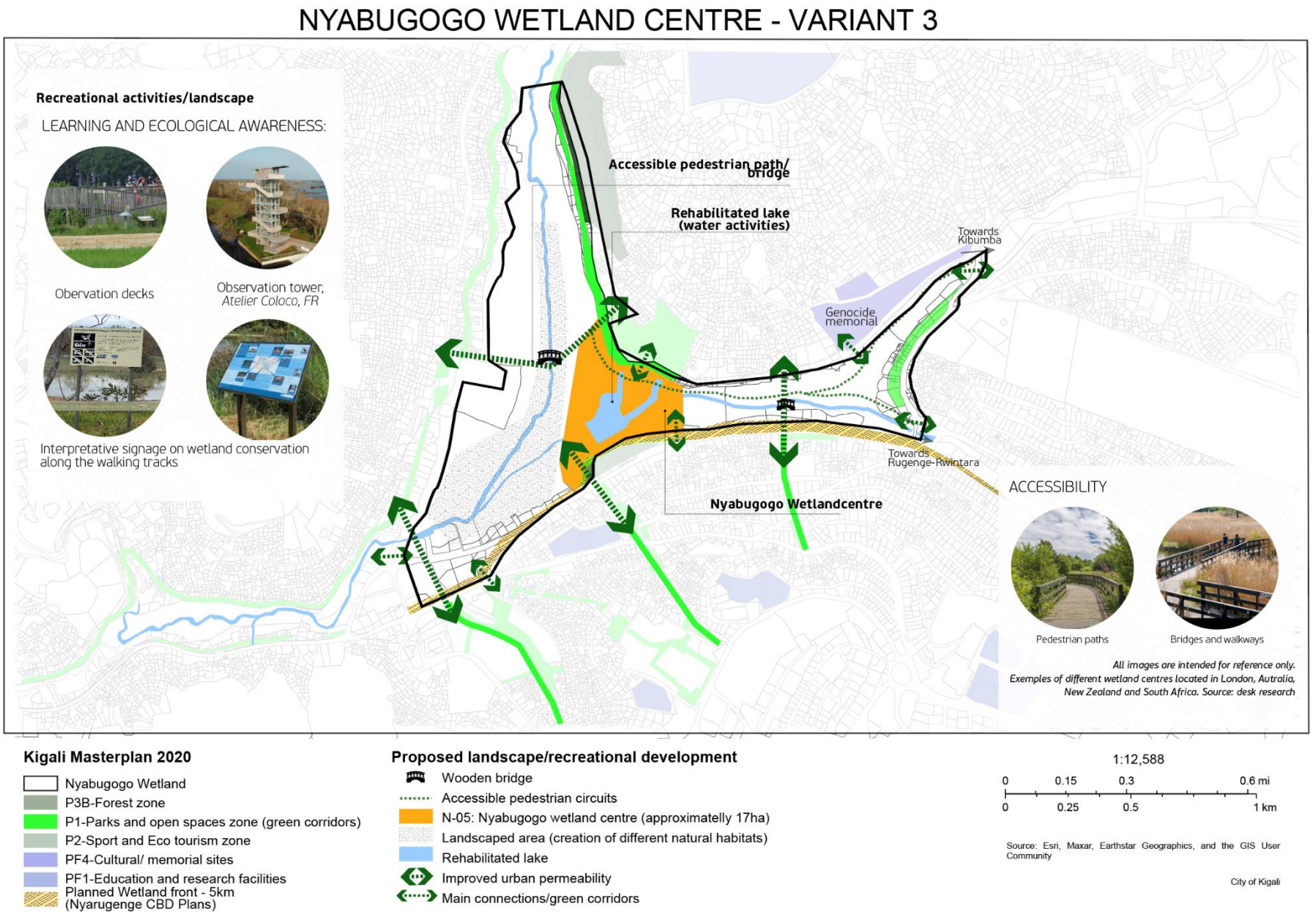


FIGURE 5-24 NYABUGOGO WETLAND CENTER UNDER VARIANT 3

5.7 MAINTENANCE REQUIREMENTS OF SOME ACTIONS

Regarding the following actions, the work shall be the subject of a technical follow-up:

- Action 1: Raising the water level in the outfalls or the river.
- Action 2: Creation of overflows on the two concrete canals to ensure overflow of water into the wetland during rainfall.
- Action 7: Re-profiling of the river with the creation of meanders and banks with different levels.

A follow-up of the profile of the restored banks and the minor bed will be carried out 6 months after the end of the work and then the year that follows. The frequency will be adapted according to the possible dysfunctions observed and the results of this follow-up.

Based on the follow-up, the followings will be characterized:

- Possible movements, departures or contributions of blocks.
- All possible traces of erosion, scouring on the zones od interventions as well as on the transition zones and the zones peripheral to the development not impacted by the works.
- All the elements of this follow-up will be recorded in a report. In conclusion, recommendations will be made on possible rework, the frequency of monitoring, and on future developments.

In addition, it is recommended to foresee maintenance of green spaces by:

- Foreseeing to clear some vegetation once a year and manage green wastes.
- Foreseeing pruning of trees and bushes.
- Monitoring of hydraulic infrastructure (culverts) to remove debris and allow free movement of water.

Sediment accumulation is a key issue in the wetlands. Buffer wetlands will have to be dredged on a regular basis to remove accumulated sediments. Removing sediments could be done manually or by an excavator. Dredging should be done at least every 7 years at the following actions:

- Action 3: Creation of buffer zones at the right of the overflows to ensure the treatment of the water before overflowing into the wetland and then the river.
- Action 12: Constructed wetland will act as buffer zones at urban discharges, sized for qualitative and quantitative water management (sizing according to the catchment area and water quality).
- Action 21: Natural weirs in cascade to limit floods.
- Action 27: Management to limit the expansion of water hyacinth and increase of the size of the existing lake.

5.8 CONFORMITY OF MEASURES WITH THE CITY MASTER PLAN

Actions were superimposed with the zoning regulation of the city to confirm the compliance with the zoning. As presented at section 4.5 there are no W-3 Sustainable Exploitation Zones in the wetlands.

Generally, all actions proposed are in line with the zoning regulation. Recreational activities are all going to be located in the W5 zone. Some comments are provided for each wetland.

- Gikondo:
  - Some proposed recreational activities (Eco-Valley) may expand in the W2 Rehabilitation zone, at this location they will however be accompanied by rehabilitation activities.
  - Areas designated for conservation (W4) will not be destroyed or impacted by recreational activities.
- Rwampara:
  - A very small section at the upstream end of Rwampara is identified for conservation (W4) but during field visits no special habitat was identified at this location.
- Rugenge-Rwintare:
  - The area designated for conservation (W4) is indeed the planted bamboo forest. Rehabilitation activities do not intend to remove the bamboo forest.

- Some proposed minor development for recreational activities may expand in the W2 Rehabilitation zone, at this location they will however be accompanied by rehabilitation activities.

- Kibumba
  - The area designated for conservation (W4) will remain untouched.
  - Some proposed minor developments for recreational activities may expand in the W2 Rehabilitation zone. At this location they will however be accompanied by rehabilitation activities.

- Nyabugogo Lower:
  - The waterfront located in the recreational area (W5) is acknowledged, some rehabilitation activities may be intertwined at this location in conformity with the purpose of W5 areas.

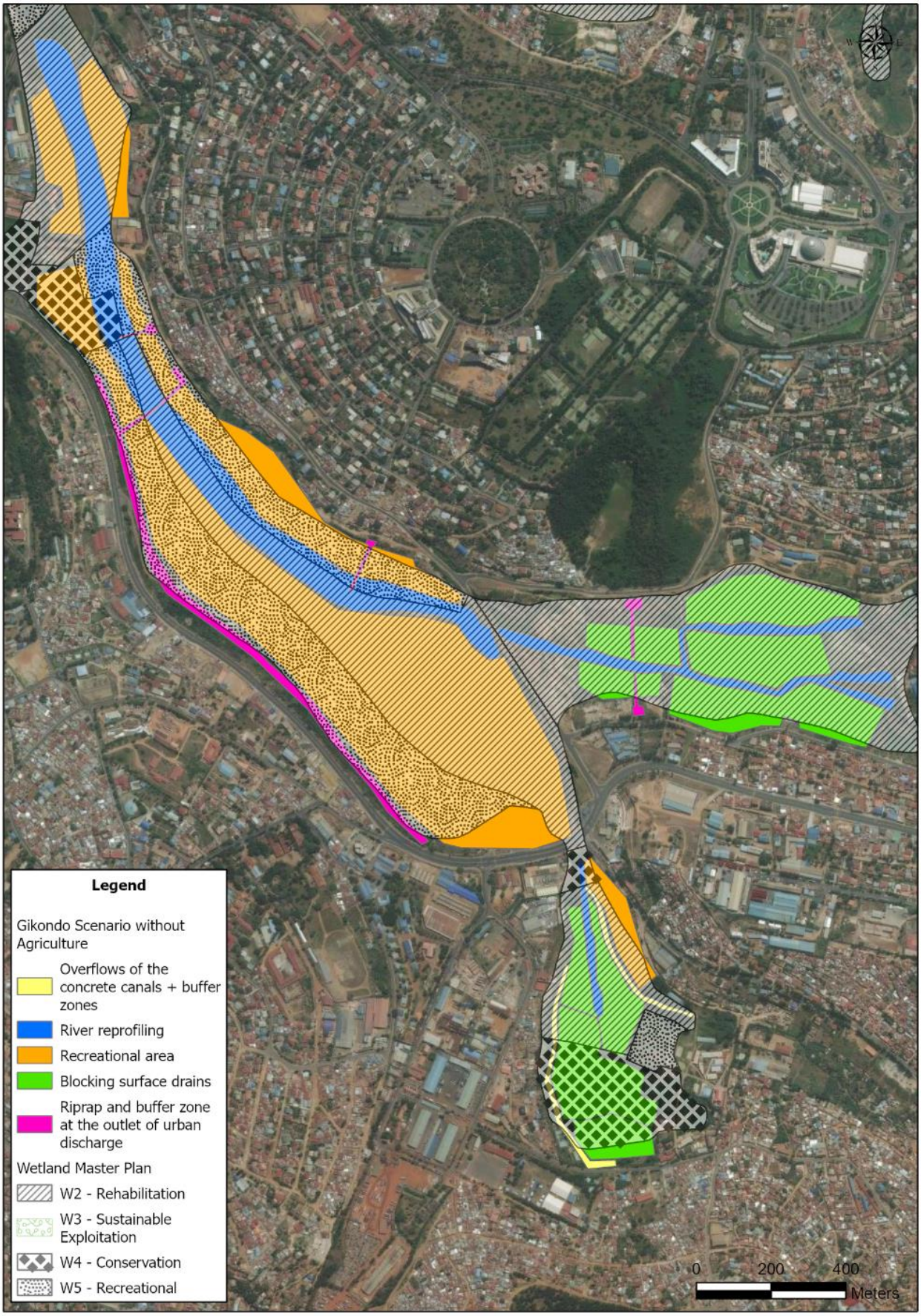


FIGURE 5-25 GIKONDO: CONFORMITY OF ACTIONS WITH THE ZONING REGULATION

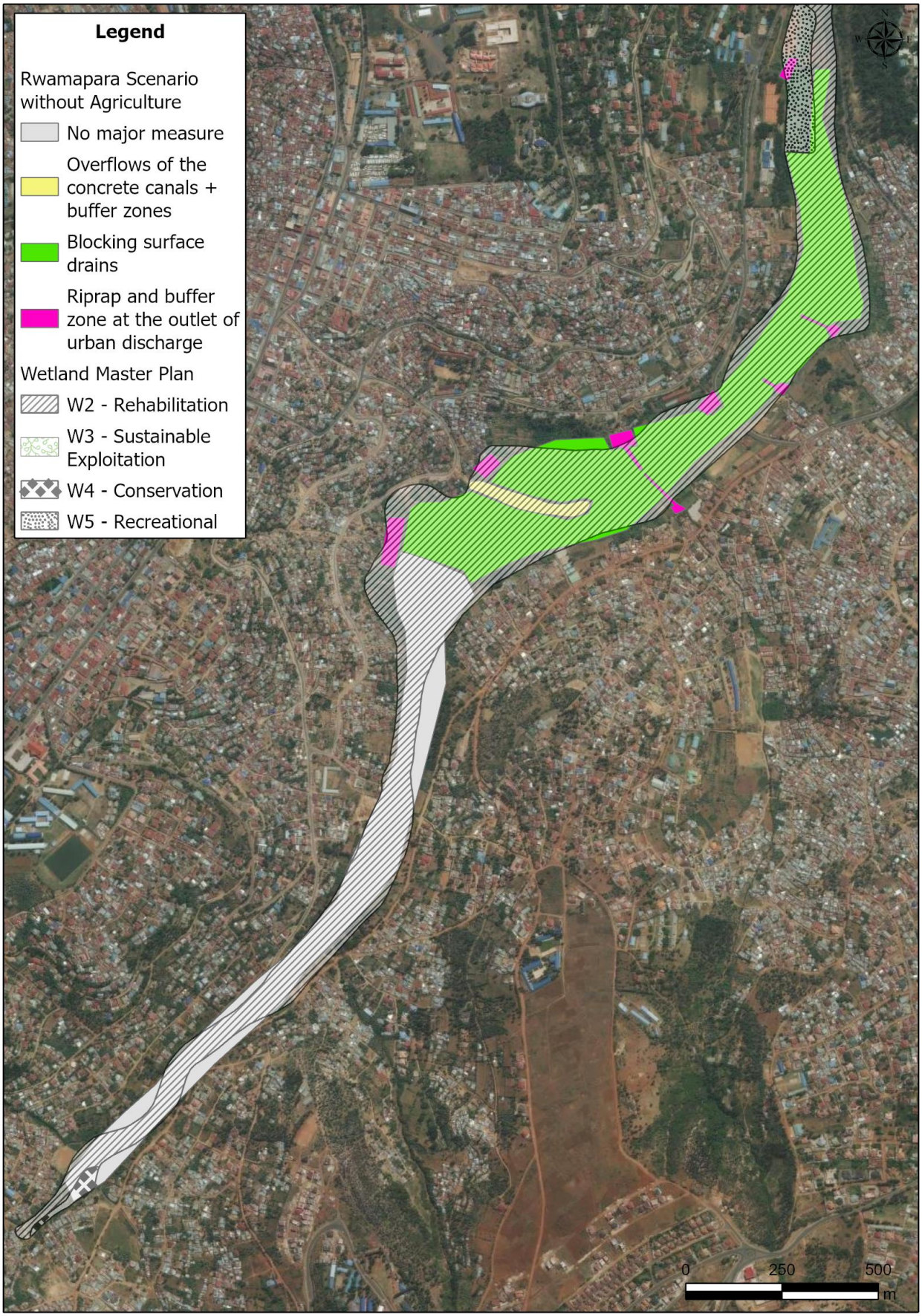


FIGURE 5-26 RWAMPARA: CONFORMITY OF ACTIONS WITH THE ZONING REGULATION

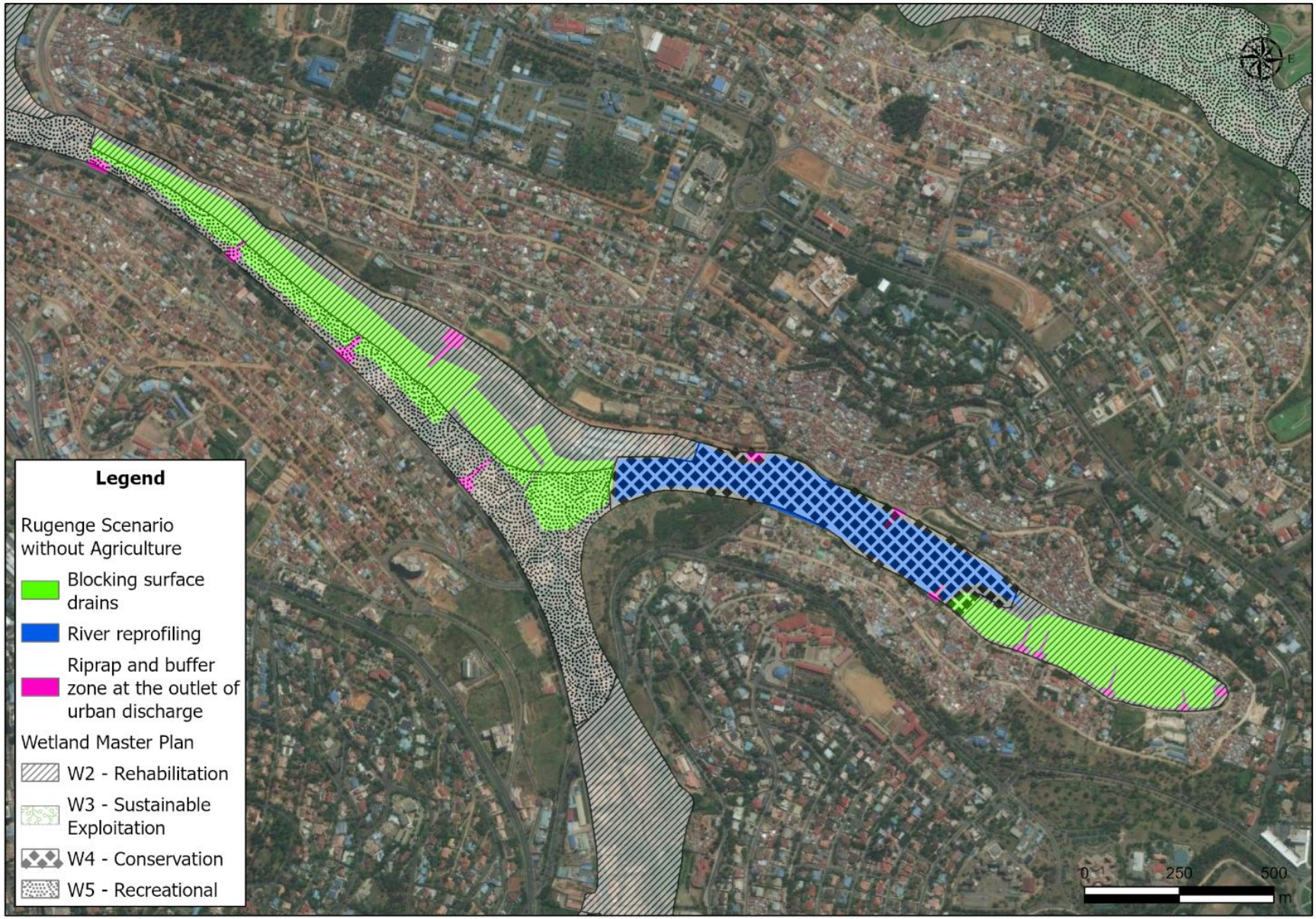


FIGURE 5-27 RUGENGE-RWINTARE: CONFORMITY OF ACTIONS WITH THE ZONING REGULATION

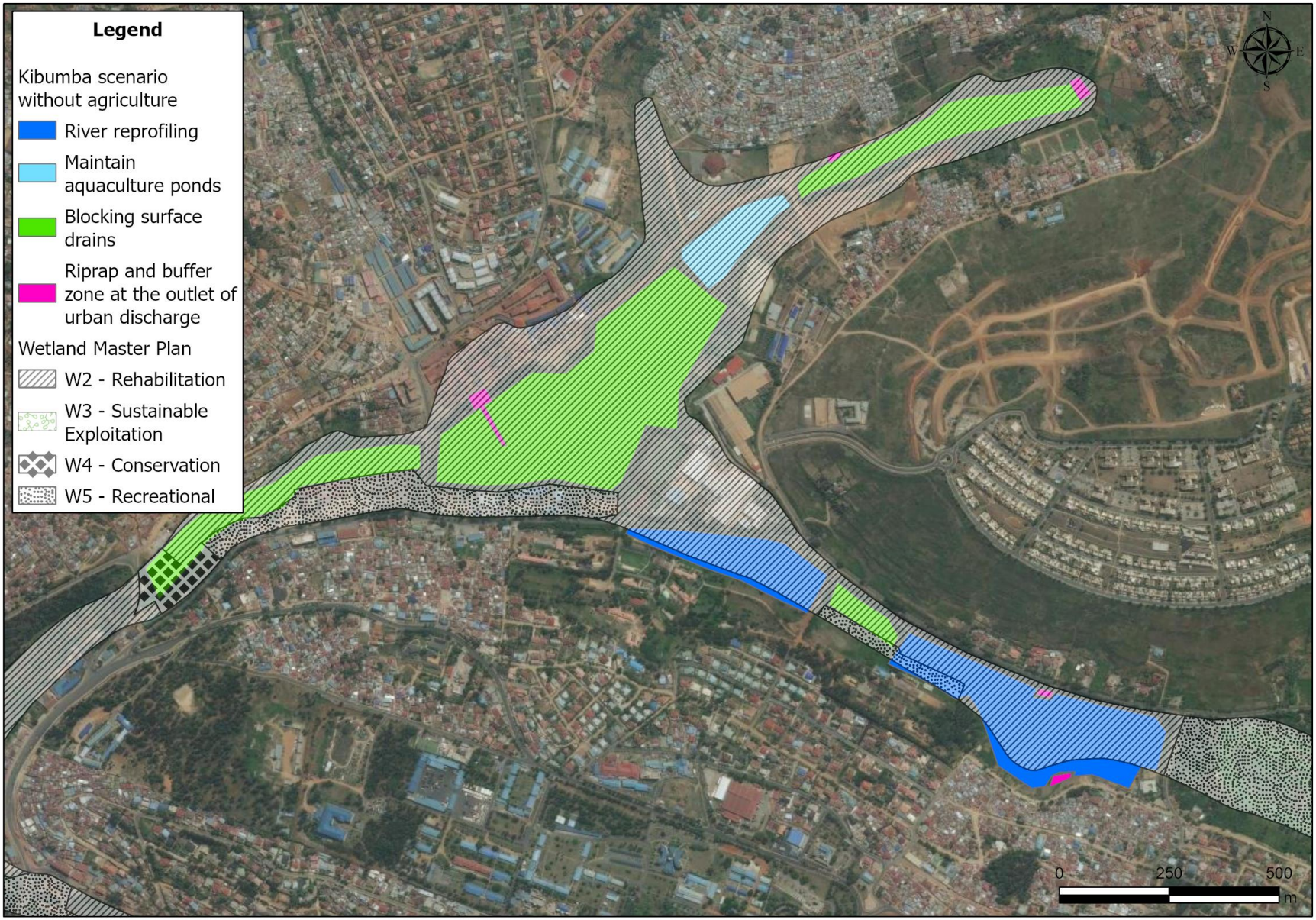


FIGURE 5-28 KIBUMBA: CONFORMITY OF ACTIONS WITH THE ZONING REGULATION

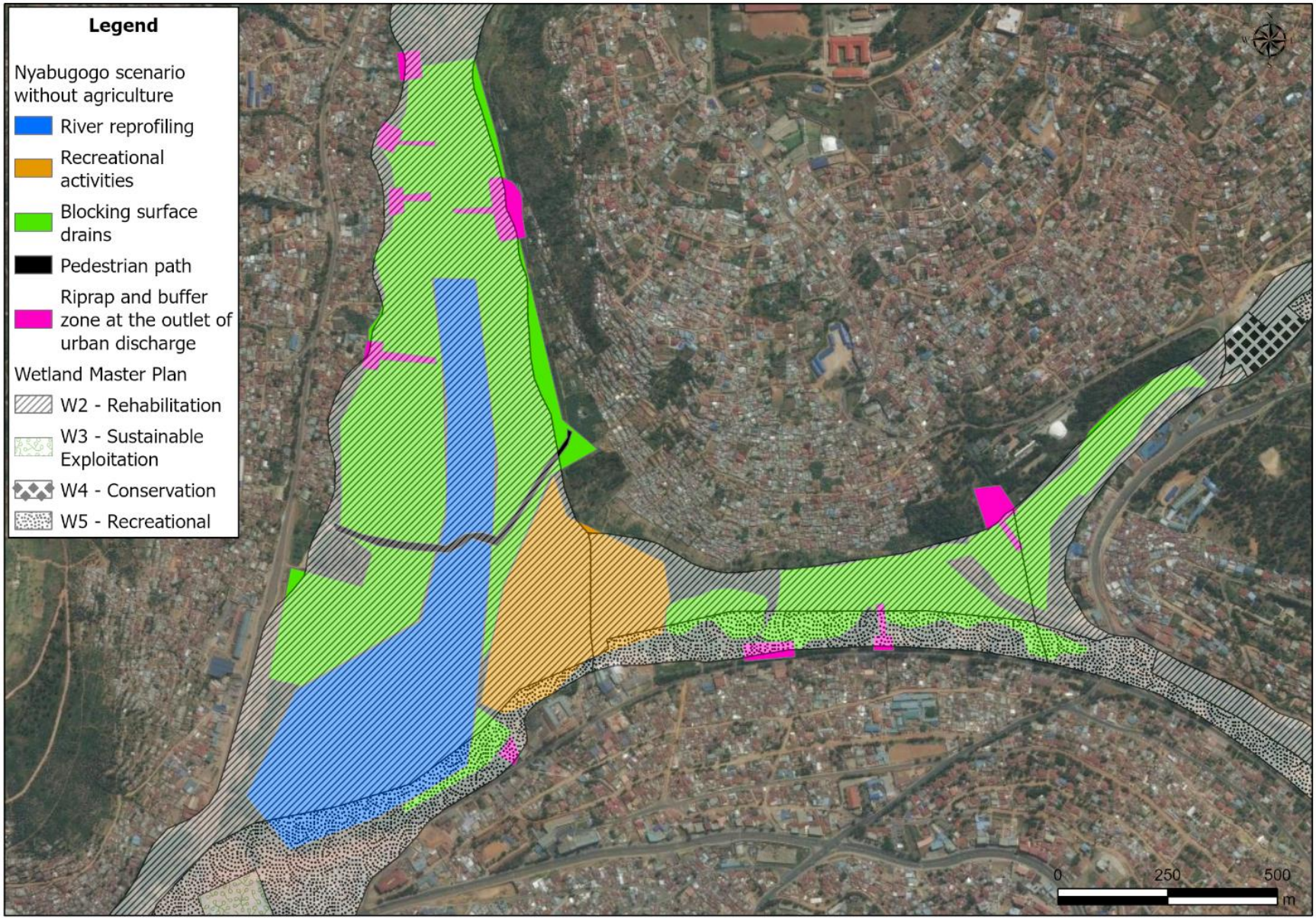


FIGURE 5-29 NYABUGOGO LOWER: CONFORMITY OF ACTIONS WITH THE ZONING REGULATION

5.9 COMPARISON OF PERFORMANCE BETWEEN VARIANTS

The comparison is based on project higher objectives. Variant 1 is an equilibrated approach, giving the same weight for all 4 project higher objectives while Variant 2 gives more value to landscape and recreational activities and Variant 3 to flood control. Wheel chart graphics for Variant 2 will therefore give more weight on landscape and recreational while wheel chart graphics for Variant 3 will give more weight on flood control as shown in the following two examples.

These results are based on a score from 1 to 10, 1 being low performances and 10 maximum performances. The higher the score, the better the Variant.

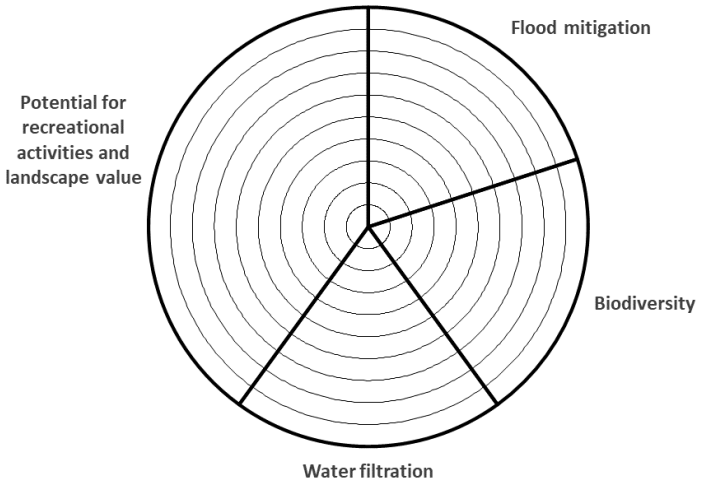


FIGURE 5-30 ADDITIONAL WEIGHT ON THE LANDSCAPE AND RECREATIONAL CRITERIA FOR VARIANT 2

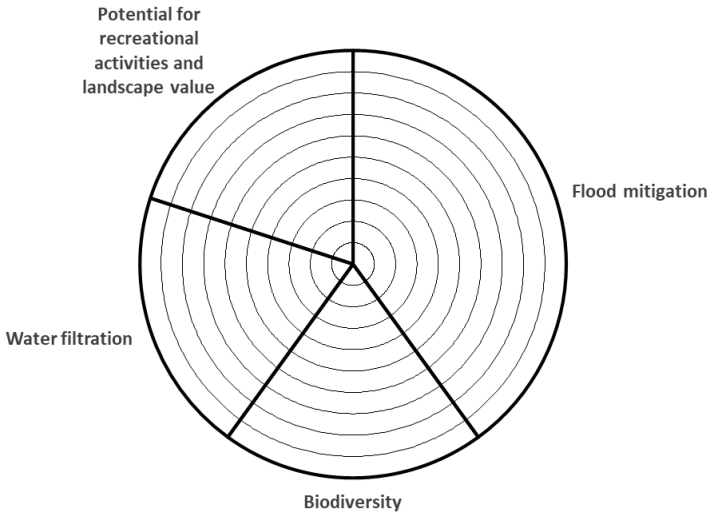
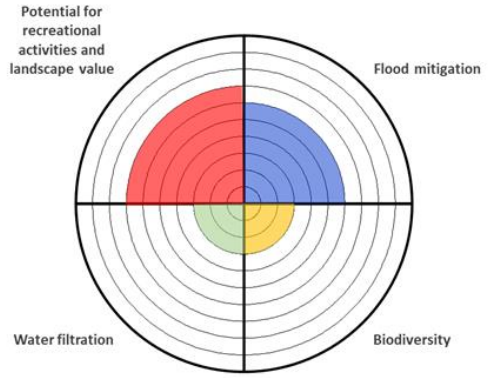


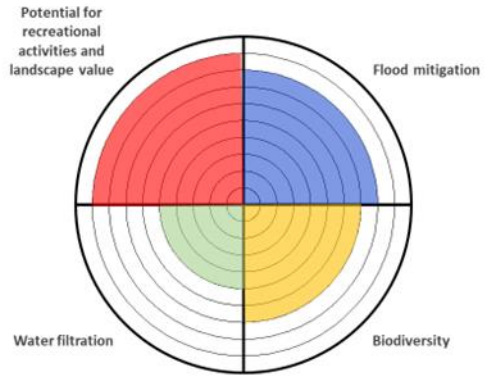
FIGURE 5-31 ADDITIONAL WEIGHT ON THE FLOOD MITIGATION CRITERIA FOR VARIANT 3

Appendix 4 presents the detail comparative analyse between Variants using the multicriteria analysis that was used to calculate scores for each variant. This section only presents the results of this analysis.

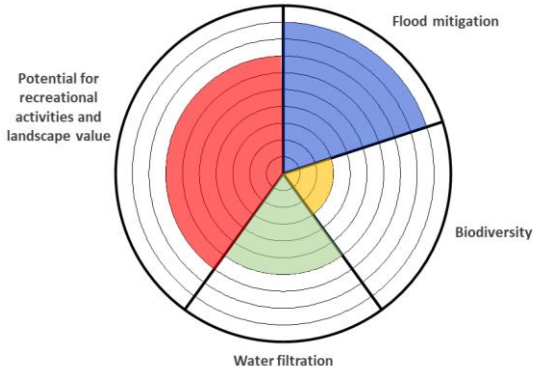
5.9.1 Comparison of performances between variants for Gikondo



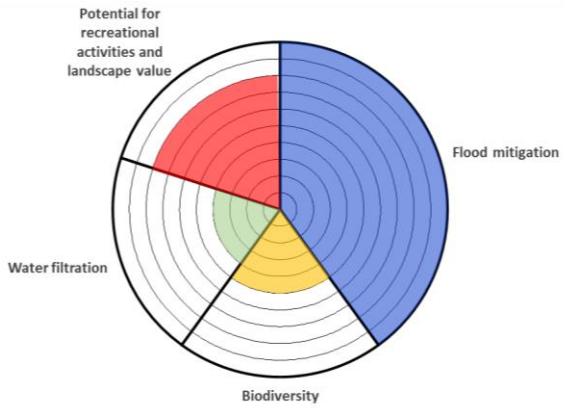
Gikondo at baseline



Gikondo, Variant 1

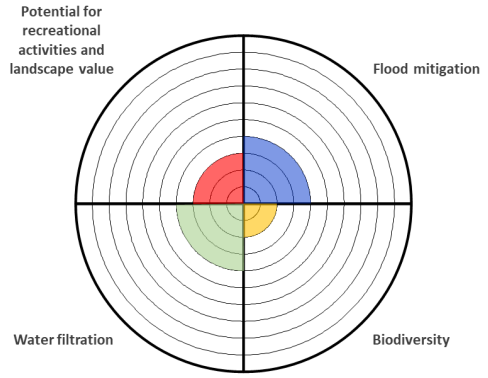


Gikondo, Variant 2, the attempt to improve landscape is counterbalanced by the limited space available for recreational activities and access limitations due to potential water pollution in the lake.

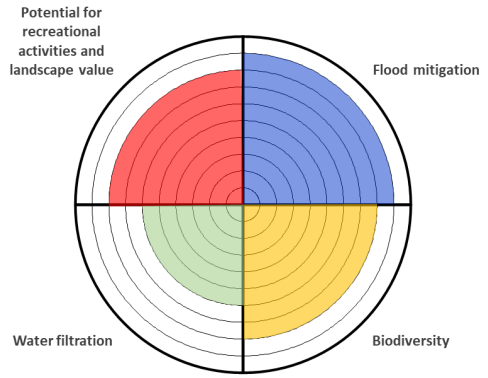


Gikondo, Variant 3 the objective of improving flood control is attained as Variant 3 performs better than Variant 1. This improvement is, however, done at the expense of other criteria.

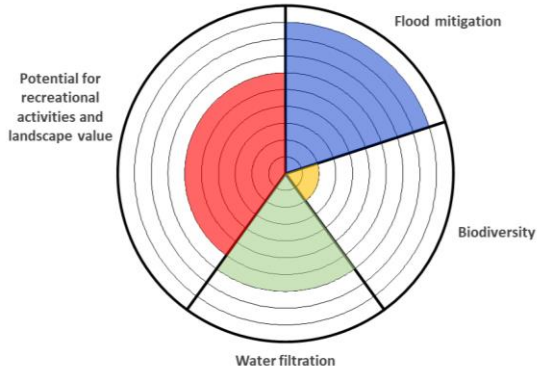
5.9.2 Comparison of performances between variants for Rwampara



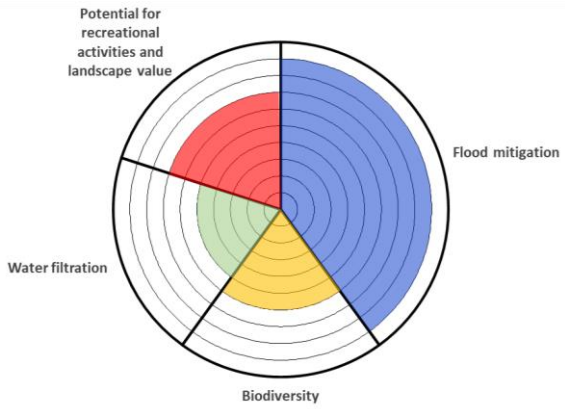
Rwampara at baseline



Rwampara, Variant 1

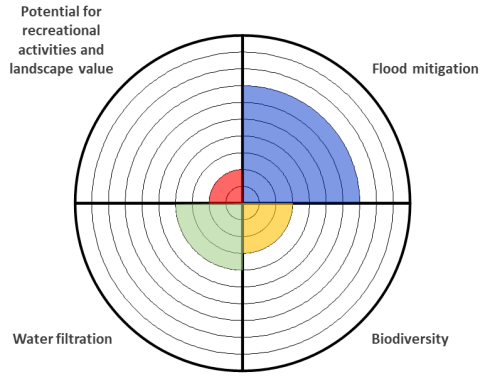


Rwampara, Variant 2, the potential for landscape and recreational activity is strongly reduced due to limited space which for a lake in this wetland. The biodiversity criteria is strongly impacted by the presence of the lake.

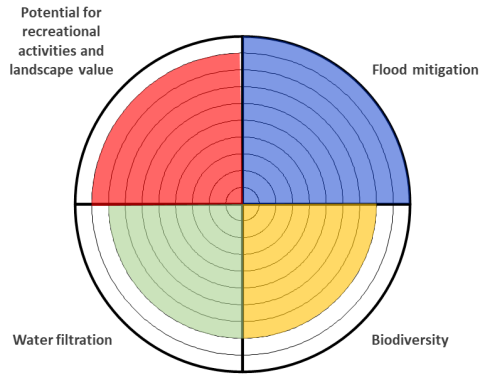


Rwampara, Variant 3, flood mitigation is highly efficient. However, gabions do not offer improved performance in comparison with Variant 1. Other criteria have lower performances.

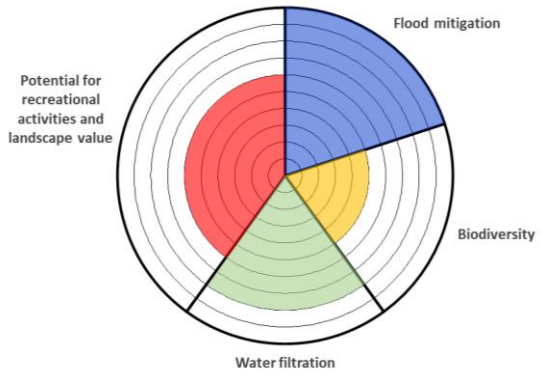
5.9.3 Comparison of performances between variants for Rugenge-Rwintare



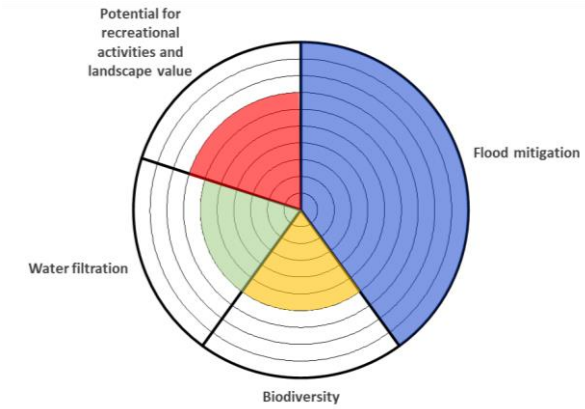
Rugenge-Rwintare at baseline



Rugenge-Rwintare, Variant 1

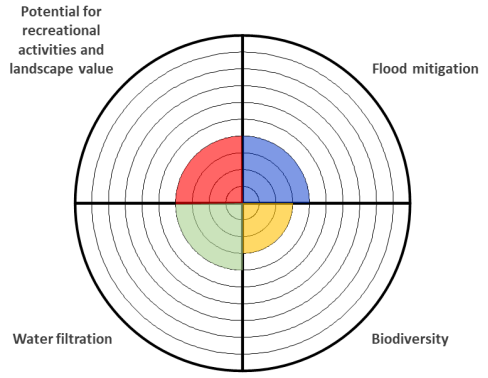


Rugenge-Rwintare, Variant 2, the potential for landscape and recreational activity is strongly reduced due to limited space which for a lake in this wetland. The Biodiversity criteria is also strongly reduced.

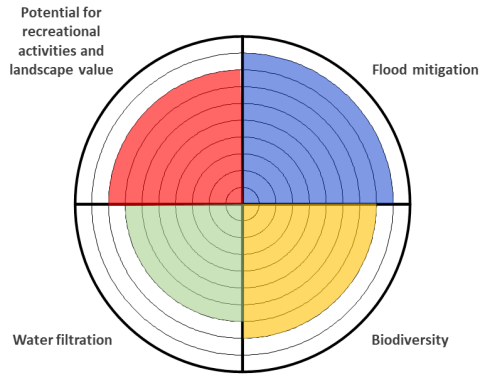


Rugenge-Rwintare, Variant 3, flood mitigation is highly efficient and offer the same performance in comparison with Variant 1. However, other criteria have lower performances.

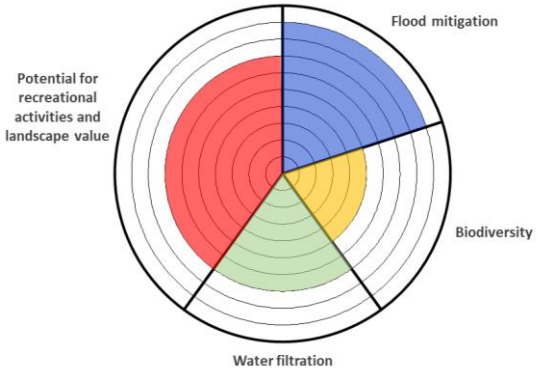
5.9.4 Comparison of performances between variants for Kibumba



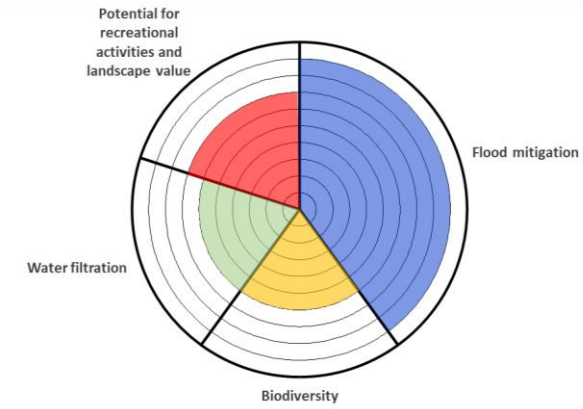
Kibumba at baseline



Kibumba, Variant 1

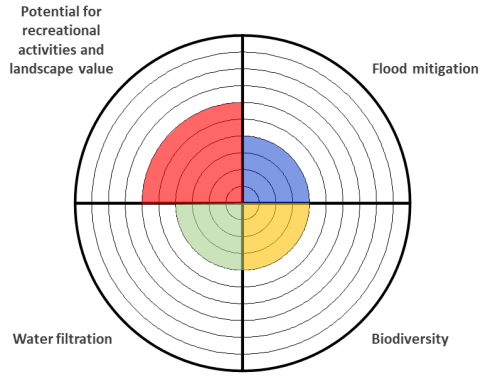


Kibumba, Variant 2, the attempt to improve landscape is counterbalanced by the reduced space available for recreational activities, the wetland still performs well for this criterion.

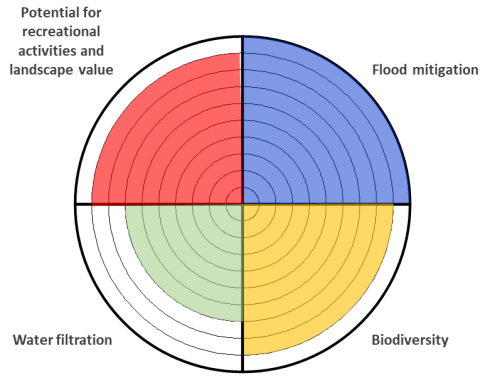


Kibumba, Variant 2, flood mitigation is highly efficient and offers the same performance in comparison with Variant 1. However, other criteria have lower performances.

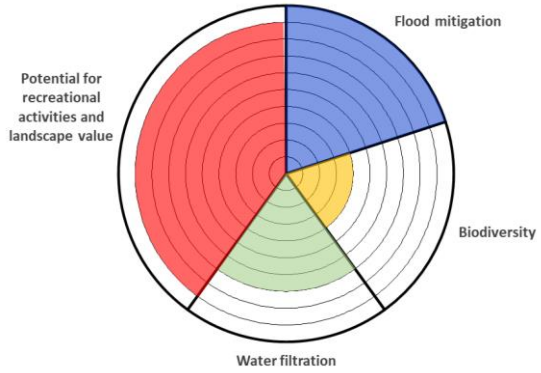
5.9.5 Comparison of performances between variants for Nyabugogo Lower



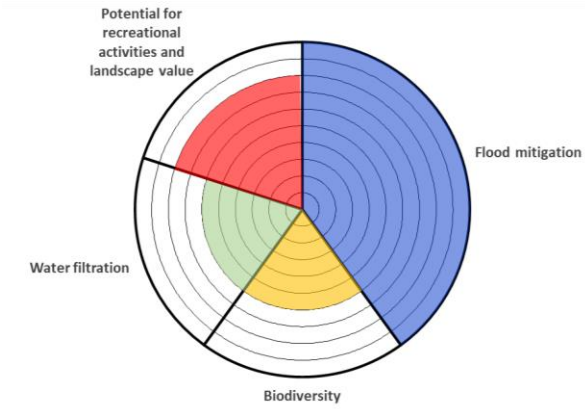
Nyabugogo Lower at baseline



Nyabugogo Lower, Variant 1



Nyabugogo Lower, Variant 2, the presence of an existing lake offers opportunities that can be exploited under Variant 2. However, a large lake will be create at the expense of biodiversity.



Nyabugogo Lower, Variant 3, flood mitigation is highly efficient and offer the same performance in comparison with Variant 1. However, other criteria have lower performances, especially water filtration and biodiversity.

5.10 CONSULTANT'S CONCLUSIONS ON PREFERRED VARIANT

Baseline analysis shows that wetlands are mostly flooded for low return periods, in particular sensitive infrastructures with risks for the population.

The developments of variant 1 solves the vast majority of problems. It makes it possible to create new overflow areas on the lateral sectors of the wetlands, in order to increase the residence time for developing other biodiversity-oriented actions. In the same time, reduction of flood levels is permitted in key areas for recreational development.

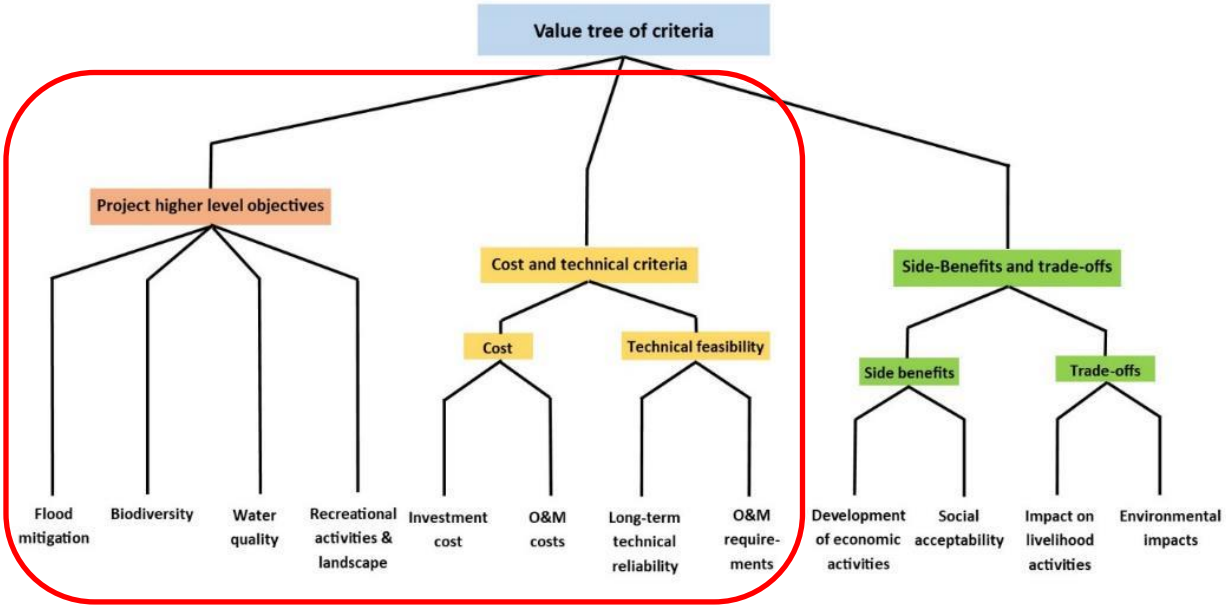
Variant 2 allows to develop several areas with open water with good potential to enhance the city landscape. However, Variant 2 has several shortcomings and offers unbalanced performances. In order to achieve the hydraulic criteria defined, the infrastructures to be built to set up these lakes are extremely consequential (high dam) which will have a significant impact on the city's landscape.

In order for open water to offer aesthetic value to the city, water must be clean and transparent free from invasive species such as the water hyacinth. Attempt to divert and isolate main urban drains from the lake to maintain acceptable water quality and transparency will be costly and not entirely successful given the high number of unformal small drains brining wastewater in the wetlands and the high number of connections between individual latrines and urban collectors. Water in the lake will therefore inevitably become eutrophic which will significantly reduce the aesthetic value of lakes. In addition, return of experience show that odours can become real problem if lakes collect wastewater, in addition to increase of waterborne disease prevalence (see section on case-study 4.15). In addition, building of a dam to retain water could degrade the landscape, if digging of the lake is preferred, the large volume of excavated soil would represent quite a challenge for its disposal. Safety of children and population could also become an issue due to the risk of drowning and dam failure. Regarding recreational activities in the created lakes, they will require previous water collection and treatment systems at urban discharge points to ensure safe use of the lake by people. These actions can be extremely costly and must be planned on a long term. Lastly, lakes are not the reference state of the wetlands.

Variant 3 would allow to slightly improve flood control in some wetlands or similar performances as Variant 1 but at the expense of all other project objectives. It is therefore not offering balanced performances. Large rows of gabions would impact the landscape because they would inevitably collect sediment and solid waste transported during high floods. In terms of water filtration, gabion could help to settle sediment, but being partly permeable, water filtration would be limited. Lastly, gabions would be helpful for large flash floods, but may not perform well at spreading small floods. Overall, the development of variant 3 allows for proper management of hydraulic flows but may create too much residence time in the wetlands which may create, as with variant 2, water quality problems

Gabions are hard-infrastructures and therefore not nature-based solutions, installing vast rows of gabions would somehow reduce the value of the rehabilitation program.

The following summary tables present the results of the scoring system for the most important criteria (encircled in red in the following figure) to show the preferred option.


Value tree of criteria
Project higher level objectives
Cost and technical criteria
Side-Benefits and trade-offs
Cost
Technical feasibility
Side benefits
Trade-offs
Flood mitigation
Biodiversity
Water quality
Recreational activities & landscape
Investment cost
O&M costs
Long-term technical reliability
O&M require-ments
Development of economic activities
Social acceptability
Impact on livelihood activities
Environmental impacts

5.10.1 Score for Gikondo

Criteria	Definition	Weighting of the criteria	Variants		
			Variant 1	Variant 2	Variant 3
Project higher level criteria	Flood mitigation	1	8	9	10
	Biodiversity enhancement	1	7	3	5
	Water quality improvement	1	5	6	4
	Development of recreational activities and landscape	1	9	7	8
Cost and Technical criteria	Investment costs	1	8	4	8
	Operation and maintenance costs	1	8	3	6
	Long term technical reliability	1	8	4	6
	O&M requirements	1	8	4	6
Total of notation			***61***	***40***	***53***

The result of the scoring system confirms that **variant 1** is the most performant variant for Gikondo.

5.10.2 Score for Rwampara

Criteria	Definition	Weighting of the criteria	Variants		
			Variant 1	Variant 2	Variant 3
Project higher level criteria	Flood mitigation	1	9	9	9
	Biodiversity enhancement	1	8	2	6
	Water quality improvement	1	6	7	5
	Development of recreational activities and landscape	1	8	6	8
Cost and Technical criteria	Investment costs	1	7	8	6
	Operation and maintenance costs	1	8	6	7
	Long term technical reliability	1	8	4	6
	O&M requirements	1	8	4	6
Total of notation			***62***	***46***	***53***

The result of the scoring system confirms that **variant 1** is the most performant variant for Rwampara.

5.10.3 Score for Rugenge-Rwintare

Criteria	Definition	Weighting of the criteria	Variants		
			Variant 1	Variant 2	Variant 3
Project higher level criteria	Flood mitigation	1	10	10	10
	Biodiversity enhancement	1	8	4	6
	Water quality improvement	1	8	8	6
	Development of recreational activities and landscape	1	9	6	8
Cost and Technical criteria	Investment costs	1	7	7	8
	Operation and maintenance costs	1	8	6	7
	Long term technical reliability	1	8	4	6
	O&M requirements	1	8	4	6
Total of notation			***66***	***49***	***57***

The result of the scoring system confirms that **variant 1** is the most performant variant for Rugenge-Rwintare

5.10.4 Score for Kibumba

Criteria	Definition	Weighting of the criteria	Variants		
			Variant 1	Variant 2	Variant 3
Project higher level criteria	Flood mitigation	1	9	9	9
	Biodiversity enhancement	1	8	5	6
	Water quality improvement	1	7	7	6
	Development of recreational activities and landscape	1	8	7	7
Cost and Technical criteria	Investment costs	1	7	6	8
	Operation and maintenance costs	1	8	5	8
	Long term technical reliability	1	8	4	6
	O&M requirements	1	8	4	6
Total of notation			***63***	***47***	***56***

The result of the scoring system confirms that **variant 1** is the most performant variant for Kibumba.

5.10.5 Score for Nyabugogo Lower

Criteria	Definition	Weighting of the criteria	Variants		
			Variant 1	Variant 2	Variant 3
Project higher level criteria	Flood mitigation	1	10	10	10
	Biodiversity enhancement	1	9	4	5
	Water quality improvement	1	7	7	5
	Development of recreational activities and landscape	1	9	9	8
Cost and Technical criteria	Investment costs	1	8	8	8
	Operation and maintenance costs	1	8	7	7
	Long term technical reliability	1	8	4	6
	O&M requirements	1	8	4	6
Total of notation			***67***	***53***	***55***

The result of the scoring system confirms that **variant 1** is the most performant variant for Nyabugogo Lower.

5.10.6 Comparison between objectives and variant 1 and 2 performances

The links between Variants 2 and 3 and restoration project goals and objectives are presented in the following table. Variants 2 and 3 attain some rehabilitation objectives but not all, unlike Variant 1.

TABLE 5-6 LINKS BETWEEN VARIANTS 2 AND 3 AND PROJECT GOALS AND OBJECTIVES

Variant 1	Variant 2	Variant 3
Gikondo		
Creation of an urban park in Gikondo, accessible for various activities including income generating activities.	This objective is attained	This objective is attained
End of floods affecting infrastructure such as roads.	This objective is attained	This objective is attained
Recreation of the natural profile of the river.	Not attained in all areas, as a lake is not the reference state of the wetland	Not attained, as gabions would replace river reprofiling
Natural treatment of stormwater at all outlets of urban drains and reduction of turbidity and water pollution for key parameters at reconnections with rivers.	This objective is attained	This objective is attained
Reduction of turbidity and water pollution for key parameters in rivers and streams.	Lakes are not efficient at filtering pollutants, and could locally increase pollution due to eutrophic conditions	This objective is attained
Rwampara		
Progressive replacement of unsustainable agricultural activities in accordance with the City' Master Plan and wetland habitat reclamation in more than 50% of Rwampara wetland in the downstream area.	Lakes are aquatic habitats and not wetlands and have lower value for biodiversity (especially plants) in comparison to wetlands. The objectives to reclaim 50% of wetland habitats would not be met.	This objective is attained
End of floods affecting infrastructure such as roads.	This objective is attained	This objective is attained
Recreation of the natural profile of the river downstream.	Not attained in all areas, as lakes are not the reference state of the wetland	Not attained, as gabions would replace river reprofiling
Natural treatment of stormwater at all outlets of urban drains and reduction of turbidity and water pollution for key parameters at reconnections with rivers.	This objective is attained	This objective is attained
Reduction of turbidity and water pollution for key parameters in rivers and streams.	Lakes are not efficient at filtering pollutants, and could locally increase pollution due to eutrophic conditions	This objective is attained

Minor developments (paths and trails) facilitate access to wetland-compatible recreational activities in designated areas.	The objective is not attained due to the lake's occupation of a large area	This objective is attained
Increase in the richness of water-dependent species of birds, amphibians and plants.	Except for plants, lake could offer interesting value for some species at their fringes (water birds, amphibians)	This objective is attained but will bring fewer positive outcomes for biodiversity (in comparison with Variant 1)
Rugenge-Rwintare		
Progressive replacement of unsustainable agricultural activities in accordance with the City' Master Plan and wetland habitat reclamation in more than 80% of Rugenge-Rwintare wetland.	Lakes are aquatic habitats and not wetlands and have lower value for biodiversity (especially plants) in comparison to wetlands. The objectives to reclaim 80% of wetland habitats would not be met.	This objective is attained
End of floods affecting infrastructure such as roads	This objective is attained	This objective is attained
Recreation of the natural profile of the river.	Not attained in all areas, as a lake is not the reference state of the wetland	Not attained, as gabions would replace river reprofiling
Natural treatment of stormwater at all outlets of urban drains and reduction of turbidity and water pollution for key parameters at reconnections with rivers.	This objective is attained	This objective is attained
Reduction of turbidity and water pollution for key parameters in rivers and streams.	Lakes are not efficient at filtering pollutants, and could locally increase pollution due to eutrophic conditions	This objective is attained
Increase in the richness of water-dependent species of birds, amphibians and plants.	Except for plants, lake could offer interesting value for some species at their fringes (water birds, amphibians)	This objective is attained but will bring fewer positive outcomes for biodiversity (in comparison with Variant 1)
Minor developments (paths and trails) facilitate access to wetland-compatible recreational activities in designated areas.	The objective is not attained due to the lake's occupation of large area	This objective is attained
Kibumba		
Progressive replacement of unsustainable agricultural activities in accordance with the City' Master Plan and wetland habitat reclamation in more than 80% of Kibumba wetland.	Lakes are aquatic habitats and not wetlands and have lower value for biodiversity (especially plants) in comparison to wetlands. The objectives to reclaim 80% of wetland habitats would not be met.	This objective is attained

End of floods affecting infrastructure such as roads.	This objective is attained	This objective is attained
Recreation of the natural profile of the river.	Not attained in all areas, as a lake is not the reference state of the wetland	Not attained, as gabions would replace river reprofiling
Natural treatment of stormwater at all outlets of urban drains and reduction of turbidity and water pollution for key parameters at reconnections with rivers.	This objective is attained	This objective is attained
Reduction of turbidity and water pollution for key parameters in rivers and streams.	Lakes are not efficient at filtering pollutants, and could locally increase pollution due to eutrophic conditions	This objective is attained
Increase in the richness of water-dependent species of birds, amphibians and plants.	Except for plants, lake could offer interesting value for some species at their fringes (water birds, amphibians)	This objective is attained but will bring fewer positive outcomes for biodiversity (in comparison with Variant 1)
Minor developments (paths and trails) facilitate access to wetland-compatible recreational activities in designated areas.	This objective is attained	This objective is attained
Nyabugogo		
Progressive replacement of unsustainable agricultural activities in accordance with the City' Master Plan and wetland habitat reclamation in more than 80% of the Nyabugogo wetland.	Lakes are aquatic habitats and not wetlands and have lower value for biodiversity (especially plants) in comparison to wetlands. The objectives to reclaim 80% of wetland habitats would not be met.	This objective is attained
End of floods affecting infrastructure such as roads.	This objective is attained	This objective is attained
Creation of a waterfront to improve the city's landscape.	This objective is attained	This objective is attained
Recreation of the natural profile of the river downstream.	Not attained in all areas, as a lake is not the reference state of the wetland	Not attained, as gabions would replace river reprofiling
Natural treatment of stormwater at all outlets of urban drains and reduction of turbidity and water pollution for key parameters at reconnections with rivers.	This objective is attained	This objective is attained
Reduction of turbidity and water pollution for key parameters in rivers and streams.	Lakes are not efficient at filtering pollutants, and could locally increase pollution due to eutrophic conditions	This objective is attained

Increase in the richness of water-dependent species of birds, amphibians and plants.	Except for plants, lake could offer interesting value for some species at their fringes (water birds, amphibians)	This objective is attained but will bring fewer positive outcomes for biodiversity (in comparison with Variant 1)
Increase attractiveness for flagship bird species	The objective is not attained	The objective is not attained
Reduction of coverage of the water hyacinth in the large pond in Nyabugogo.	The objective is not attained, and the situation would most likely worsen	This objective is attained

Based on this conclusion and the fact that some goals and objectives are not attained with Variants 2 and 3, it is not advised to further study the feasibility to develop these two variants. Neither cost and technical criteria nor side benefits and trade-offs are therefore evaluated for these two variants.

Based on the multicriteria analysis which demonstrated lower scores for Variant 2 and Variant 3, the Feasibility Study report concluded that it is not advised to further study the feasibility to develop Variant 1 and Variant 2.

Variant 1 is therefore proposed as the preferred variant. The following section present the performance of variant 1 for all criteria

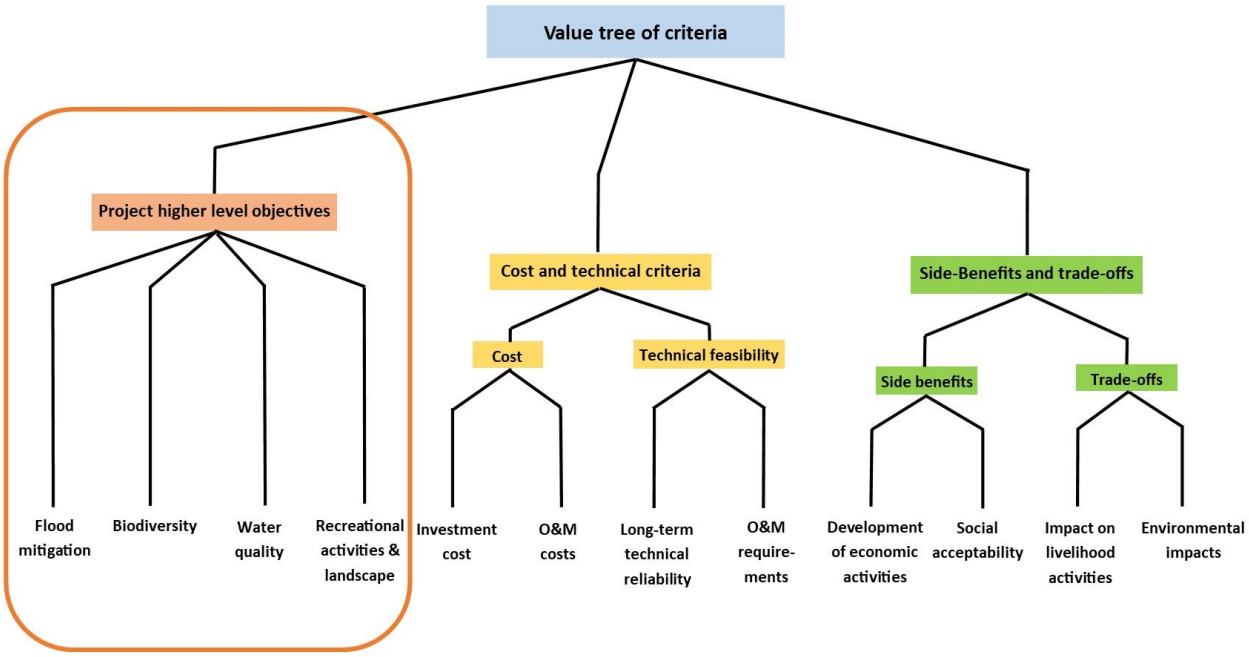
The following recommendations are to be done:

- Variant choice: this hydraulic analysis should serve as a basis for selecting the best variant for the rehabilitation of each wetland. From a flood management point of view, the analysis shows that the 3 defined variants allow an almost similar improvement of the situation. However, the other criteria are significantly more favorable for variant 1, which is therefore recommended for all 5 wetlands.
- Additional hydraulic calculation: Once the variant choice validated, more precise hydraulic calculations should be implemented:
- Hydraulic simulation with lower time-return periods in order to precisely define the flows and residence time for detailed design preparation (in the coming wekks)
- A more precise collaboration could be set up with the stakeholders of the "hotspots" project in order to clarify the few differences observed and to identify the possibilities of pooling certain strategic sectors (Nyabugogo river in particular).

5.11 COMPARISON OF PERFORMANCE OF VARIANT 1 WITH THE BASELINE SITUATION

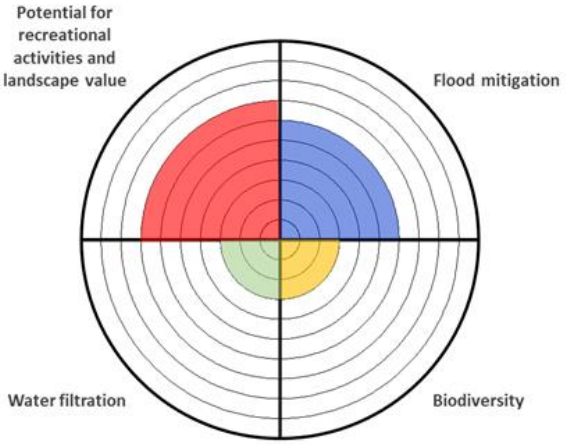
5.11.1 Comparison of project higher objectives with baseline

The following sections compare Variant 1 with the baseline situation for higher project objectives.

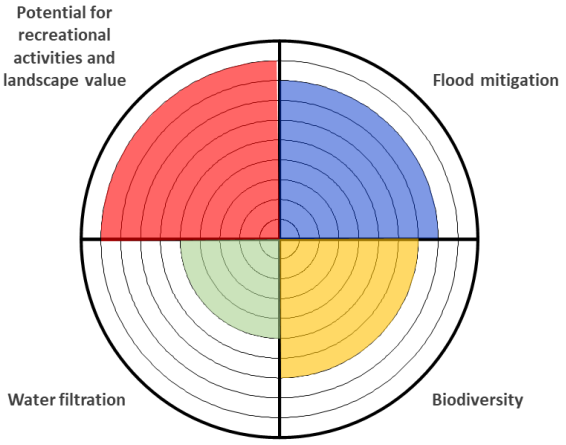


The following figures show the average score for all 4 criteria (based on an **average of sub-criteria**).

5.11.1.1 Gikondo

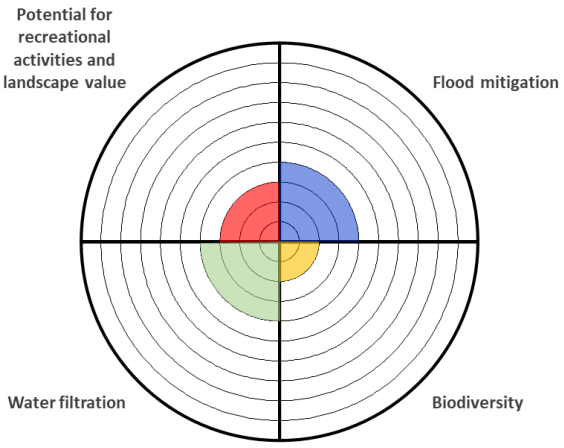


At baseline, Gikondo system show medium performance in terms of flood mitigation, Gikondo wetland does not perform well in terms of biodiversity and habitat value and water filtration and has medium value in terms of potential for recreational activities and landscape.

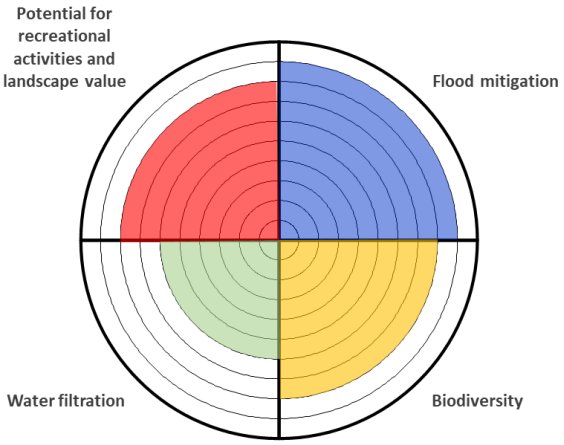


With Variant 1, recreational activities and landscape value significantly increases, while water filtration only modestly increases since the main purpose of Gikondo is to develop recreational activities. Biodiversity value increases at a good level.

5.11.1.2 Rwampara



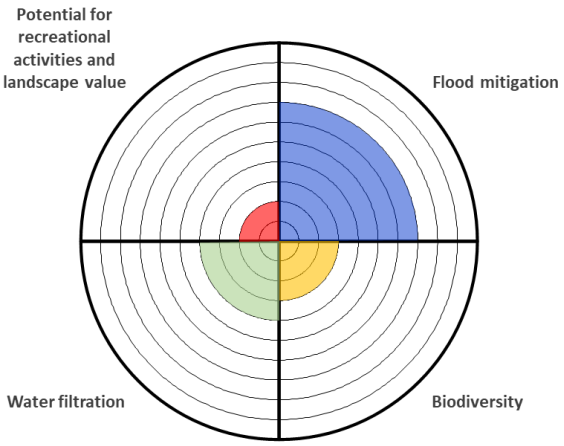
At baseline, Rwampara system shows poor performance in terms of flood mitigation, Rwampara wetland has very low value in terms of biodiversity and habitat in terms of potential for recreational activities and landscape. Water filtration also performs poorly. The presence of a deeply eroded canyon upstream is the main reason for these low scores.



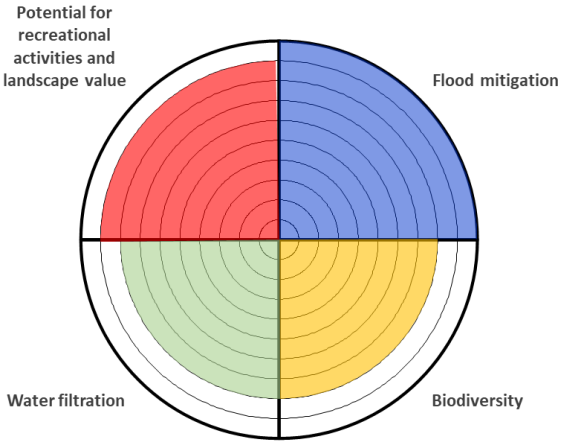
With Variant 1, Rwampara system shows significant improvement in terms of biodiversity, flood mitigation and value for recreational activities and landscape value. Water filtration is medium given the lack of floodplain and important erosion in the upstream area of the wetland, a situation that cannot be improved in this area.

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5.11.1.3 Rugenge-Rwintare

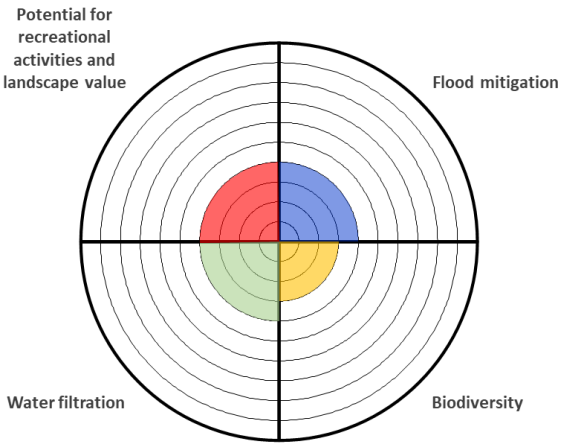


At baseline, Rugenge-Rwintare system shows good performance in terms of flood mitigation, Rugenge-Rwintare wetland has very low value in terms of potential for recreational activities and landscape. Water filtration also performs poorly and the value for biodiversity is low.

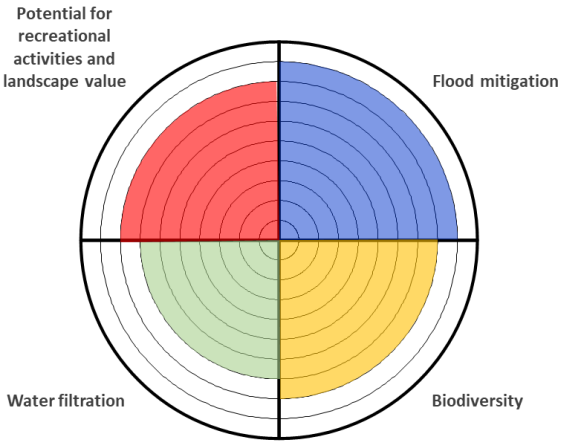


With Variant 1, Rugenge-Rwintare system shows very good performance for flood mitigation and good performance for biodiversity conservation and good value for recreational activities and landscape. Water filtration performance is good.

5.11.1.4 Kibumba

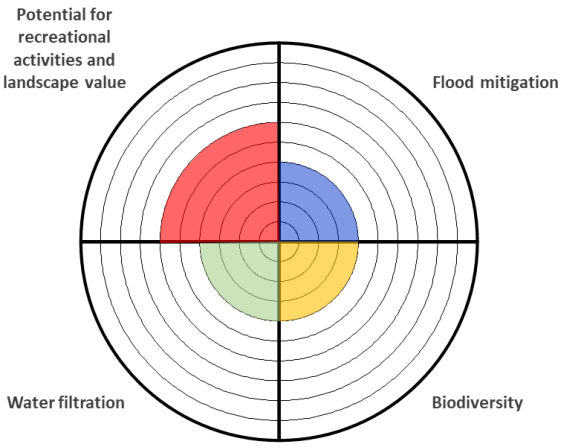


At baseline, Kibumba has rare poor performance for all criteria, the lowest value is biodiversity value.

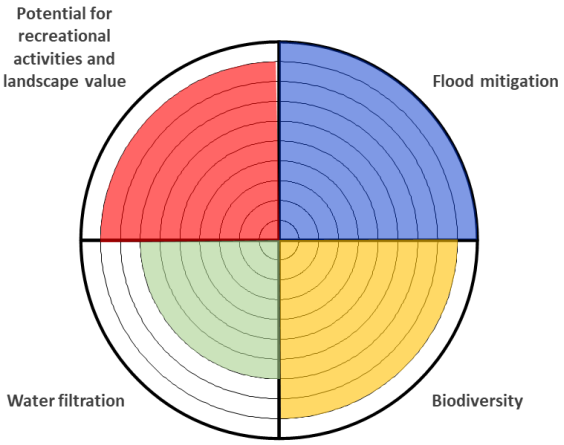


With Variant 1, flood mitigation of the system shows very good performance, while other criteria show good performance.

5.11.1.5 Nyabugogo Lower



At baseline, Nyabugogo Lower system has rather performance to mitigate floods, as rather poor value for biodiversity conservation and the water filtration function performs poorly. The highest score is the potential of the wetland for recreational activities and development of landscape.

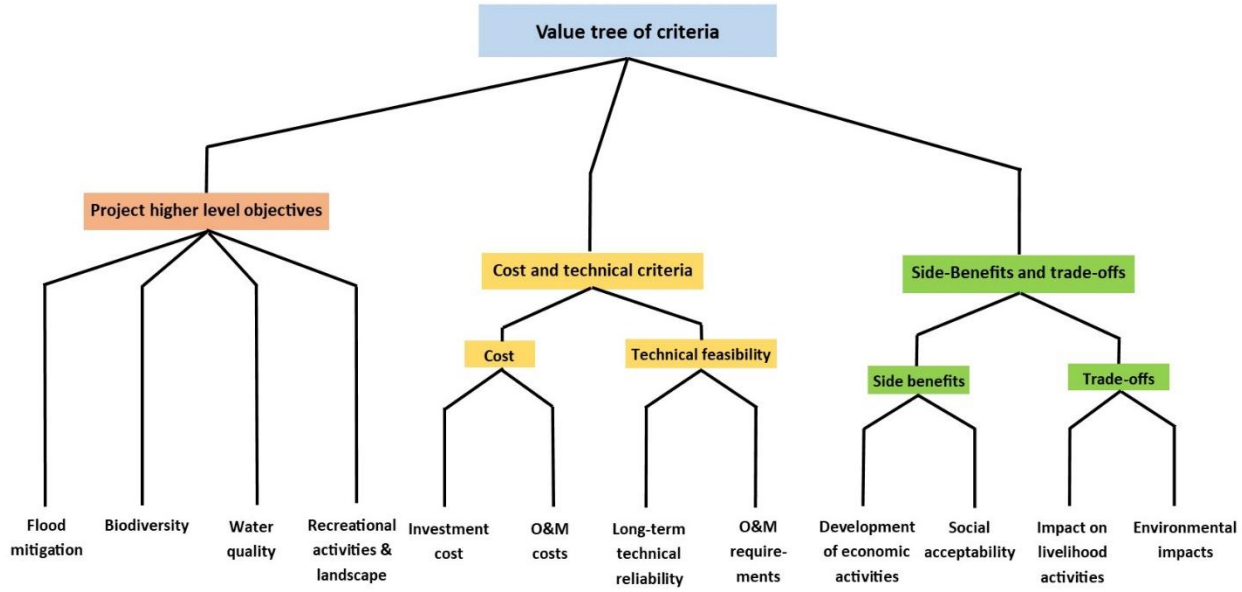


With Variant 1, Nyabugogo Lower system performs very well for flood mitigation, for its value for biodiversity conservation and its value for recreational activities and landscape. Water filtration also improve to a good level.

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5.11.2 Overall performance for all criteria

This section compares all criteria (average scores).



5.11.2.1 Gikondo

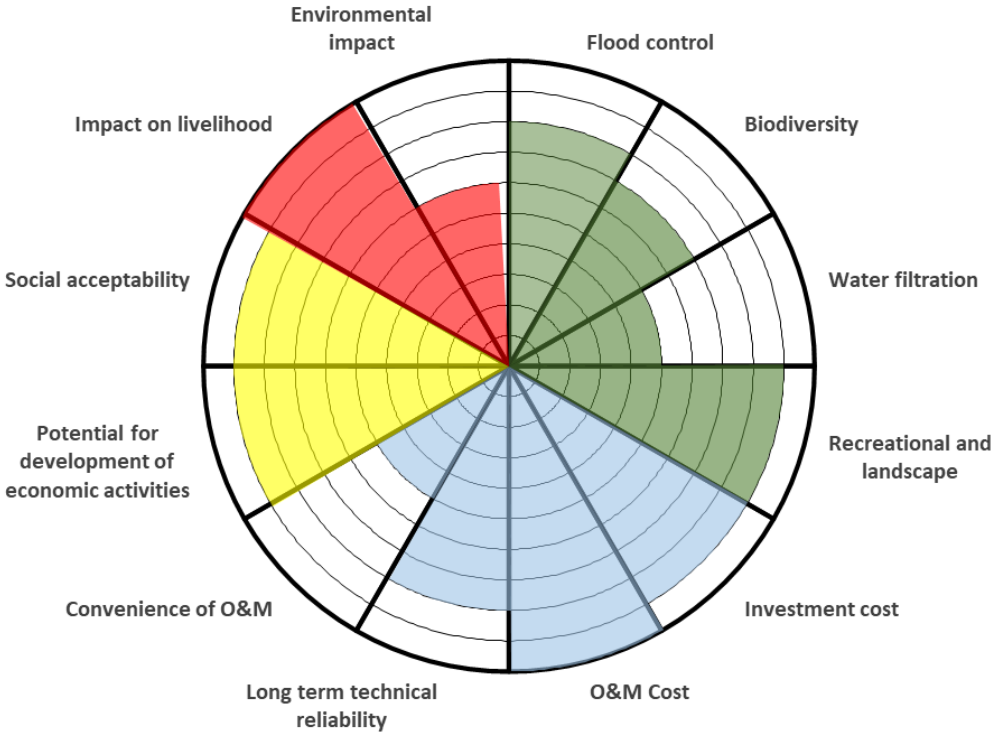


FIGURE 5-32 FULL IMPLEMENTATION OF VARIANT 1, OVERALL PERFORMANCE OF GIKONDO

With full implementation of Variant 1, the investment cost and O&M costs are very high, thus given a high score for these criteria. However, the long-term technical reliability is good given the value of investments. Convenience for O&M ranks medium given the little return of experience locally and the complexity of some actions.

With full implementation of Variant 1, the potential for economic development and social acceptability in Gikondo are very high. Many stakeholders are expecting the Gikondo to become a recreational area, and this has largely been advertised by the city. However, the small patches of agriculture will all be displaced thus leading to some social impacts. Environmental impacts are related to the potential for contaminated soil in Gikondo.

5.11.2.2 Rwampara

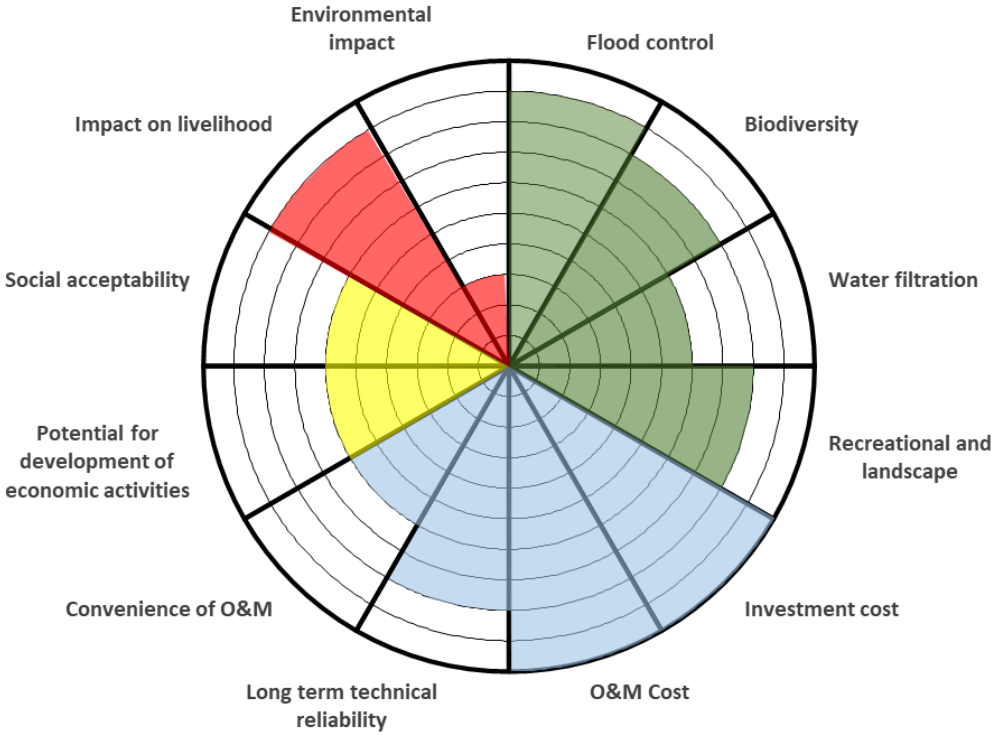


FIGURE 5-33 FULL IMPLEMENTATION OF VARIANT 1, OVERALL PERFORMANCE OF RWAMPARA

With full implementation of Variant 1, the investment cost and O&M costs are very high (mainly because Rw01 is severely degraded and would require important investments), thus given a high score for these criteria. The long-term technical reliability is good (as it relates to the quality of investments). Convenience for O&M ranks medium given the little return of experience locally and the complexity of implementing numerous actions at once.

With full implementation of Variant 1, the potential for development of economic activities would be medium, as the area is a bit disconnected from the city center. Impact on livelihood would be very high as most agricultural activities would be replaced and land reclaimed this would affect social acceptability. Given the state of Rwampara and its location in a more rural areas, potential for development of economic activities is limited. Environmental impacts are minimum as the area was not previously occupied by industrial activities and the potential for soil contamination is minimal. Variant 1 does not create many ponds thus the risk of water borne diseases is low.

5.11.2.3 Rugenge-Rwintare

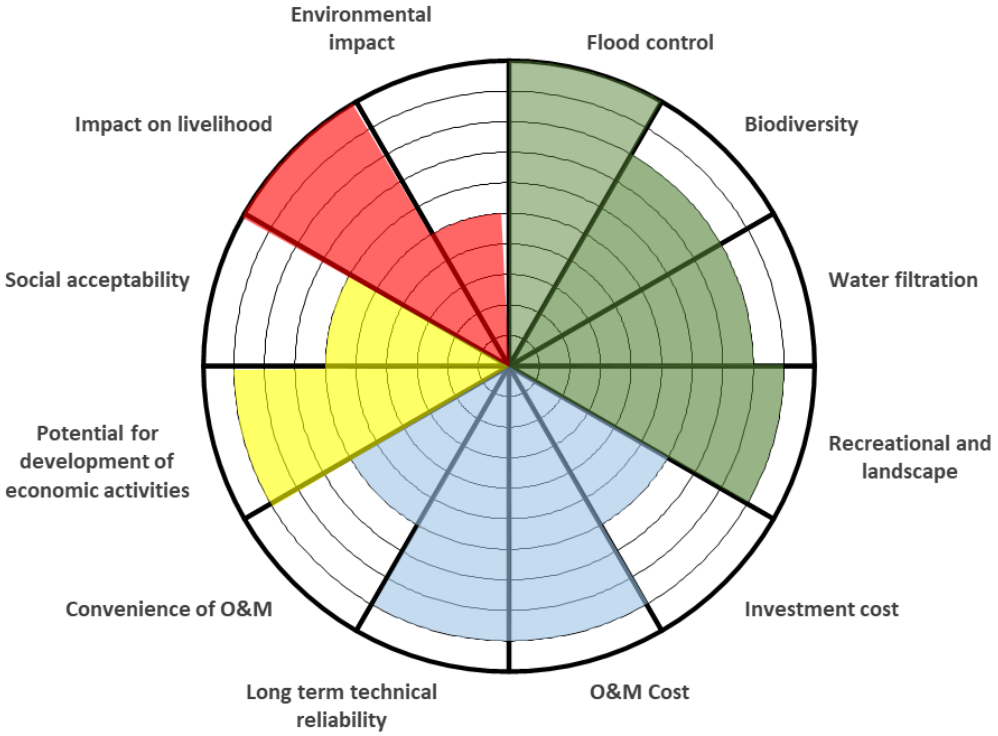


FIGURE 5-34 FULL IMPLEMENTATION OF VARIANT 1, OVERALL PERFORMANCE OF RUGENGE-RWINTARE

With full implementation of Variant 1, the investment cost and O&M costs are rather high, thus given a high score for these criteria. The long-term technical reliability is good. Convenience for O&M ranks medium given the little return of experience locally and the complexity of some actions.

With full implementation of Variant 1, the potential for development of economic activities is very good thanks to the prime location of some parts of the wetland in front of the business center. All agriculture would be displaced leading to very high social impacts and could affected social acceptability in this wetland where subsistence agriculture is important. Environmental impacts would be rather low as there is limited risk related to movement of contaminated soil.

5.11.2.4 Kibumba

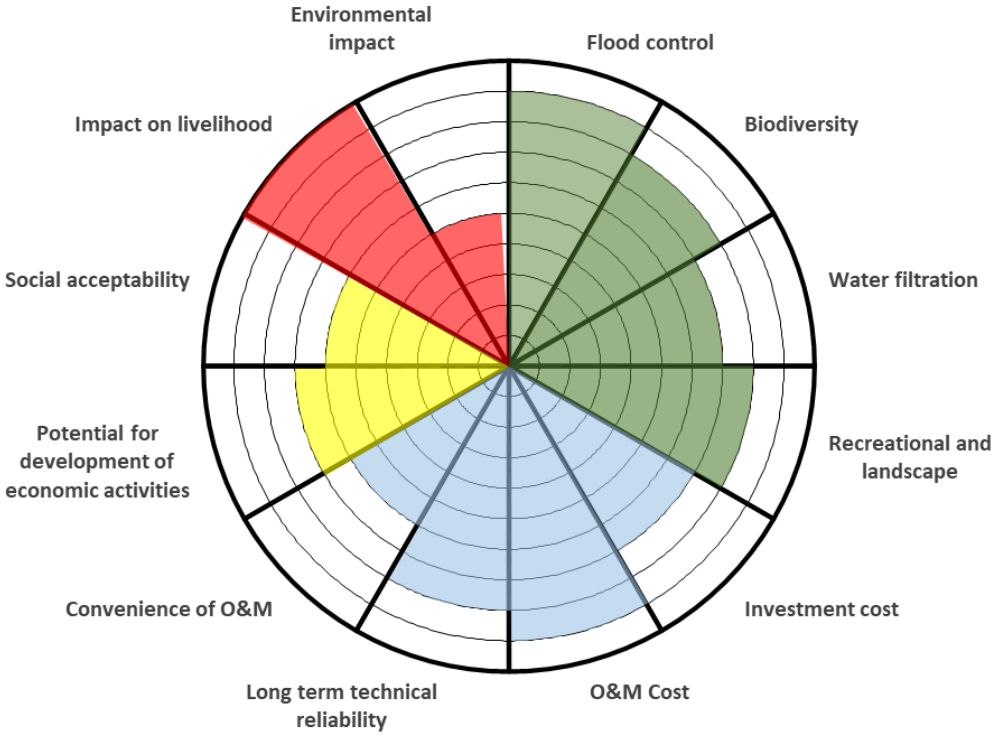


FIGURE 5-35 FULL IMPLEMENTATION OF VARIANT 1, OVERALL PERFORMANCE OF KIBUMBA

With full implementation of Variant 1, O&M particularly high and O&M is not convenient. Investment costs are medium and long-term reliability is good.

With full implementation of Variant 1, all agriculture will end which could also affect social acceptability. In Kibumba, many farmers are well organized in cooperatives. The potential for economic development would be good, the area holds some potential but is disconnected from the center. Environmental impacts would mainly be associated with the risk of increase of water borne disease with the creation of small ponds and building of small weirs (berms) upstream.

5.11.2.5 Nyabugogo Lower

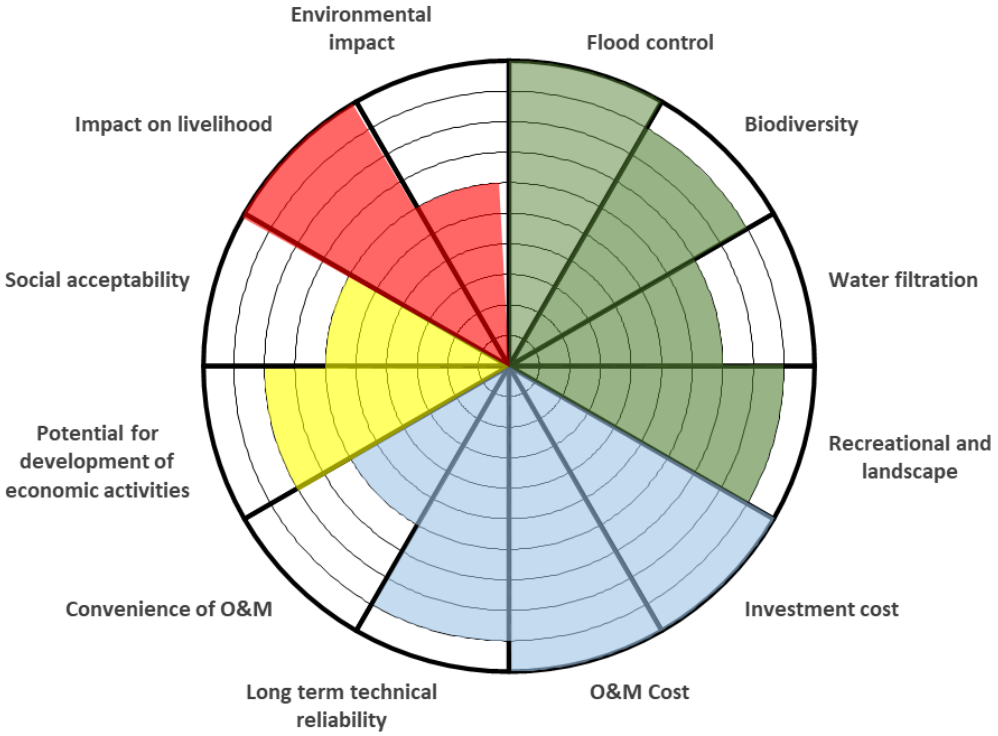


FIGURE 5-36 FULL IMPLEMENTATION OF VARIANT 1, OVERALL PERFORMANCE OF NYABUGOGO LOWER

With full implementation of Variant 1, the investment and O&M costs are very high, thus given a high score for these criteria, some measures are complex (such as the inland delta). However, the long-term technical reliability is very good. Convenience for O&M ranks medium given the little return of experience locally and complexity of some actions.

With full implementation of Variant 1, Nyabugogo Lower would have good potential to attract businesses, given its good location close to CBD (business district). However, impacts on livelihood would be significant affecting social acceptability as agriculture is well organized in this wetland. Environmental impacts would be associated with the potential presence of contaminated soils at the southern end of the wetland and risk of increase of water borne disease with the creation of an inland delta.

5.11.3 Conclusion

Because of the high investment and O&M costs for all 5 wetlands, the Feasibility Study recommends implementing actions in three phases focusing on implementing the most relevant measures in priority 1.

- Priority 1 actions: these are short term action to be implemented by 2025. They represent the most urgent actions to allow the wetlands to be partially rehabilitated.
- Priority 2 actions: these are the medium-term action to be implemented by 2035. They represent the second most urgent actions to allow the wetlands to be partially rehabilitated.
- Priority 3 actions: these are the long-term actions to be implemented by 2050. They represent the least urgent rehabilitation activities

Priority 1 action would allow to have a more balanced approach, with lower costs, especially in term of O&M.

The draft version of the Feasibility Study report made first proposals for phasing. Phasing actions is further developed in the next chapter.

5.12 OUTCOMES OF STAKEHOLDER ENGAGEMENT ACTIVITIES AND DISCUSSIONS WITH REMA ON PREFERRED VARIANT

Two stakeholder workshops and one high-level consultative meeting were organized to present the selection of the preferred Variant by the Consultant as developed in the draft feasibility (one workshop that was held in June 2022 and the other one was held in September 2022. The high level consultative meeting was held in October 2022).

Even though stakeholders largely agreed with actions of Variant 1, some comments were collected these related to three topics:

1. Changes in priority actions

This study recommends phasing Variant 1 activities in three phases as follow:

- Priority 1 actions: these are short term action to be implemented by 2025. They represent the most urgent actions to allow the wetlands to be partially rehabilitated.
- Priority 2 actions: these are the medium-term action to be implemented by 2035. They represent the second most urgent actions to allow the wetlands to be partially rehabilitated.
- Priority 3 actions: these are the long-term actions to be implemented by 2050. They represent the least urgent rehabilitation activities.

The draft Feasibility distinguished all actions in each wetland based on three priorities which were reviewed by REMA and stakeholders.

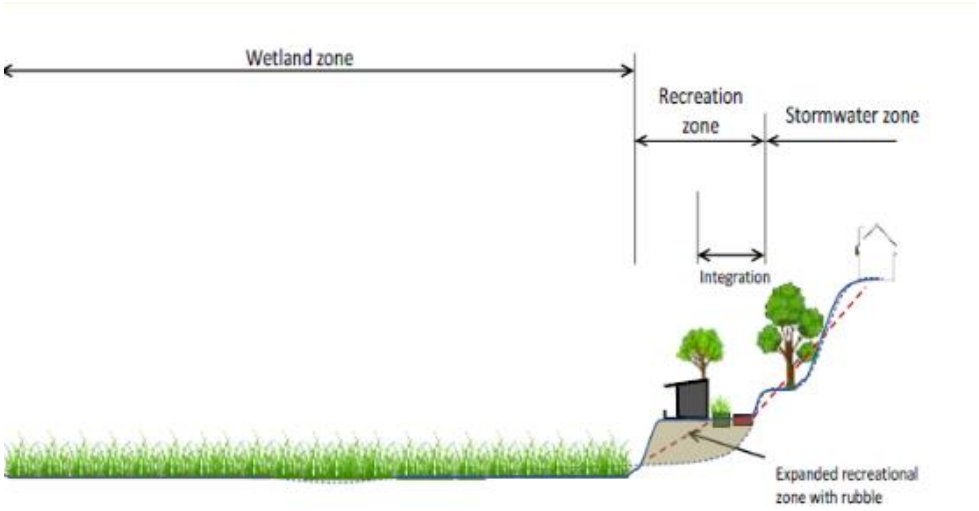
While in the draft Feasibility Study report, priorities were made considering several factors including the high investment and O&M costs and the need to safeguard agriculture, new priorities shall be made focusing on upstream actions in wetlands to mitigate floods while acknowledging that **Project budget is sufficient to implement more actions in Priority 1** (than those proposed in the draft-final Feasibility report)**.**

2. Improving the existing lake in Nyabugogo was recommended

- Stakeholders requested that the current lake in Nyabugogo be improved. This lake would have both aesthetic value and allow for improved navigability for recreational purposes. For this purpose, water hyacinth would be remove and the edge of the lake would be excavated. **The difference between this lake and the lake as presented in Variant 2 is that no hard infrastructure would be needed (no dams) and the lake shall remain at a reasonable size (large ponds).**

3. Some measures from Variant 1 need to be removed or changed

- REMA and stakeholders do not wish to have too much permanent infrastructures in the wetland and therefore recreational activities will have to be limited to 4% of the total area of the wetland (in order to avoid compaction of soils of the wetlands). This includes playgrounds, sports fields, and picnic sites. This comment is valid for all wetlands.
- Gikondo: more recreational activities (trails and paths) shall be proposed for the southern edge of the main branch, on higher ground (to give vantage points over this wetland). This could be made by pushing rubble and contaminated soils to the edge of the wetland as shown in the following figure.
- Gikondo: the use of aggregate should be avoided when blocking agricultural drains.
- Gikondo: there is a need to increase storage in the main branch to optimize flood attenuation as shown in the following figure. In order to take into account this recommendation, *Action 15: Clearance over a large width to facilitate the overflow of the river during flood periods* at G15 should be further enlarged. *Action 7: Re-profiling of the Rugenge river with the creation of meanders and banks with different levels* would have to be removed.



- Gikondo: in the Southern branch: there is a need to create habitat niche in the form of small islands (on slightly higher grounds) in G03, G04 and G05.
- Gikondo and Rwampara: existing concrete canals shall be entirely removed, instead of partially removed as described in *Action 2: Creation of overflows on the two concrete canals to ensure overflow of water into the wetland during rainfall*.
- Rugenge-Rwintare: there is a need for more justification why in the Southern arm there is no action proposed. Additional information on this issue is provided in the report.
- Kibumba: *Action 21: Natural weirs in cascade to limit floods* needs to highlight that it will be implemented after blocking surface drains (*Action 5: Blocking of surface drains to limit the lowering of the groundwater and increase the residence time of the water in the wetland*).
- Kibumba: *Action 7: Reprofiling of the Rugenge River with the creation of meanders and banks with different levels* (in K03) needs to be replaced by *Action 15: Clearance over a large width to facilitate the overflow of the river during flood periods is covering all the main branch.* At this location (K03), there is no need to create meanders but there will be a need to recharge the river to increase the bed level.
- Nyabugogo Lower: there is a need to provide more explanation on whether the delta will sustain high sediment loads and that channels will not fail over time. This measure is maintained and further explained in the feasibility.

Chapter 7 shows how stakeholder comments were acknowledged in this final version of the Feasibility Study report

6. IMPACT OF "FLOOD HOTSPOT PROJECT" – COK/YREC ON THE REHABILITATION ACTIONS AND VARIANTS

6.1 INTERACTIONS BETWEEN THE 2 STUDIES

The 6 flood hotspots project implemented by the City of Kigali, consultant YREC, is evolving in parallel with our project with very important interactions. Therefore, we felt it was relevant to analyze in detail the information contained in the "20220824 FS, PED, DED & TD for the Six Flood Risk Hotspots in CoK Preliminary Design(Draft)" report and to integrate these elements into our study.

At the request of REMA, the impact of the hotspot project on actions and variants are assessed in this chapter.

The interactions are summarized in the following table.

TABLE 6-1 INTERACTION BETWEEN THE FLOOD HOTSPOT PROJECT AND THE WETLAND REHABILITATION

Hotspots	Proposed construction by YREC		Wetland	Impact on proposed actions for Wetland Rehabilitation
	Grey infrastructure	NBS		
Karuruma	Construct a new Karuruma Gisozi Road Bridge, connecting with Kigali Gatuna Rd and KG 744 St. For the new bridge, the total length is 330 m, the width is 11 m, the deck elevation is higher than the design water level of 1:100 AEP, the superstructure is a 20 m hollow slab simply supported beam and the pier is of pile column type.	-	Nyabugogo	Located upstream of our study area. Impact taken into account as an increase in flow conveyed in condition at the upstream boundaries of the model.
Kinamba	Construction of one or more additional culverts does not bring significant improvement. Recommended to demolish the road and build a new bridge: recommended to demolish the river crossing road KN 8Ave and built a bridge to avoid hindering flood discharge of the river channel and to eliminate the ill effects of upstream inundation; however, the construction period of building the new bridge will be far longer than that of Alternative 2 and the project investment far higher.	Creation of the Kinamba node: a sort of buffer zone between the two roads.	Nyabugogo / Rugenge	Located at the boundary between the two wetlands. The consequence will be an increase in the flow arriving at Nyabugogo and therefore a significant impact on downstream actions / no impact on upstream: - Action 15: clearance over a large width to facilitate the overflow -Action 26: Creation of a delta before the confluence of the Nyabugogo River and its right bank tributary (Rwenzagoro River).
Gisozi-Mukindo	Creation of a new, larger culvert in place of the old one	-	Kibumba	The consequence will be an increase in the flow arriving at Kibumba downstream and Nyabugogo. Impact to be foreseen on the dimensioning of the actions of sector K01 and N07 in particular: - Action 15: Clearance over a large width of the river to facilitate the overflow of the river during floods. - Action 18: Creation of a depression disconnected from the river which will be fed by flood waters and the water table.

Hotspots	Proposed construction by YREC		Wetland	Impact on proposed actions for Wetland Rehabilitation
	Grey infrastructure	NBS		
Cadillac	Construction of one or more additional culverts does not bring significant improvement. Recommended to demolish the road and build a new bridge: recommended to demolish the river crossing road KN 8Ave and built a bridge to avoid hindering flood discharge of the river channel and to eliminate the ill effects of upstream inundation; however, the construction period of building the new bridge will be far longer than that of Alternative 2 and the project investment far higher.	Creation of the Kinamba node: a sort of buffer zone between the two roads.Ncessity to modifiy the action G15 upstream	Gikondo	Located at the border between the two wetlands. The consequence will be an increase in the flow arriving at Rugenge. Impact to be expected on the actions of the RU 02, RU 03 and Ru 04 sectors, in particular: - Action 7: Reprofiling of the river with the creation of meanders and banks of different levels. - Action 18: Creation of a depression disconnected from the river which will be fed by flood waters and the water table.
Kanogo	Creation of a new culvert: Remove the existing downstream bridge and culvert, and built a new two hole reinforced concrete box culvert with a single hole size of 3m × 3m (B × H) at the same position. Dredge and expand the river channel between the two holes as well as the lower river channel, and line the river banks with gabion.	-	Rwampara	Located at the border between the two wetlands. The consequence will be an increase in the flow arriving at Gikondo downstream (G15) and at Rugenge. Impact to be expected on the dimensioning of the actions of the G15, RU 02, RU 03 and Ru 04 sectors, in particular: - Action 7: Reprofiling of the river with the creation of meanders and banks with different levels. - Action 18: Creation of a depression disconnected from the river which will be fed by flood water and the groundwater.
Rugunga	Creation of a new, larger culvert in place of the old one	-	Rwampara	The consequence will be an increase in the flow arriving at Gikondo downstream (G15) and at Rugenge - idem Kanogo
Rwampara	Rehabilitation of the existing bridge : Remove the existing bridge and culvert and build a new 20m span hollow slab bridge at the same position, with the bridge deck elevation being above the flood level. Reroute or relocate the outlet pipeline to both sides of the road to avoid blocking the flood discharge channel.	-	Rwampara	The consequence will be an increase in the flow arriving at Gikondo downstream (G15) and at Rugenge - idem Kanogo. No impact a priori on the planned actions at Rwampara.
Rwandex	Creation of a new, larger culvert in place of the old one	Creation of the Rwandex node : buffer zone dowstream the road. Necessity to modifiy the action G20	Gikondo	The consequence will be an increase in the flow arriving at Gikondo Impact to be foreseen on the dimensioning of the actions of the G15 sector in particular: - Action 7: Reprofiling of the river with the creation of meanders and banks with different levels. - Action 1: Raising the water level of the river in order to limit the lowering of the groundwater and to favour the flooding of the river on the riparian plots.

The impact of proposed infrastructure is described in the following chapter.

6.2 HYDRAULIC STUDY FOR THE BASELINE / COMPARISON WITH AND WITHOUT PROPOSED INFRASTRUCTURE

6.2.1 Introduction

The following sections present a comparison for a ten-year return period event and the current landscape before and after the improvement of the hotspots proposed infrastructure, with IBC/SGI model.

The following observations are detailed in the following chapters, and they are quite logical:

- Decrease of the water level on the bed banks and on the roads with the proposed infrastructure
- Decrease of the area impacted by the flooding with the proposed infrastructure
- Increase of the discharge in the riverbed with the proposed infrastructure

It is important to note that:

- For a better reading only the values around the peak are shown on the maps, therefore the flow figures do not start at time step 0.
- The maximum water level for each critical point is also summarized in a table for each scenario.
- Only one simulation for a return period of ten year with the current landscape and climate scenario has been done with all modification made at the same time.
- A comparison of the value with the YREC report, the value differs but this is because the calibration was not the same in both models and the climate change scenario are not the same.

6.2.2 Kinamba

Results for IBC-SGI modelling

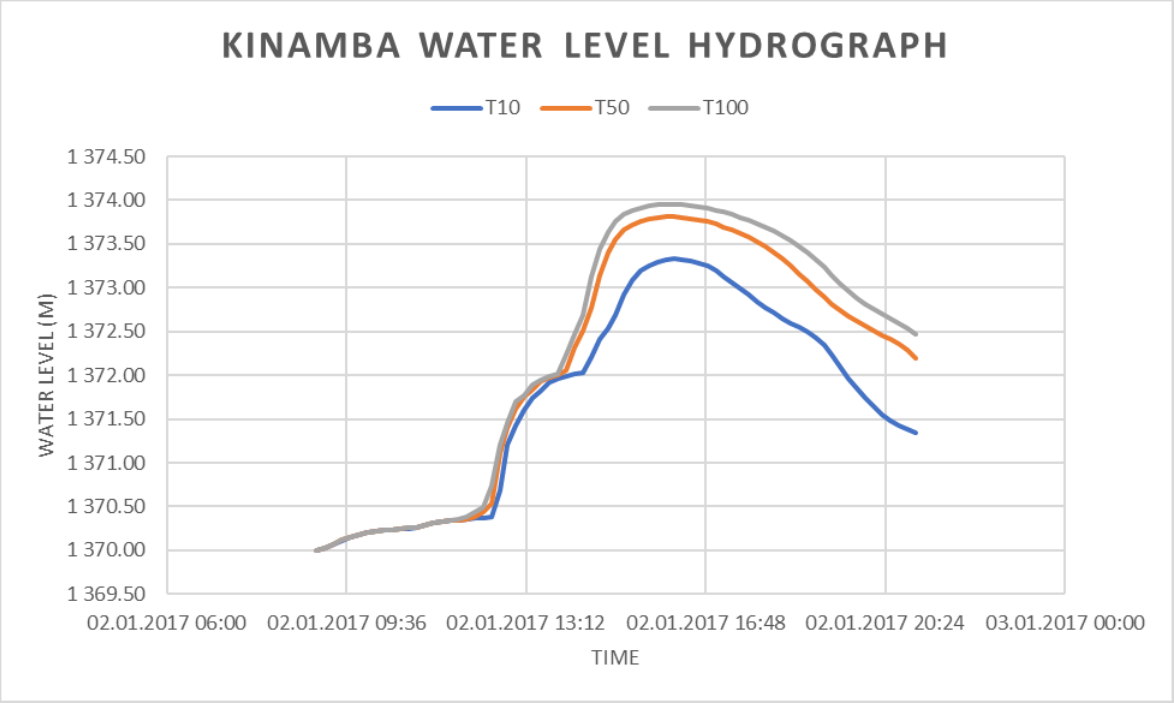


FIGURE 6-1 BASELINE – WATER LEVEL IN KIBAMBA

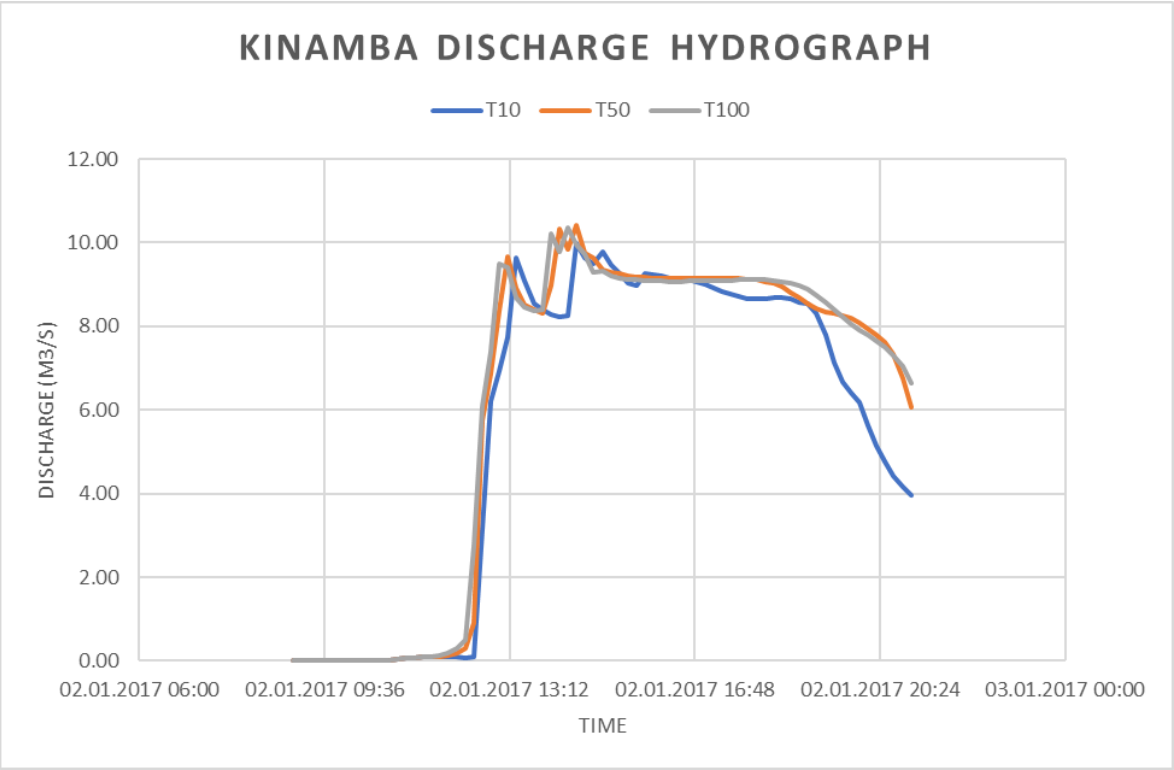


FIGURE 6-2 BASELINE – DISCHARGE IN KIBAMBA

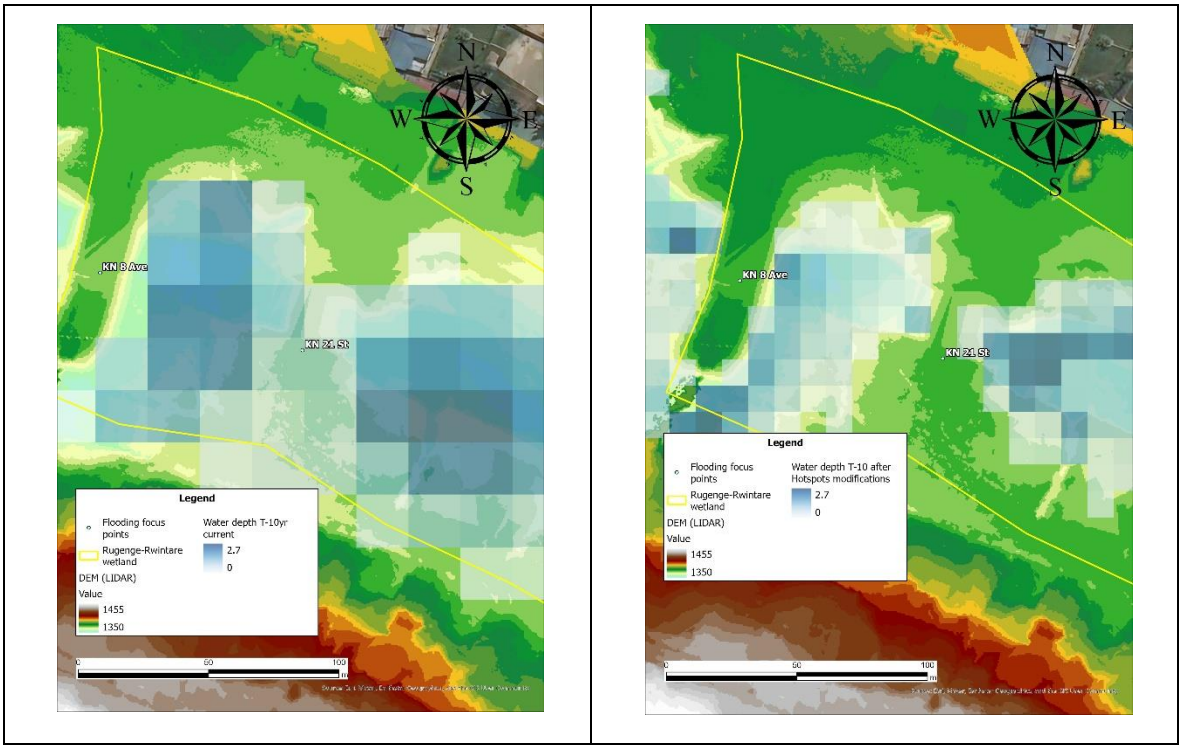


FIGURE 6-3 COMPARISONS OF WATER LEVELS, BEFORE AND AFTER THE KINAMBA HOTSPOT MODIFICATIONS

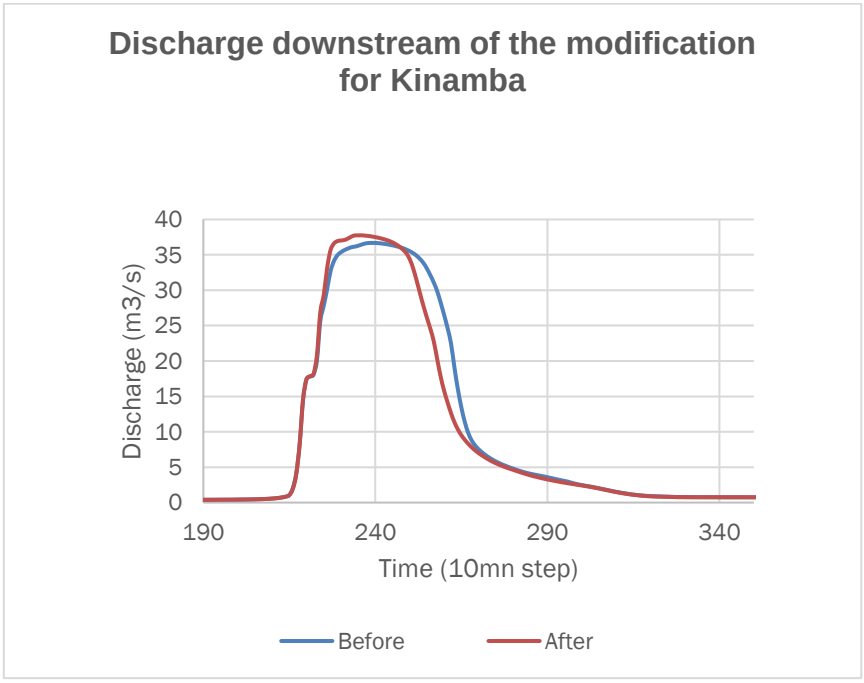


FIGURE 6-4 DISCHARGE DOWNSTREAM THE MODIFICATION BEFORE AND AFTER THE MODIFICATION FOR KINAMBA

TABLE 6-2 WATER DEPTH FOR DIFFERENT SCENARIO FOR KINAMBA

Return Period	Land use	Climate Change	Hotspots Modification	Max water depth IBC/SGI [m]
10 Y	Current	Current	No	0.78
50 Y	Current	Current	No	1.13
100 Y	Current	Current	No	1.27
10 Y	2050	Extreme	No	1.15
10 Y	Current	Current	Yes	0.30

TABLE 6-3 COMPARISONS BETWEEN YREC REPORT AND IBC/SGI REPORT FOR KINAMBA

Return Period	Land use	Hotspots Modification	Max. inundation depth IBC/SGI [m]	Max. inundation depth YREC [m] (ch:4.4)	Max. inundation depth YREC[m] (ch:5)
10	Current	No	0.78	1.85	1.05
50	Current	No	1.13	2.36	
100	Current	No	1.27	2.60	
10	2050	No	1.15	2.48	
		Yes	0.3		1.09 - 1.11

Observations and interpretations are the following:

- Modification in Kinamba provides a smaller inundation depth with proposed infrastructure.
- Increasing the section of the culverts results in a discharge slightly higher before reaching the peak as the previous case without modification. This has to be considered for the sizing of actions for the chosen variant.
- Kinamba is located at the beginning of Nyabugogo wetland. Therefore action 15 and action 26 on the proposed actions for wetland Rehabilitation will be impacted.
- Values given in YREC report for the max. inundation depth for the current state come from table in chapter 4.4 and the value from after the modification comes from table in chapter 5, which may be different. Both values are higher than the one calculated by IBC-SGI model, which could be explained by difference of calibration of the 2 models and by potential wrong interpretation of the YREC results.
- Both models however follow the same trend, an increase of the return period led to an increase of the maximum inundation depth. According to the information we got from YREC report, YREC model doesn't show a significant amelioration while IBC/SGI model improve the situation by 0.48m.

Additional meetings will be needed at the beginning of Detailed design phase of the project to align results of both simulations.

6.2.3 Gisozi-Mukindo

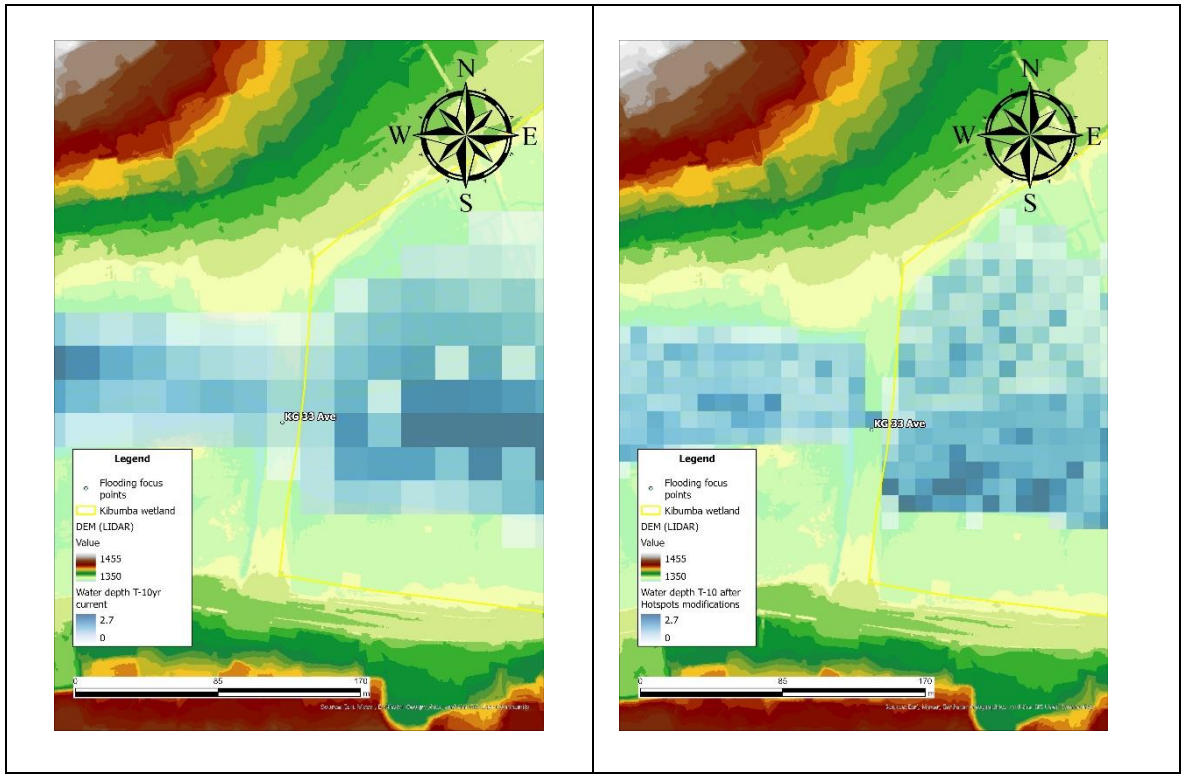


FIGURE 6-5 COMPARISONS OF WATER LEVELS, BEFORE AND AFTER THE GISOZI-MUKINDO HOTSPOT MODIFICATIONS

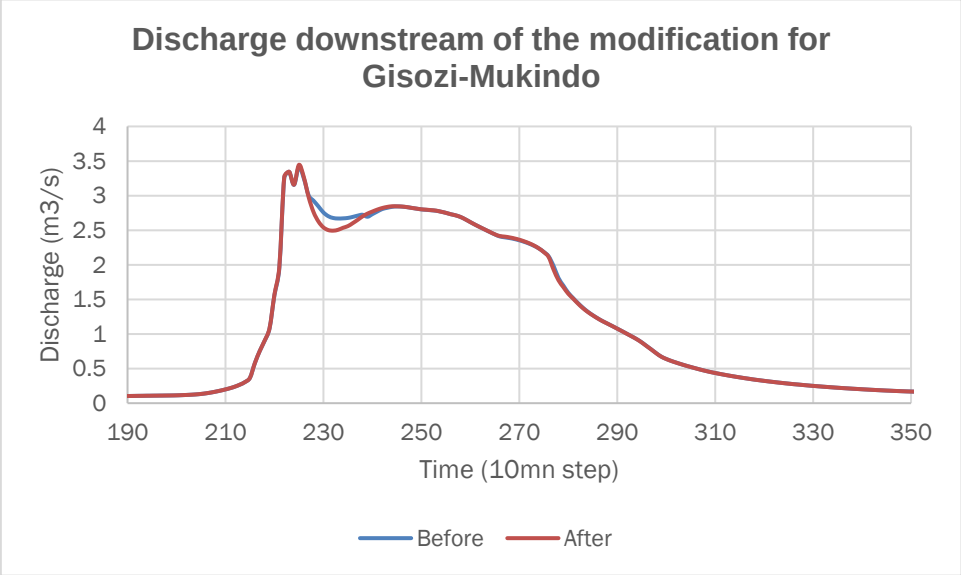


FIGURE 6-6 DISCHARGE DOWNSTREAM THE MODIFICATION BEFORE AND AFTER THE MODIFICATION FOR GISOZI-MUKINDO

TABLE 6-4 WATER DEPTH FOR DIFFERENT SCENARIO FOR GISOZI-MUKINDO

Return Period	Land use	Climate Change	Hotspots Modification	Max water depth IBC/SGI [m]
10 Y	Current	Current	No	0.54
50 Y	Current	Current	No	1.97
100 Y	Current	Current	No	2.17
10 Y	2050	Extreme	No	2.15
10 Y	Current	Current	Yes	0.40

TABLE 6-5 COMPARISONS BETWEEN YREC REPORT AND IBC/SGI REPORT FOR GISOZI-MUKINDO

Return Period	Land use	Hotspots Modification	Max. inundation depth IBC/SGI [m]	Max. inundation depth YREC [m] (ch:4.4)	Max. inundation depth YREC[m] (ch:5)	Reminder of max. inundation depth Deltares [m]
10	Current	No	0.54	0.05	0.67	2.1
50	Current	No	1.97	0.12		2.4
100	Current	No	2.17	0.15		2.6
10	2050	No	2.15	0.18		-
		Yes	0.4	-	0.1	-

Values of YREC for the max. inundation depth for the current state come from table in chapter 4.4 and the value from after the modification comes from table in chapter 5. Both models follow the same trend, an increase of the return period led to an increase of the maximum inundation depth. Each model permits with the modification to improve the situation, YREC reduce the depth by 0.57m and IBC/SGI by 0.14m.

Observations and interpretations are the following:

- Modification in Gisozi-Mukindo provides a smaller inundation depth with proposed infrastructure.
- Increasing the section of the culverts results in a discharge slightly higher before reaching the peak as the previous case without modification. This has to be considered for the sizing of actions for the chosen variant.
- Gisozi-Mukindo is located at the beginning of Nyabugogo wetland. Therefore action 15 and action 18 on the proposed actions for wetland Rehabilitation will be impacted.
- Values given in YREC report for the max. inundation depth for the current state come from table in chapter 4.4 and the value from after the modification comes from table in chapter 5, which may be different. Both values are lower than the one calculated by IBC-SGI model, which could be explained by difference of calibration of the 2 models and by potential wrong interpretation of the YREC results.
- Comparing the values with the Deltares report, it can be seen that the YREC values are far away from the values calculated by Deltares, while the SGI values seem to be closer to them.
- Both models however follow the same trend, an increase of the return period led to an increase of the maximum inundation depth. According to the information we got from YREC report, each model allows improvement of the situation, YREC reduce the depth by 0.57m and IBC/SGI by 0.14m.

6.2.3.1 Cadillac

Results for IBC-SGI modelling

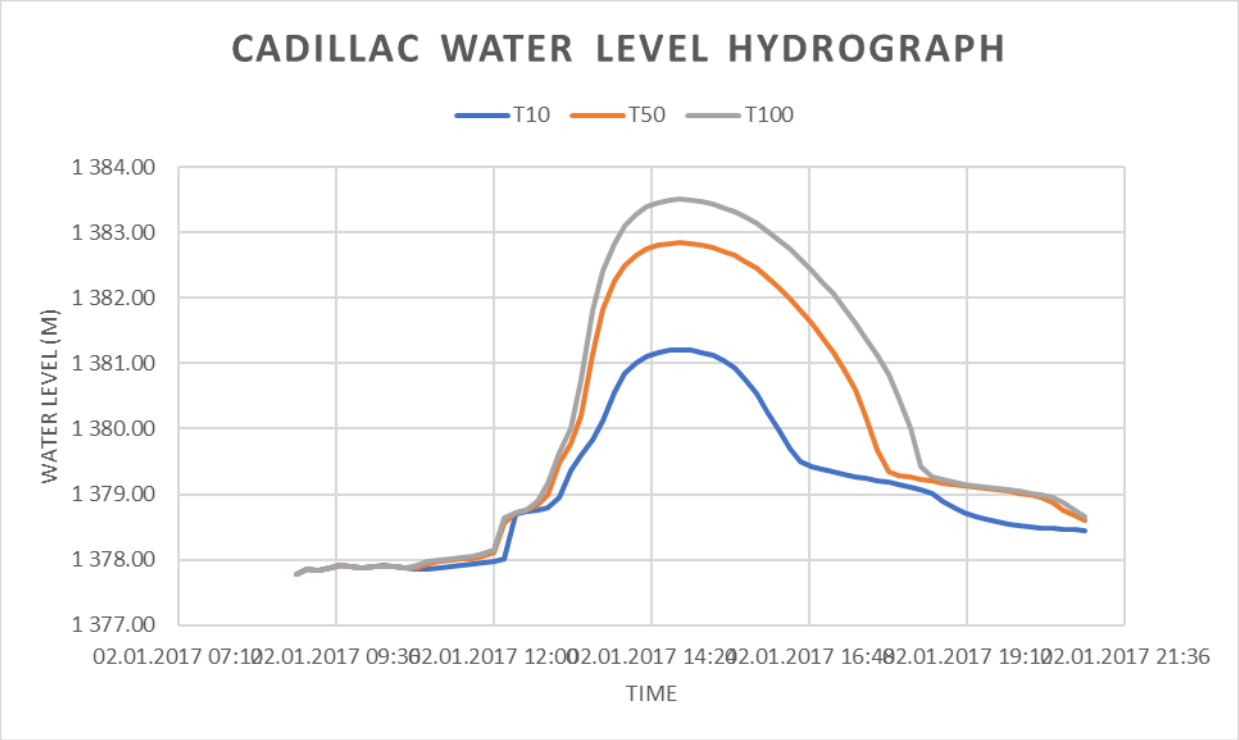


FIGURE 6-7 BASELINE – WATER LEVEL IN CADILLAC

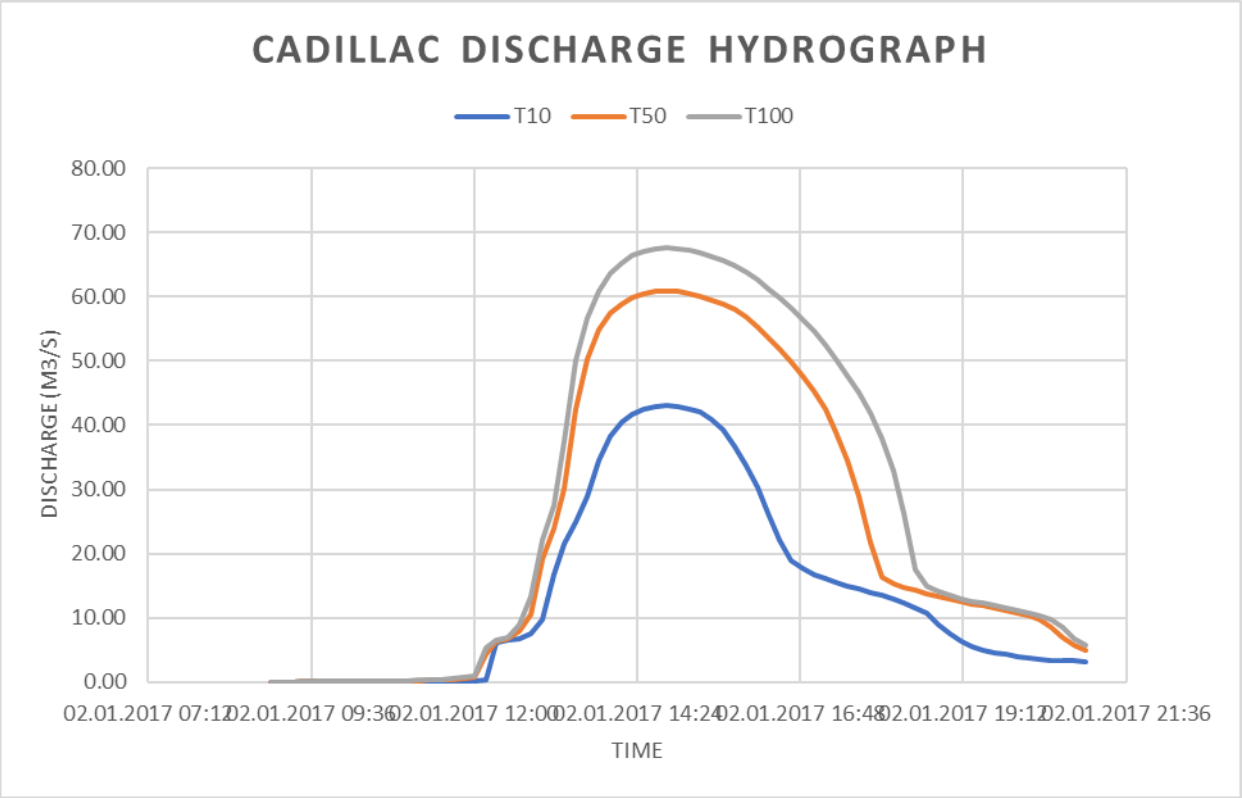


FIGURE 6-8 BASELINE – DISCHARGE IN CADILLAC

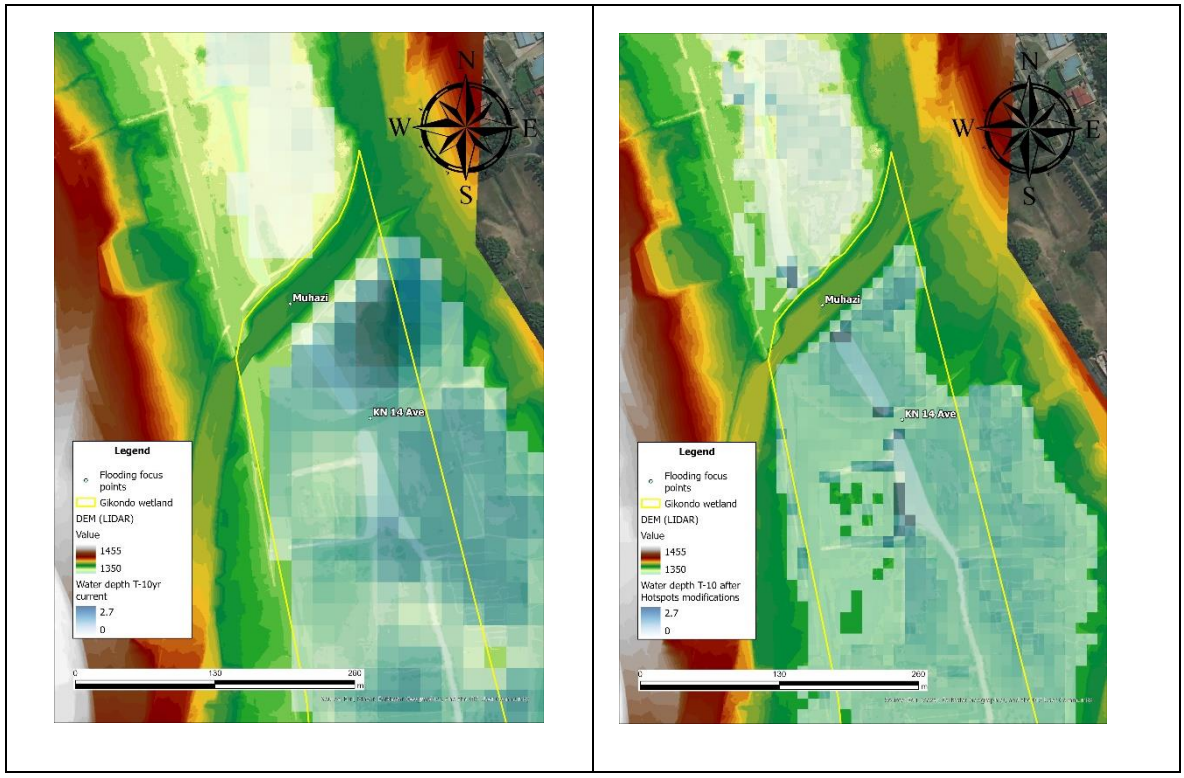


FIGURE 6-9 COMPARISONS OF WATER LEVELS, BEFORE AND AFTER THE CADILLAC HOTSPOT MODIFICATIONS

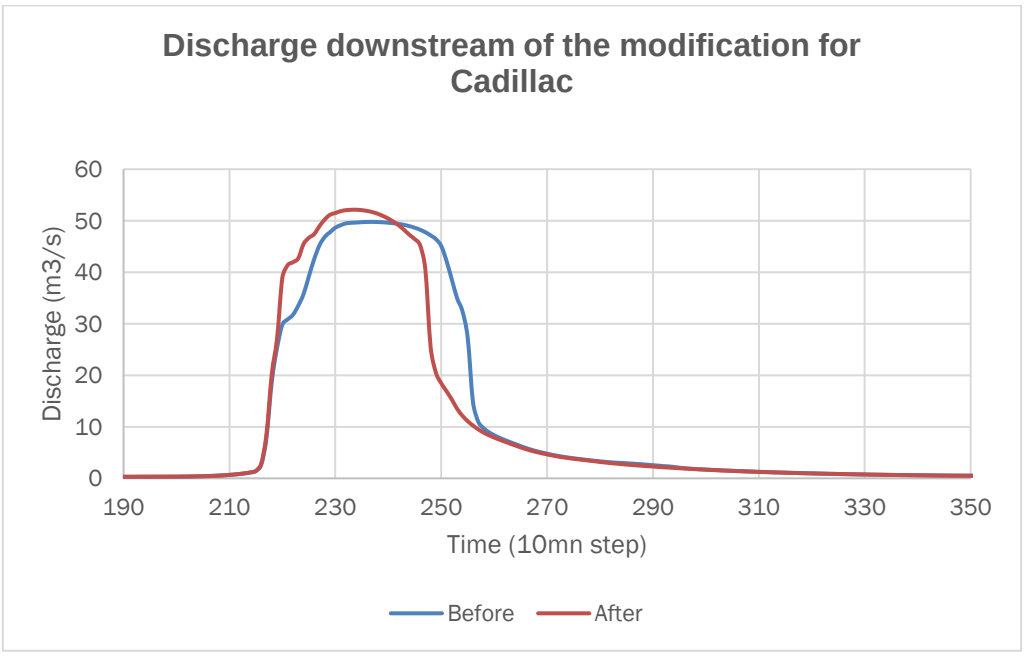


FIGURE 6-10 DISCHARGE DOWNSTREAM THE MODIFICATION BEFORE AND AFTER THE MODIFICATION FOR CADILLAC

TABLE 6-6 WATER DEPTH FOR DIFFERENT SCENARIO FOR CADILLAC

Return Period	Land use	Climate Change	Hotspots Modification	Max water depth IBC/SGI [m]
10 Y	Current	Current	No	2.28
50 Y	Current	Current	No	3.59
100 Y	Current	Current	No	4.27
10 Y	2050	Extreme	No	3.84
10 Y	Current	Current	Yes	0.89

TABLE 6-7 COMPARISONS BETWEEN YREC REPORT AND IBC/SGI REPORT FOR CADILLAC

Return Period	Land use	Hotspots Modification	Max. inundation depth IBC/SGI [m]	Max. inundation depth YREC [m] (ch:4.4)	Max. inundation depth YREC[m] (ch:5)
10	Current	No	2.28	0.37	3.67
50	Current	No	3.59	1.50	
100	Current	No	4.27	1.77	
10	2050	No	3.84	1.85	
		Yes	0.89		3.23

Observations and interpretations are the following:

- Modification in Cadillac provides a smaller inundation depth with proposed infrastructure.
- Increasing the section of the culverts results in a discharge slightly higher before reaching the peak as the previous case without modification. This has to be considered for the sizing of actions for the chosen variant.
- Cadillac is located at the beginning of Rugenge wetland. Therefore action 7 and action 18 on the proposed actions for wetland Rehabilitation will be impacted. Moreover, the nature-based solution proposed in other to reduce inundation depth reduces the area of the action G15.
- Values given in YREC report for the max. inundation depth for the current state come from table in chapter 4.4 and the value from after the modification comes from table in chapter 5, which may be different. Both values are lower than the one calculated by IBC-SGI model, even if the value in chapter 5 is closer, This could be explained by difference of calibration of the 2 models and by potential wrong interpretation of the YREC results.
- Both models however follow the same trend, an increase of the return period led to an increase of the maximum inundation depth. According to the information we got from YREC report, each model allows improvement of the situation, YREC reduce the depth by 0.44m and IBC/SGI by 1.39m.

6.2.3.2 Kanogo

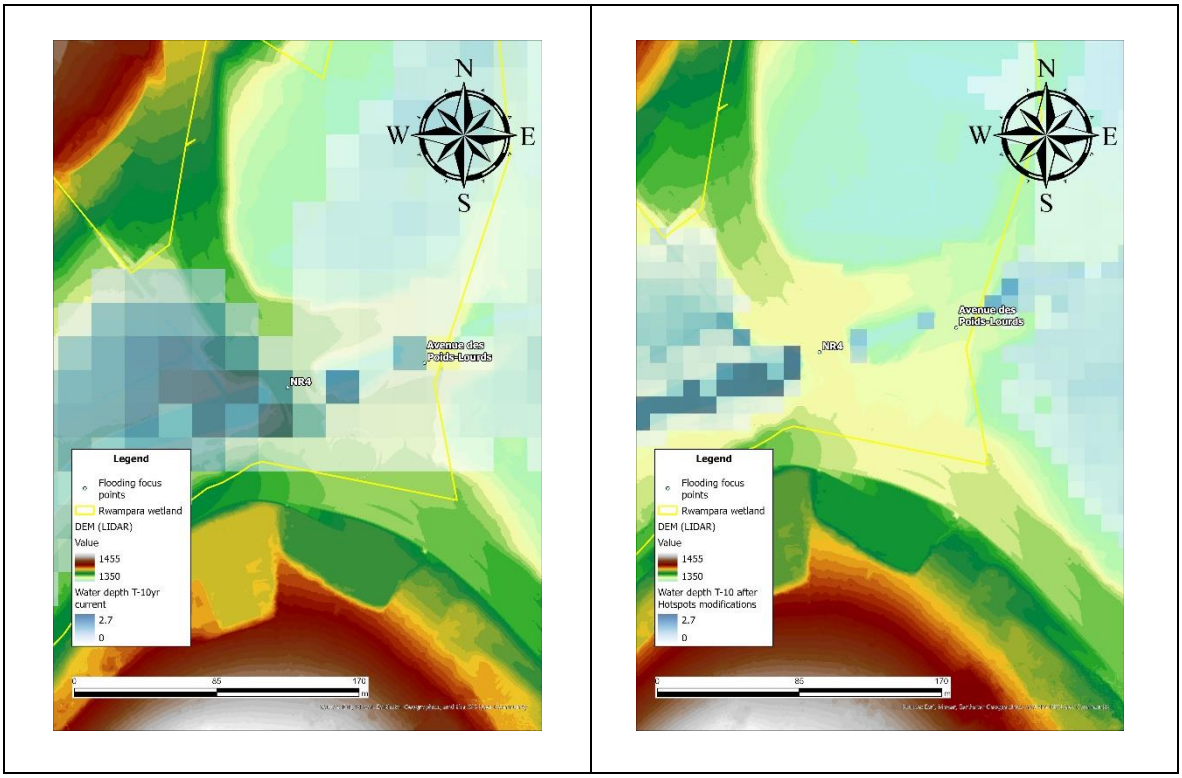


FIGURE 6-11 COMPARISONS OF WATER LEVELS, BEFORE AND AFTER THE KANOGO HOTSPOT MODIFICATIONS

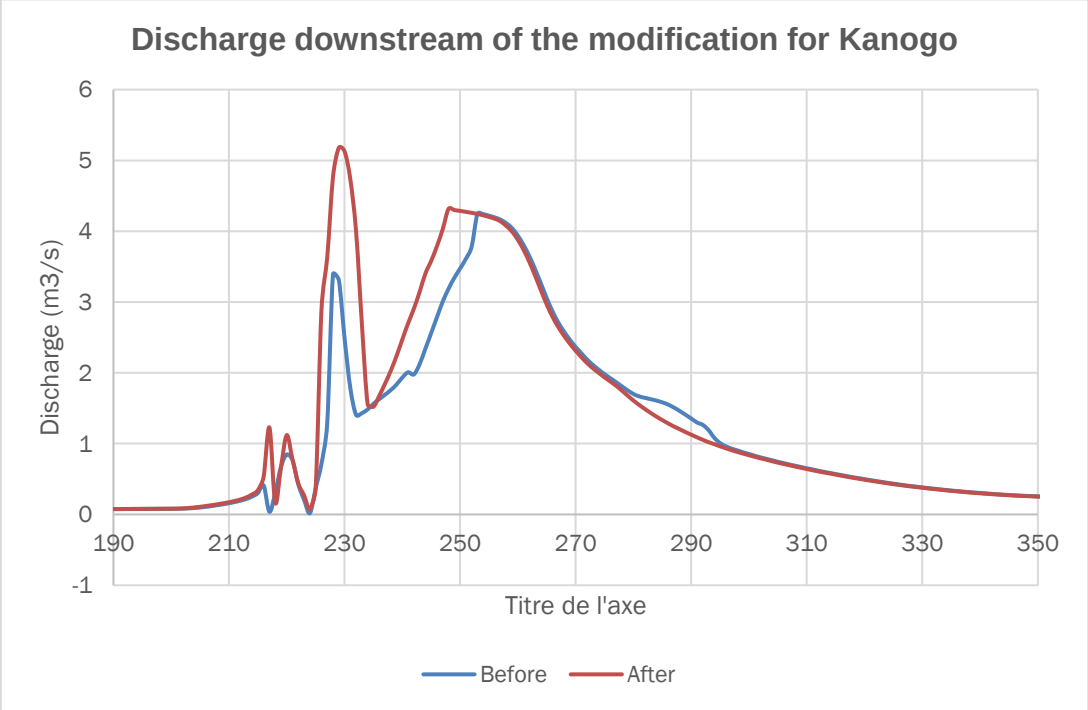


FIGURE 6-12 DISCHARGE DOWNSTREAM THE MODIFICATION BEFORE AND AFTER THE MODIFICATION FOR KANOGO

TABLE 6-8 WATER DEPTH FOR DIFFERENT SCENARIO FOR KANOGO

Return Period	Land use	Climate Change	Hotspots Modification	Max water depth IBC/SGI [m]
10 Y	Current	Current	No	0.40
50 Y	Current	Current	No	0.48
100 Y	Current	Current	No	0.57
10 Y	2050	Extreme	No	0.57
10 Y	Current	Current	Yes	0.00

TABLE 6-9 COMPARISONS BETWEEN YREC REPORT AND IBC/SGI REPORT FOR KANOGO

Return Period	Land use	Hotspots Modification	Max. inundation depth IBC/SGI [m]	Max. inundation depth YREC [m] (ch:4.4)	Max. inundation depth YREC[m] (ch:5)
10	Current	No	0.40	0.56	0.86
50	Current	No	0.48	0.92	
100	Current	No	0.57	1.02	
10	2050	No	0.57	1.15	
		Yes	0.00		0.74

Observations and interpretations are the following:

- Modification in Kanogo provides a smaller inundation depth with proposed infrastructure.
- Increasing the passing section results in a maximum discharge higher than the previous case without modification. This has to be considered for the sizing of actions for the chosen variant.
- Kanogo is located at the end of Rwampara wetland and will therefore impact the downstream en Gikondo wetland. Therefore action 7 and action 18 on the proposed actions for wetland Rehabilitation will be impacted.
- Values given in YREC report for the max. inundation depth for the current state come from table in chapter 4.4 and the value from after the modification comes from table in chapter 5, which may be different. Both values are a little bit lower to the the one calculated by IBC-SGI model, even if the value in chapter 5 seems to be closer. This could be explained by difference of calibration of the 2 models and by potential wrong interpretation of the YREC results.
- Both models however follow the same trend, an increase of the return period led to an increase of the maximum inundation depth. According to the information we got from YREC report, each model allows improvement of the situation, YREC reduce the depth by 0.12m and IBC/SGI by 0.40m

6.2.3.3 Rugunga

Results for IBC-SGI modelling

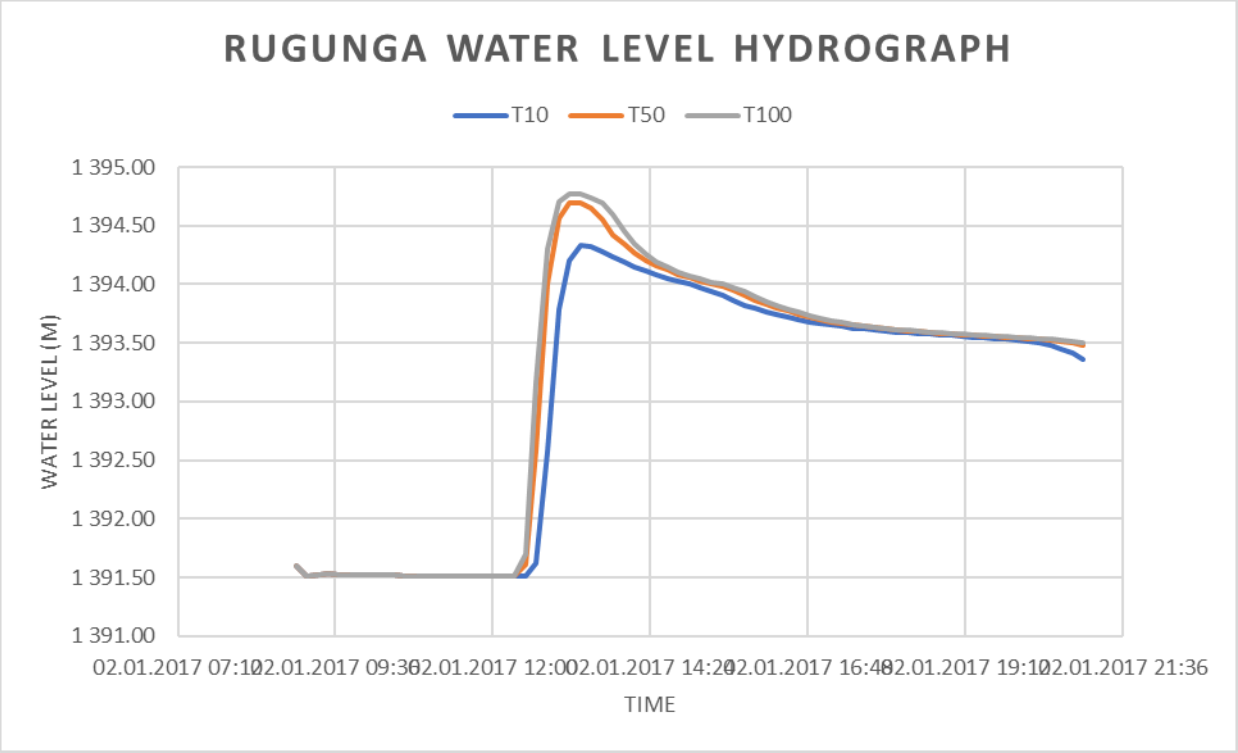


FIGURE 6-13 BASELINE – WATER LEVEL IN RUGUNGA

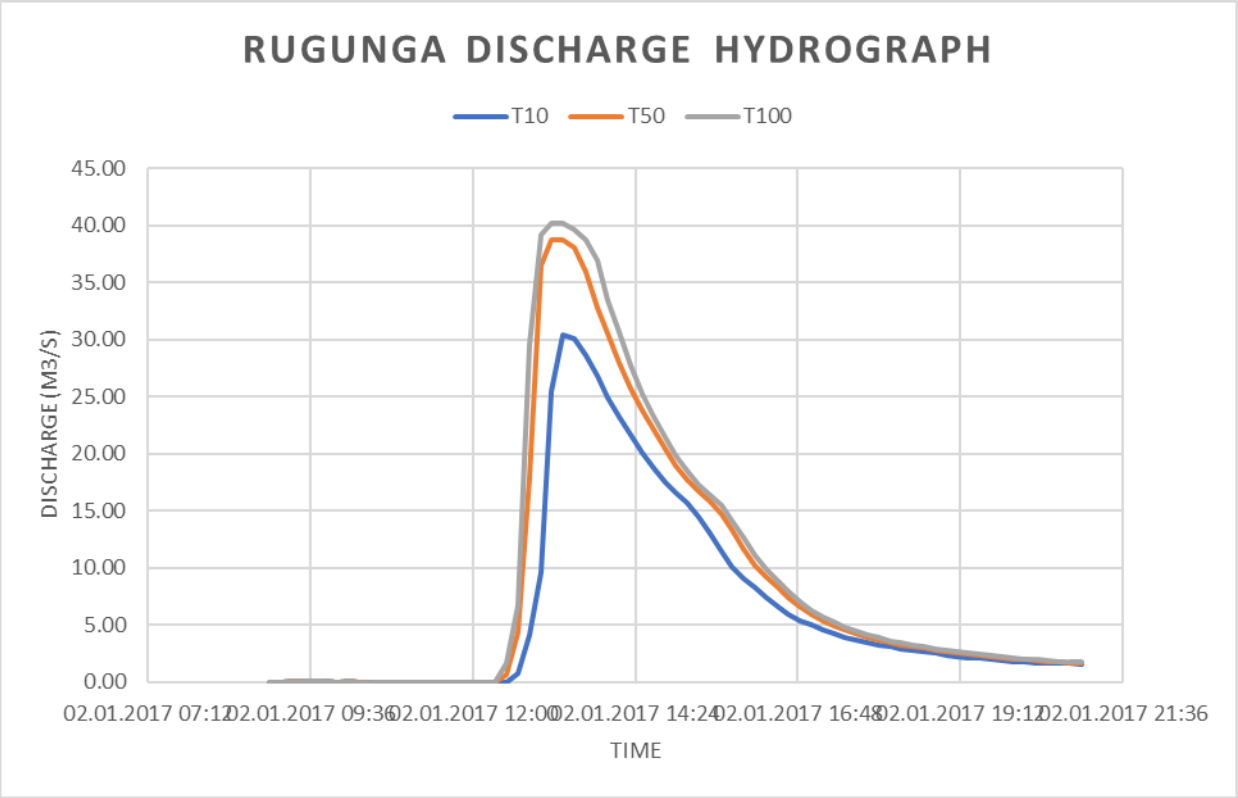


FIGURE 6-14 BASELINE – DISCHARGE IN RUGUNGA

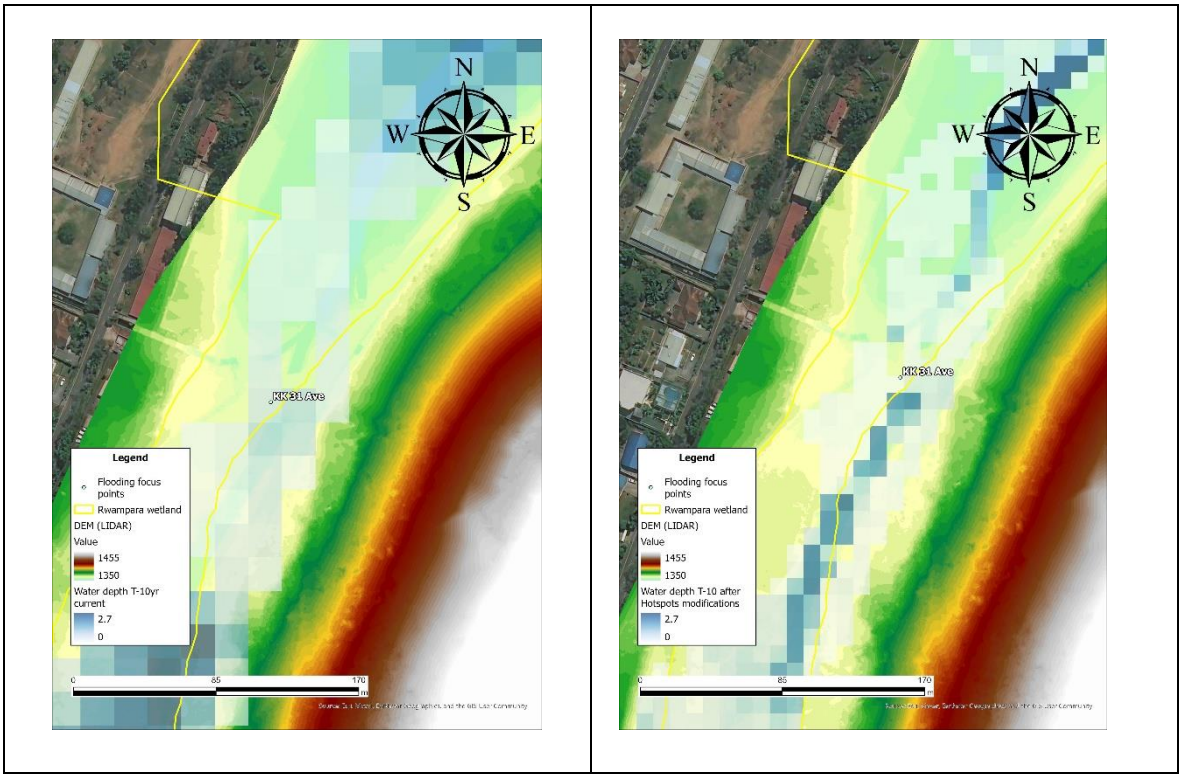


FIGURE 6-15 COMPARISONS OF WATER LEVELS, BEFORE AND AFTER THE RUGUNGA HOTSPOT MODIFICATIONS

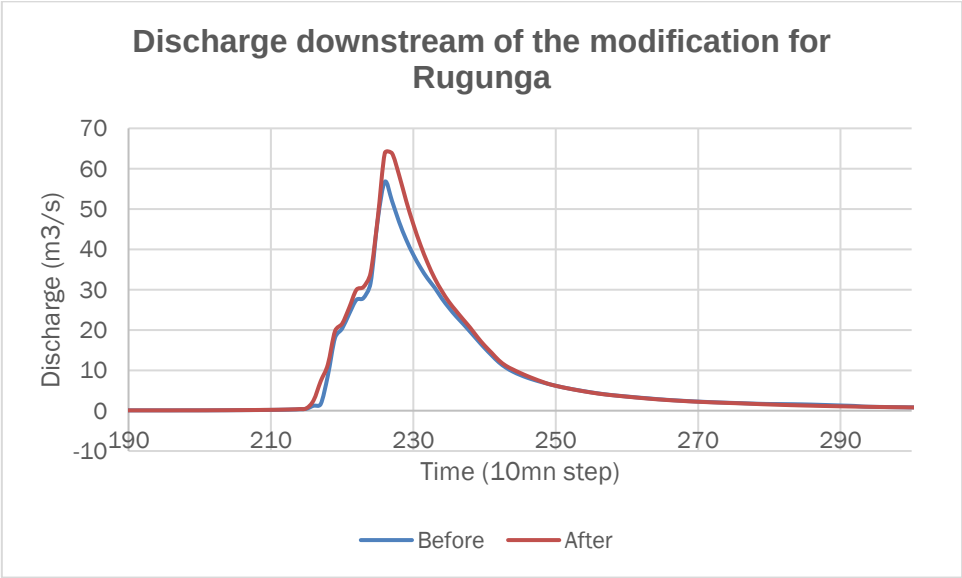


FIGURE 6-16 DISCHARGE DOWNSTREAM THE MODIFICATION BEFORE AND AFTER THE MODIFICATION FOR RUGUNGA

TABLE 6-10 WATER DEPTH FOR DIFFERENT SCENARIO FOR RUGUNGA

Return Period	Landscape	Climate Change	Hotspots Modification	Max water depth IBC/SGI [m]
10 Y	Current	Current	No	0.78
50 Y	Current	Current	No	1.01
100 Y	Current	Current	No	1.10
10 Y	2050	Extreme	No	1.11
10 Y	Current	Current	Yes	0.32

TABLE 6-11 COMPARISONS BETWEEN YREC REPORT AND IBC/SGI REPORT FOR RUGUNGA

Return Period	Land use	Hotspots Modification	Max. inundation depth IBC/SGI [m]	Max. inundation depth YREC [m] (ch:4.4)	Max. inundation depth YREC[m] (ch:5)	Reminder of max. inundation depth Deltares [m]
10	Current	No	0.78	1.02	1.96	2.9
50	Current	No	1.01	1.26		3.8
100	Current	No	1.10	1.36		4.0
10	2050	No	1.11	1.46		-
		Yes	0.32		1.60	-

Observations and interpretations are the following:

- Modification in Rugunga provides a smaller inundation depth with proposed infrastructure.
- Increasing the section of the culverts results in a discharge slightly higher before reaching the peak as the previous case without modification. This has to be considered for the sizing of actions for the chosen variant.
- Values given in YREC report for the max. inundation depth for the current state come from table in chapter 4.4 and the value from after the modification comes from table in chapter 5, which may be different. Both values are very close to the one calculated by IBC-SGI model.
- Comparing the values with the Deltares report, it can be seen that the values calculated both by YREC and IBC/SGI are much lower than the Deltares ones. This could be explained by difference of calibration of the 2 models and the different values of elevation (new LIDAR not considered by Deltares).
- Both models follow the same trend, an increase of the return period led to an increase of the maximum inundation depth. According to the information we got from YREC report, each model allows improvement of the situation, YREC reduce the depth by 0.36m and IBC/SGI by 0.46m.

6.2.3.4 Rwampara

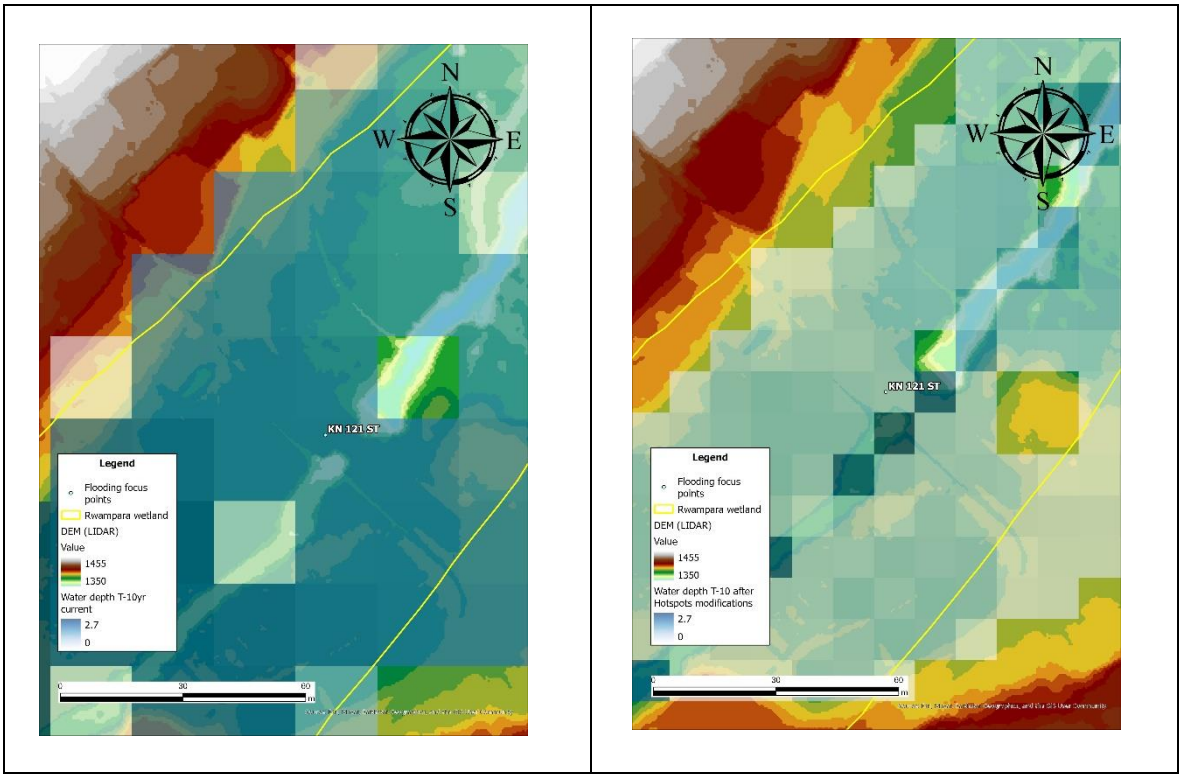


FIGURE 6-17 COMPARISONS OF WATER LEVELS, BEFORE AND AFTER THE RWAMPARA HOTSPOT MODIFICATIONS

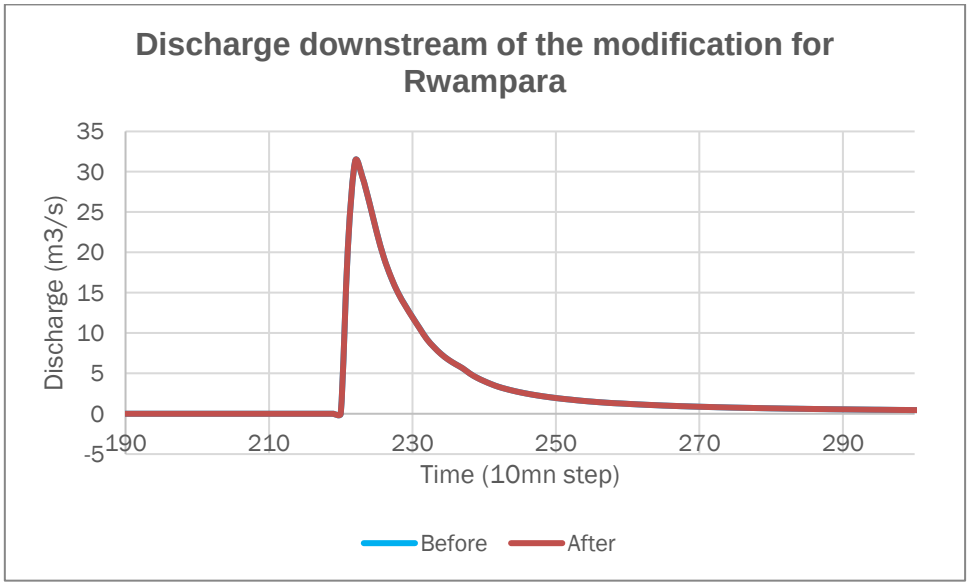


FIGURE 6-18 DISCHARGE DOWNSTREAM THE MODIFICATION BEFORE AND AFTER THE MODIFICATION FOR RWAMPARA

TABLE 6-12 WATER DEPTH FOR DIFFERENT SCENARIO FOR RWAMPARA

Return Period	Landscape	Climate Change	Hotspots Modification	Max water depth IBC/SGI [m]
10 Y	Current	Current	No	1.06
50 Y	Current	Current	No	1.34
100 Y	Current	Current	No	1.46
10 Y	2050	Extreme	No	1.60
10 Y	Current	Current	Yes	0.77

TABLE 6-13 COMPARISONS BETWEEN YREC REPORT AND IBC/SGI REPORT FOR RWAMPARA

Return Period	Land use	Hotspots Modification	Max. inundation depth IBC/SGI [m]	Max. inundation depth YREC [m] (ch: 4.4)	Max. inundation depth YREC[m] (ch:5)
10	Current	No	1.06	0.42	1.34
50	Current	No	1.34	0.68	
100	Current	No	1.46	0.78	
10	2050	No	1.60	0.91	
		Yes	0.77		0.00

Observations and interpretations are the following:

- Modification in Rwampara provides a smaller inundation depth. Here in this hotspot the discharge before and after the modification remains the same. Therefore, no major impact will be transferred downstream.
- Values given in YREC report for the max. inundation depth for the current state come from table in chapter 4.4 and the value from after the modification comes from table in chapter 5, which may be different. Values of chapter 4 are lower than the one calculated by IBC-SGI model whereas the value given in chapter 5 is very close.
- Both models follow the same trend, an increase of the return period led to an increase of the maximum inundation depth. According to the information we got from YREC report, each model allows improvement of the situation, YREC reduce the depth by 1.34m and IBC/SGI by 0.29m.

6.2.3.5 Rwandex

IBC-SGI Modelling results

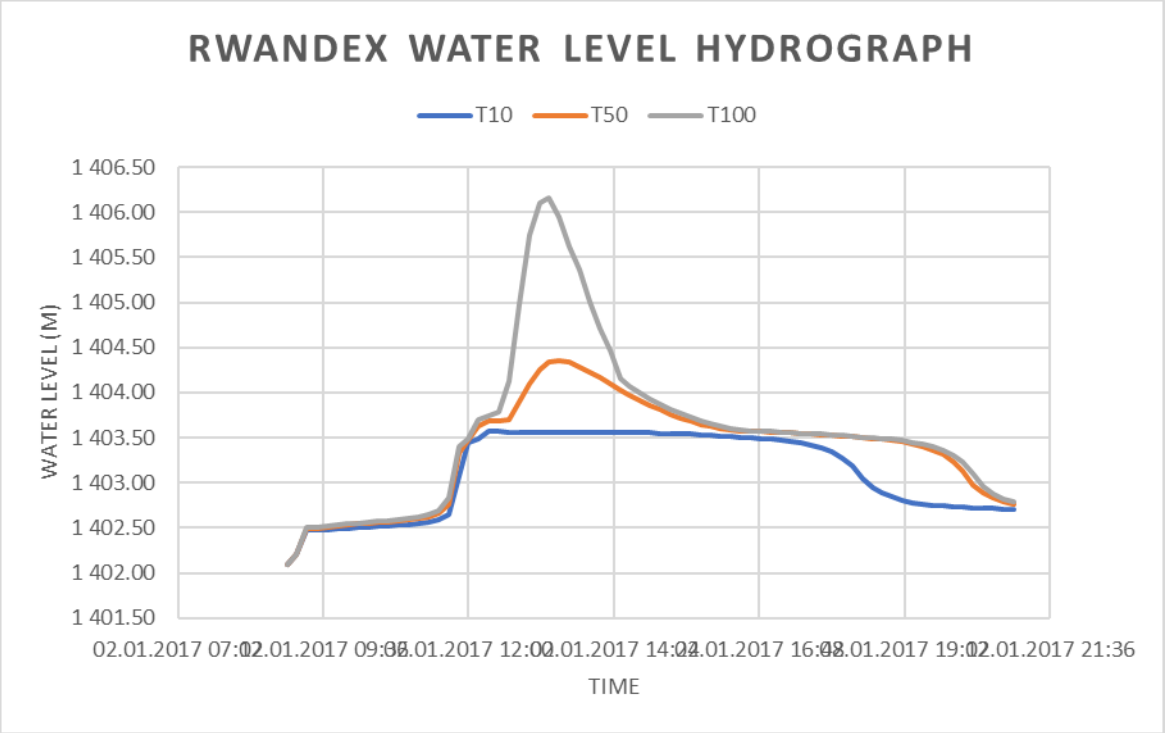


FIGURE 6-19 BASELINE – WATER LEVEL IN RWANDEX

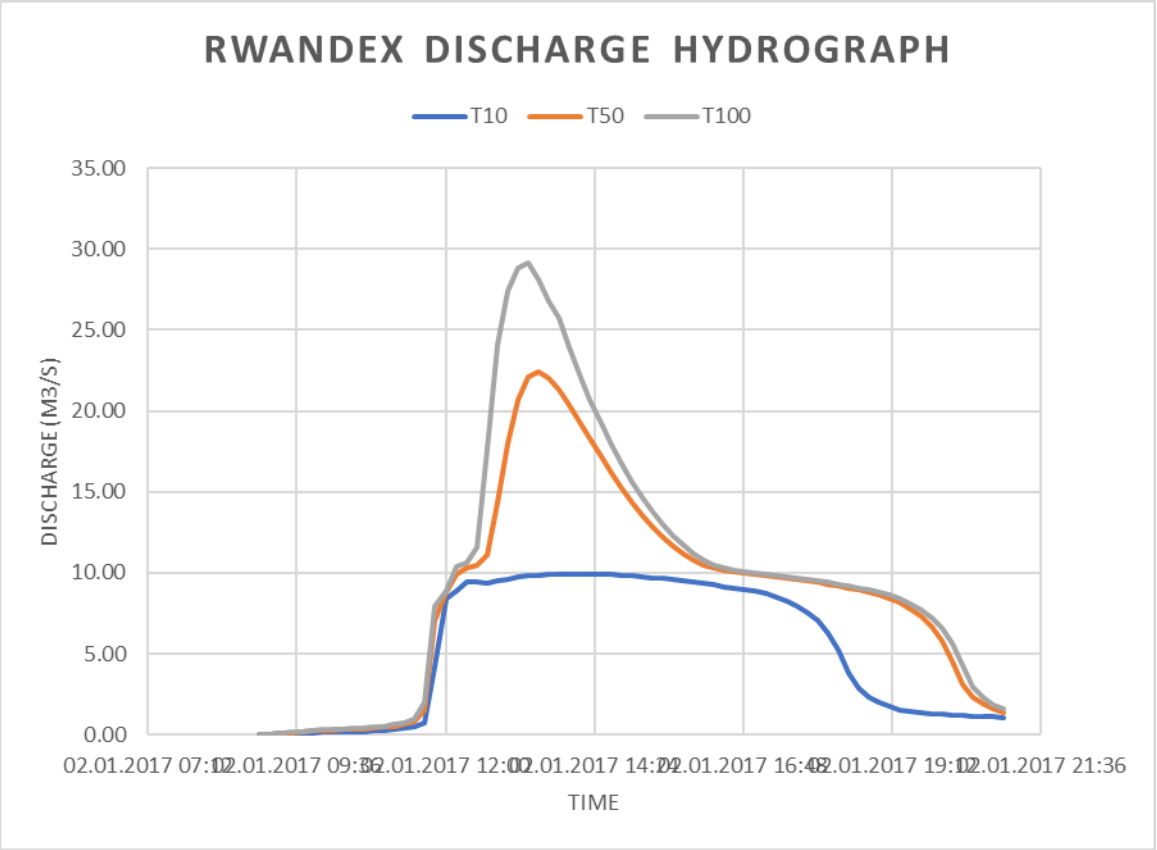


FIGURE 6-20 BASELINE – DISCHARGE IN RWANDEX

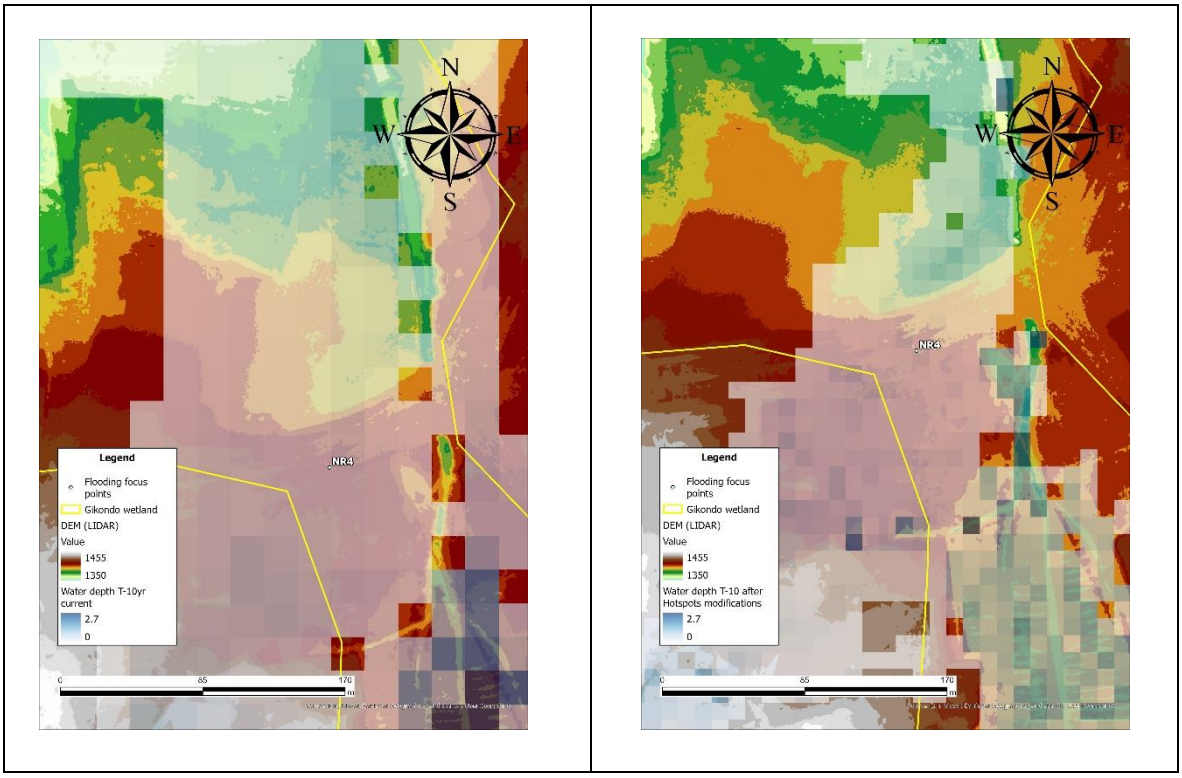


FIGURE 6-21 COMPARISONS OF WATER LEVELS, BEFORE AND AFTER THE RWANDEX HOTSPOT MODIFICATIONS

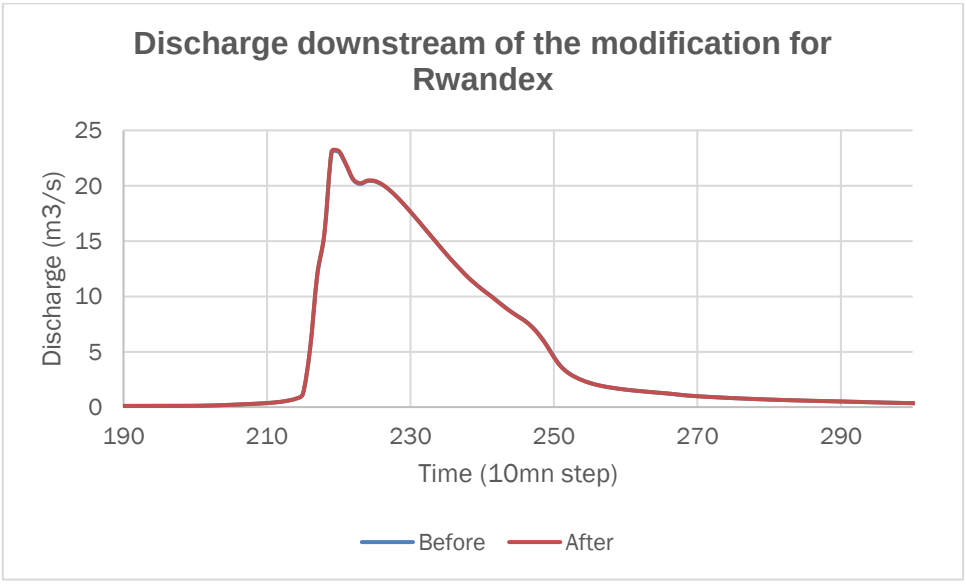


FIGURE 6-22 DISCHARGE DOWNSTREAM THE MODIFICATION BEFORE AND AFTER THE MODIFICATION FOR RWANDEX

TABLE 6-14 WATER DEPTH FOR DIFFERENT SCENARIO FOR RWANDEX

Return Period	Landscape	Climate Change	Hotspots Modification	Max water depth IBC/SGI [m]
10 Y	Current	Current	No	0.04
50 Y	Current	Current	No	0.14
100 Y	Current	Current	No	0.27
10 Y	2050	Extreme	No	0.29
10 Y	Current	Current	Yes	0.03

TABLE 6-15 COMPARISONS BETWEEN YREC REPORT AND IBC/SGI REPORT FOR RWANDEX

Return Period	Land use	Hotspots Modification	Max. inundation depth IBC/SGI [m]	Max. inundation depth YREC [m] (ch:4.4)	Max. inundation depth YREC[m] (ch:5)
10	Current	No	1.06	0.00	0.19
50	Current	No	1.34	0.36	
100	Current	No	1.46	0.37	
10	2050	No	1.60	0.43	
		Yes	0.03		0.10

Observations and interpretations are the following:

- Modification in Rwandex provides a smaller inundation depth. Here in this hotspot the discharge before and after the modification remains the same. Therefore, no major impact will be transferred downstream.
- Values given in YREC report for the max. inundation depth for the current state come from table in chapter 4.4 and the value from after the modification comes from table in chapter 5, which may be different. Both values are lower than the one calculated by IBC-SGI model whereas the value given in chapter 5 is very close. This could be explained by the difference of calibrations between the 2 models.
- Both models follow the same trend, an increase of the return period led to an increase of the maximum inundation depth. According to the information we got from YREC report, each model allows improvement of the situation, YREC reduce the depth by 0.09m and IBC/SGI by 1.03m.

6.2.3.6 Conclusion

6.2.3.6.1 Specific analysis for 4 hotspots

A specific analysis of water level and discharge was carried out for 4 hotspots as a specific requirement on October 2022 – see graphs before. The following table is a summary of the main values to be observed on theses specific points.

TABLE 6-16 SUMMARY OF THE INITIAL MAIN VALUE FOR 4 REPRESENTATIVE HOTSPOTS

		T10	T50	T100
Rwandex	Peak discharge (m3/s)	9,93	22,40	29,11
	Peak water level (m)	1403,57	1404,36	1406,16
	Volume of runoff (m3)	351 199,34	571 522,34	670 370,70
Rugunga	Peak discharge (m3/s)	30,45	38,76	40,21
	Peak water level (m)	1394,34	1394,69	1394,77
	Volume of runoff (m3)	250 527,99	365 272,44	366 360,32
Cadillac	Peak discharge (m3/s)	42,98	60,88	67,56
	Peak water level (m)	1381,21	1382,84	1383,51
	Volume of runoff (m3)	617 709,13	1 030 849,97	1 220 328,20
Kinamba	Peak discharge (m3/s)	9,97	10,42	10,37
	Peak water level (m)	1373,33	1373,81	1373,95
	Volume of runoff (m3)	246 601,92	266 112,00	272 506,03

Initial values with wrong data extraction points for the model. See §6.2.3.6.2 for the T10 values considering the right extracting points.

The following comments can be made regarding the graphs and table presented:

- Differences are observed between our model results and other simulations (Deltares, YREC). The explanations could be the following:
  - Difference with Deltares results: Deltares approach was very large and was not considering the new LIDAR data. The accuracy of the results seems to be quite low.
  - Difference with YREC results: YREC considers more important rain events for the same return periods (around 28% of intensity). This explains that the flow, water levels and flood volume **are always higher**.
  - Model calibration: in order to improve the accuracy of our modelling, we calibrated our model with **5 on-site measurement points** during spring 2022. As far as we know both YREC and Deltares models were only calibrated with measurement at Nemba station. This could explain some differences.
- The value of discharge we presented is **only the discharge in the main part of the channel**. Lateral discharges are very difficult to estimate for important events, since flooding is very important. The discharge does not seem to be a good way to compare results since it is very variable and the cumulative flow rate is difficult to estimate at a given time. It is more relevant to think in terms of water level.
- For most of the hotspots, the existing culverts and bridges act like buffers for the floods which leads to a spread of the peak of the hydrograph. Thus, according to the results of our model, the water level is higher for a longer time.

It is important to remind that the precise location where the values were taken is very sensitive to the value displayed. We took the information just upstream the main structure, as close as possible from the centre of the channel, we expect YREC will take the same point.

Finally, it is necessary to recall that a fine-tuning of the results will be necessary when starting the detailed design phase.

6.2.3.6.2 Conclusion with the right extracting point

After a meeting done in October regarding the specific analysis report done earlier, a final report was produced to conclude on the request. In this report, the discharge values were considering the overland discharge and the data taken from better extracting points.

NEW SIMULATIONS FOR T10		Rugunga	Cadillac	Rwandex	Kinamba
PEAK FLOW	YREC VALUE	75.3 m3/s	84.9 m3/s	21.4 m3/s	88.9 m3/s
	IBC-SGI PREVIOUS VALUE	30.4 m3/s	64.5 m3/s	13.6 m3/s	51.0 m3/s
	IBC-SGI CORRECTED VALUE WITH NEW EXTRACTING POINTS (see detail above)	53.4 m3/s	64.5 m3/s	14.9 m3/s	66.2 m3/s
	PREVIOUS DIFFERENCE BETWEEN IBC-SGI AND YREC	59.5%	24.1%	36.6%	42.6%
	NEW DIFFERENCE BETWEEN IBC-SGI AND YREC	29.1%	24.1%	31.4%	25.5%
	REMINDER OF DIFFERENCE OBSERVED ON RAIN INTENSITY BETWEEN THE MODELS	**28%**	**28%**	**28%**	**28%**
	FINAL DIFFERENCE	**1.1%**	**3.9%**	**3.4%**	**2.5%**
RUNOFF VOLUME	YREC VALUE	880 000 m3	1 922 000 m3	605 000 m3	2 214 000 m3
	IBC-SGI PREVIOUS VALUE	250 529 m3	881 939 m3	289 485 m3	897 968 m3
	IBC-SGI CORRECTED VALUE WITH NEW EXTRACTING POINTS (see detail above)	400 433 m3	881 939 m3	289 740 m3	1 069 103 m3
	PREVIOUS DIFFERENCE BETWEEN IBC-SGI AND YREC	71.5%	54.1%	52.2%	59.4%
	NEW DIFFERENCE BETWEEN IBC-SGI AND YREC	54.5%	54.1%	52.2%	48.2%
	REMINDER OF DIFFERENCE OBSERVED ON RAIN INTENSITY BETWEEN THE MODELS	**Certainly around 50%**	**certainly around 50%**	**certainly around 50%**	**certainly around 50%**
	FINAL DIFFERENCE	**Less than 5%**	**less than 5%**	**less than 5%**	**less than 5%**

As a conclusion to this report, the results were considered satisfying regarding the objectives of the models.

6.3 AIMPACT OF FLOOD HOTSPOTS ON WETLAND FOR THE REHABILITATION ACTIONS PROPOSED

The following sections present:

- A reminder of hydraulic simulation results for actions proposed for wetland rehabilitation
- A comparison for a ten-year return period event and the current landscape before and after the improvement of the rehabilitation proposed actions and the proposition of the 6 hotspots by YREC

6.3.1 Methodology

As described in detail in this report, the following actions have been proposed:

Name of the measure	**Description**	**Implementation in Sobek**
Raising the water level in the outfalls	Placement of aggregate at the bottom of the bed of the outfalls	Section modification
Creation of overflows on the 2 concrete canals	Creation of a lateral weir along the canal	Section modification
Removal of existing backfills	Removal of existing backfills	Section modification
Blocking of surface drains	Fill in the drains with aggregate	Increased lateral inflow
Re-profiling the river with meanders and banks	Creation of meanders and banks	Section modification
Recharge of the riverbed with aggregate	Recharge of the riverbed with aggregate	Section modification
Re-profiling of the hydraulic outlets from the discharge	Creation of different riverbed ground level	Modification of elevation
Clearance over a large width to facilitate the overflow	Clearance of the outer areas of the meanders	Modification of elevation
Ground levelling and vegetation to create an urban green space	Ground levelling and vegetation to create an urban green space	Modification of elevation
Raising the water level of the river	Placement of aggregate at the bottom of the bed	Section modification
Creation of a delta before the confluence of the Nyabugogo river	Creation of a delta before the confluence of the Nyabugogo river	Section modification
Pedestrian path to connect both sides of the wetlands	Pedestrian path to connect both sides of the wetlands	No major impact

The section modification was mainly implemented by raising the bottom of the river bed, as illustrated in the figure below :

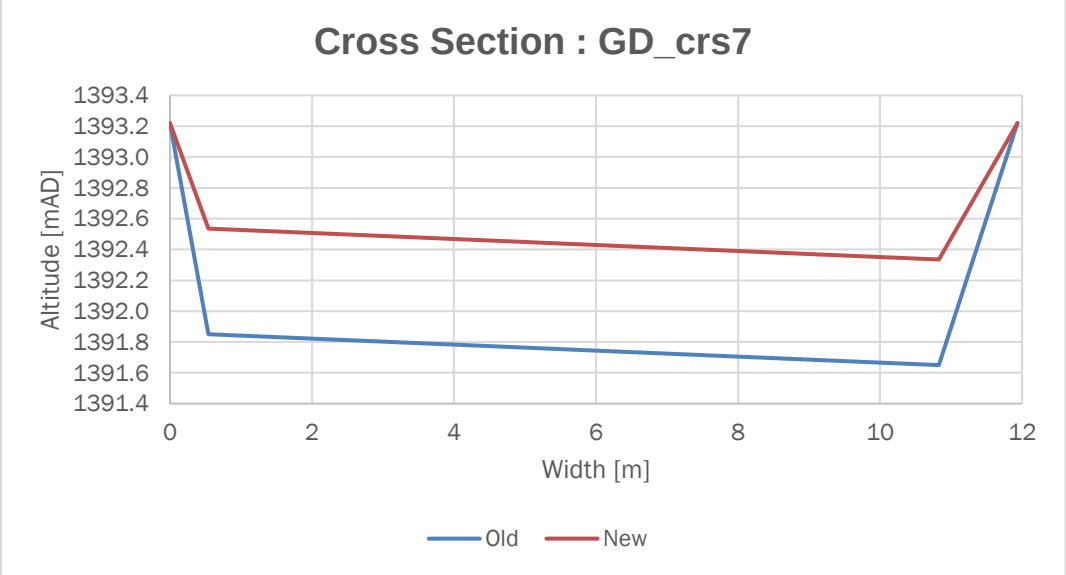


FIGURE 6-23 EXAMPLE OF MODIFICATION OF A CROSS SECTION IN ZONE G15 (GIKONDO)

Some actions were simulated by increasing the lateral inflows by considering less infiltration:

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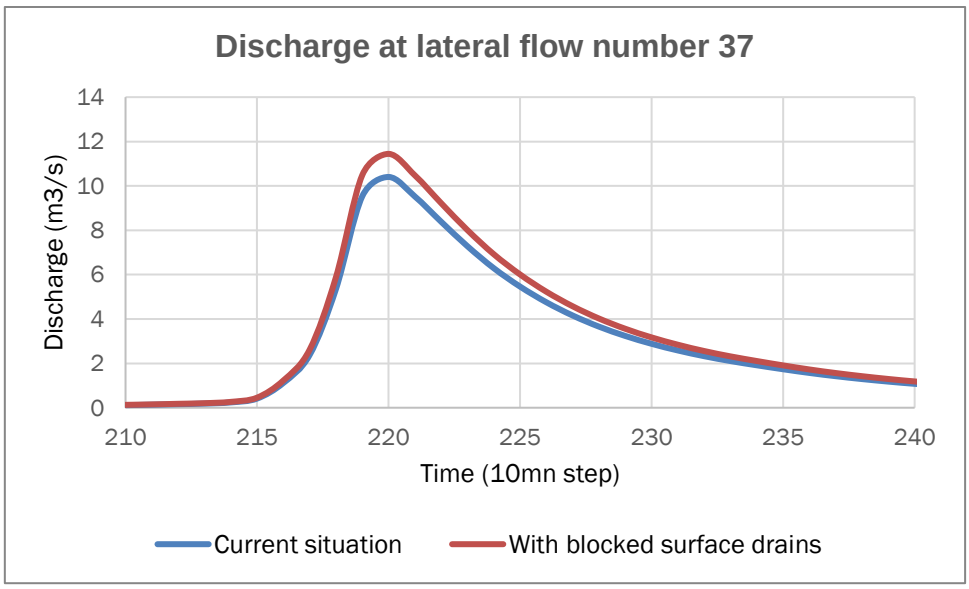


FIGURE 6-24 EXEMPLE IN GIKONDO FOR THE INCREASE OF RUNOFF DUE TO BLOCKING DRAINS

The measure “Creation of a delta before the confluence of the Nyabugogo river” can also be simulated by changing the cross section in the model. Therefore, a gradual widening of the bed width down the river has been implemented into the model to simulate the delta.

Finally, the pedestrian path will not impact the water depth in case of heavy rain event, “Clearance over a large width to facilitate the overflow” is partially considered in the widening of the river as mentioned above, moreover what will be cleared is not modelled into the model and therefore no need to be implemented into the model.

6.3.2 Results for variant 1

The objective of variant 1 in terms of flood control is twofold:

- to reduce overflows on the main roads and sensitive points and
- to increase the flooded area inside the wetlands in order to develop specific facilities favouring biodiversity.

The following sections present:

- For each wetland, a map comparing the flooded area and maximum water level:
  - For baseline situation (in blue).
  - With the proposed actions of variant 1 (new flooded areas in red)
- For each flooding focus point (common with “Flooding Hotspots study – city of Kigali, consultant YREC”), a comparison between :
  - current state (baseline)
  - the state after the IBC/SGI rehabilitation proposed actions
  - the state with the IBC/SGI and YREC proposed improvements.

The following observations are detailed in the following chapters, and they are quite logical:

- Decrease of the water level on the bed banks and on the roads with the proposed wetland rehabilitation actions (consistent with the notation of sub-criteria presented in the main feasibility report)
- Increase of the impacted area by the flooding with the proposed wetland rehabilitation actions
- Decrease of the discharge in the riverbed with the proposed rehabilitation actions
- Additional decrease in the riverbed for sensitive points with hotspot proposed infrastructure
- Significant increase of flow to be considered for actions downstream

All values presented below are for:

- Return period event: 10 years
- Climate change: Current
- Land use: Current

6.3.2.1 Gikondo

Important notice : during the final validation workshop a request to design a small lake has been made to the consultant, this lake would be smaller that the original lake proposed in Variant 2 (see chapter 5). A new calibration of the model for Gikondo will be made at Detailed Design taking into account this late change in the Project.

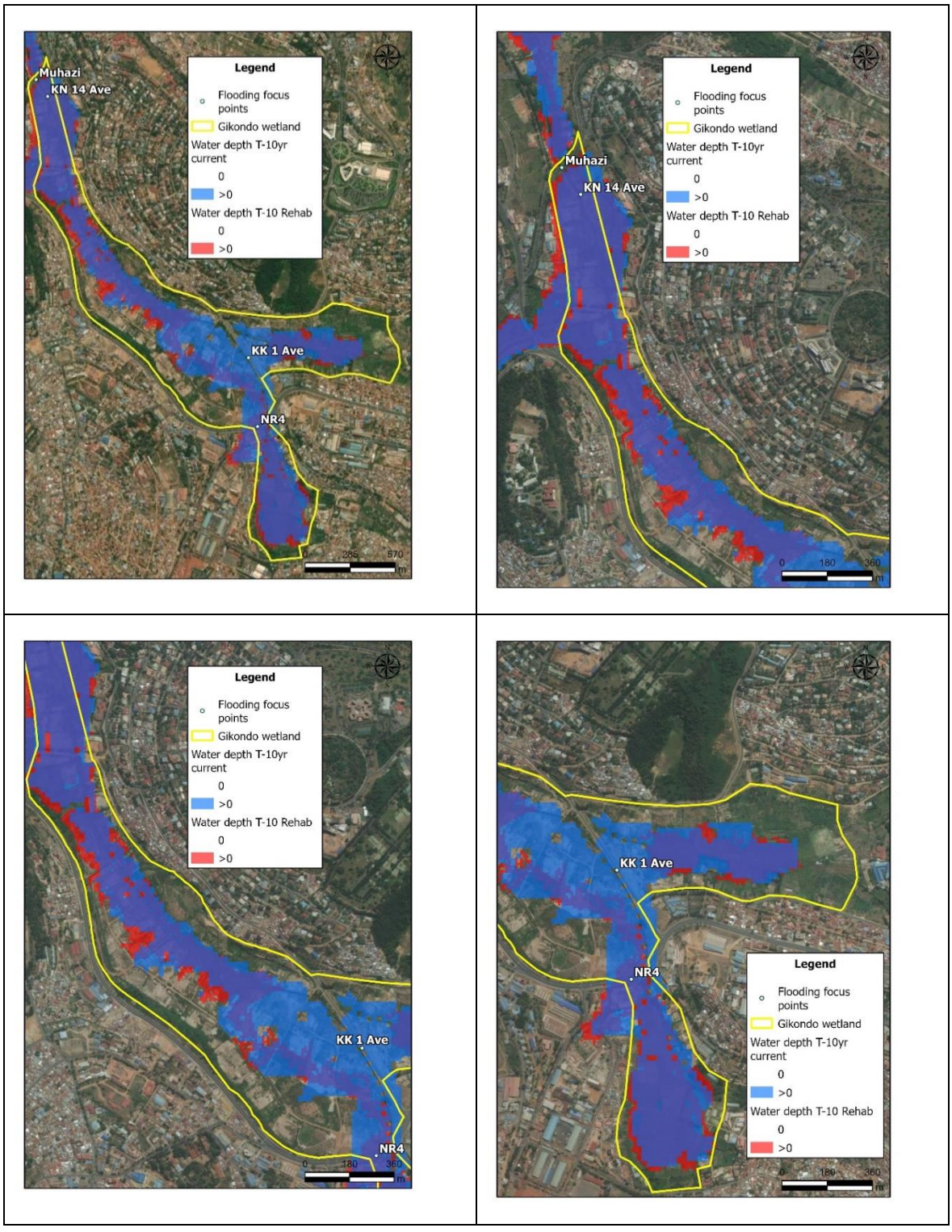
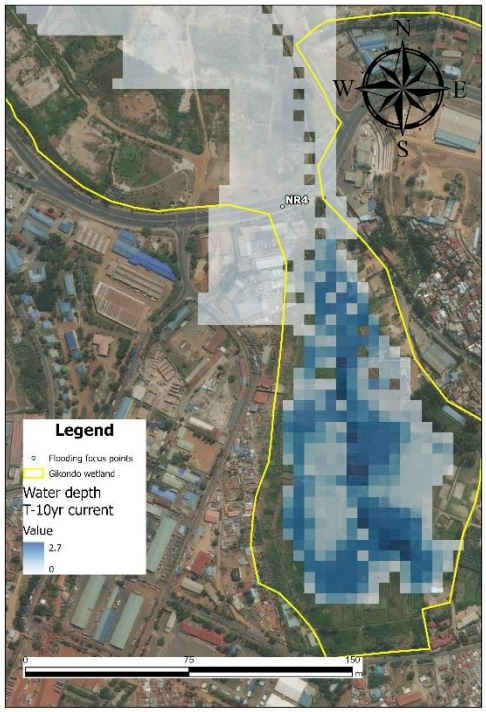


FIGURE 6-25 COMPARISONS OF FLOODED AREAS FOR GIKONDO BEFORE AND AFTER THE WETLAND REHABILITATION ACTIONS FOR THE CURRENT STATE (BASELINE)

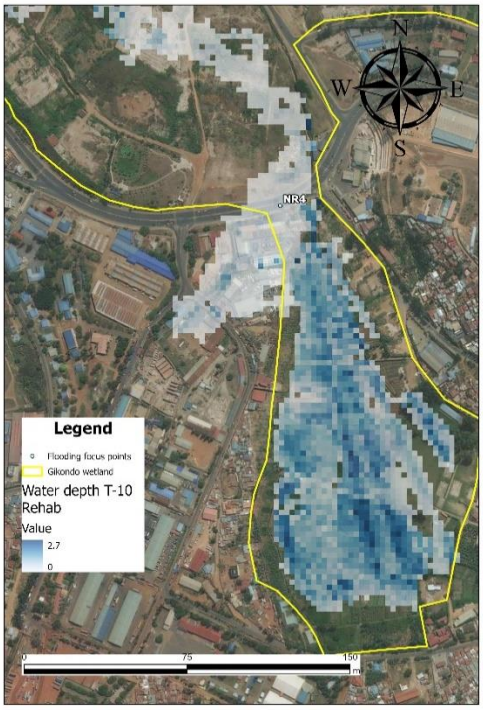
Observations and interpretations are the following:

- New peripheric areas are flooded (in red) with proposed actions, which is consistent with the objective to increase the area of water inundation
- Raise riverbed permits to slower the flows and reduce the discharge as described below

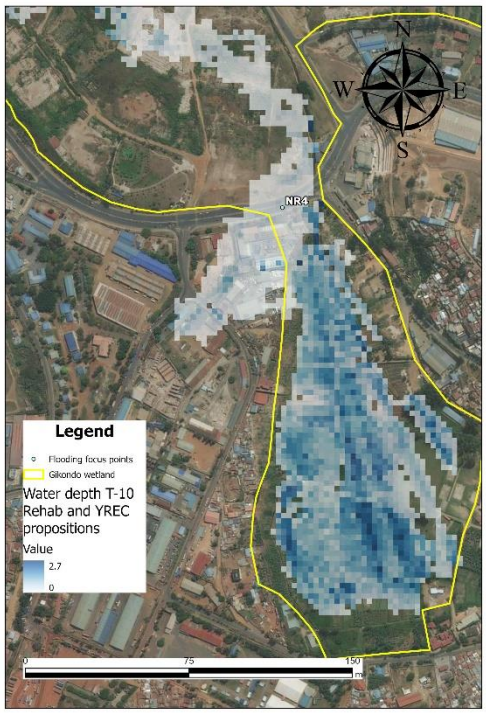
Flooding focus point: NR4



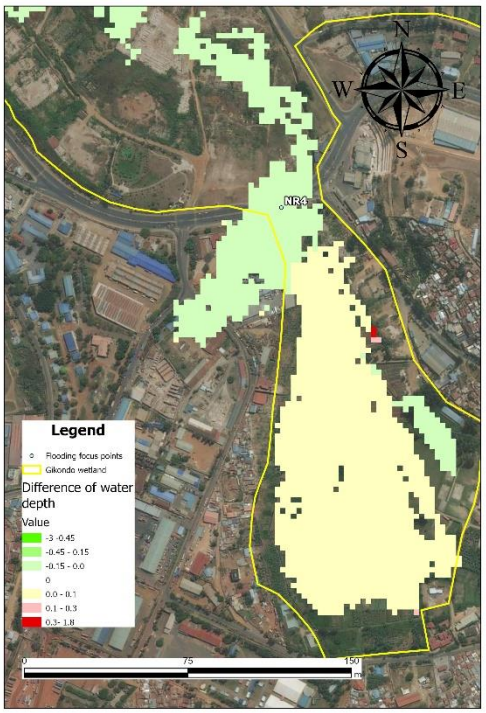
Hydraulic simulation results for baseline



Hydraulic simulation results with IBC / SGI actions



Hydraulic simulation results with IBC / SGI actions and YREC proposed infrastructure



Evolution of maximal water level with proposed rehabilitation actions
Yellow -red = increase / Green = decrease

FIGURE 6-26 COMPARISONS OF WATER LEVELS, BEFORE AND AFTER THE PROPOSED REHABILITATION IN NR4

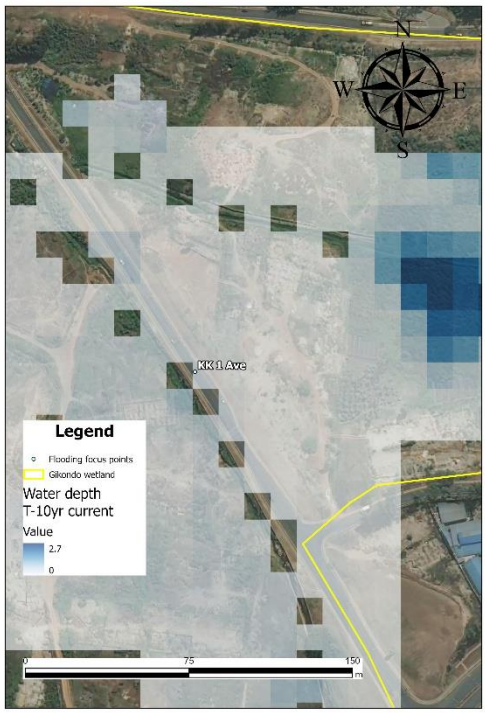
TABLE 6-17 WATER DEPTH FOR DIFFERENT SCENARIO FOR NR4

Return Period	Land use	Climate Change	Proposed Rehabilitation IBC/SGI	Hotspots Rehabilitation (YREC)	Max water depth IBC/SGI [m]
10 Y	Current	Current	No	No	0.04
10 Y	Current	Current	Yes	No	0.01
10 Y	Current	Current	Yes	Yes	0.01

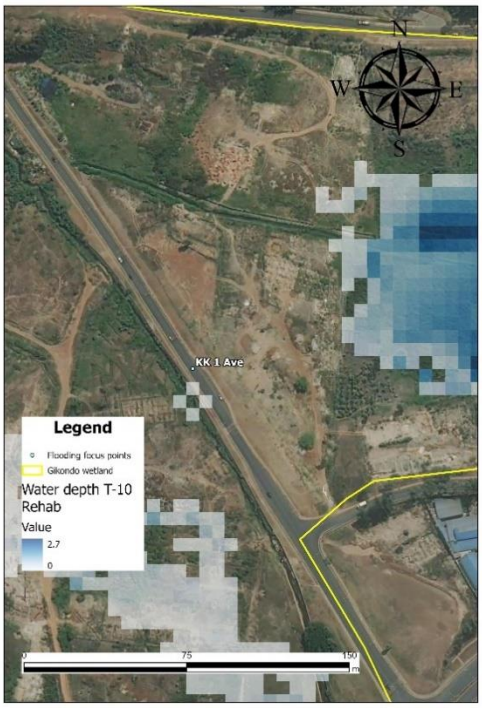
Observations and interpretations are the following:

- Wetland rehabilitation actions result in increasing water depth and flooded area upstream the point NR4 which is important to develop the actions G02 to G05
- Wetland rehabilitation actions result in reducing the water depth at NR4 (as seen on the map at the bottom right) as well as reducing the flooding area and maximal water level for development of action G20 (Recreative area for Gikondo)
- As no more water flooding is remaining with wetland proposed rehabilitation actions, the hotspot infrastructure is not modifying the situation significantly

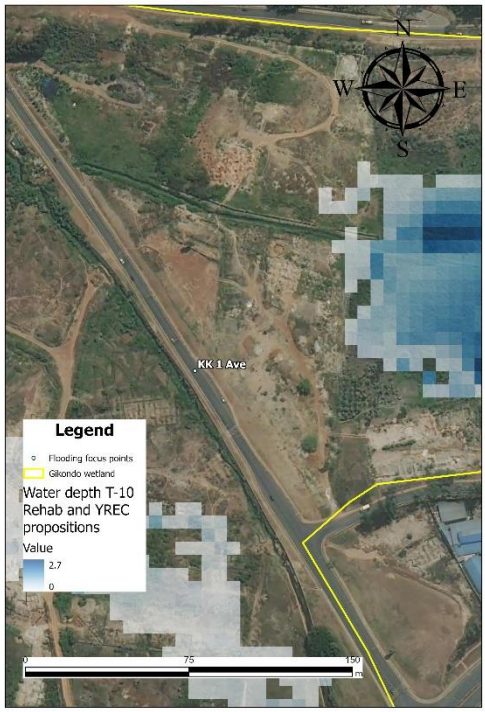
Flooding focus point: KK 1 Avenue



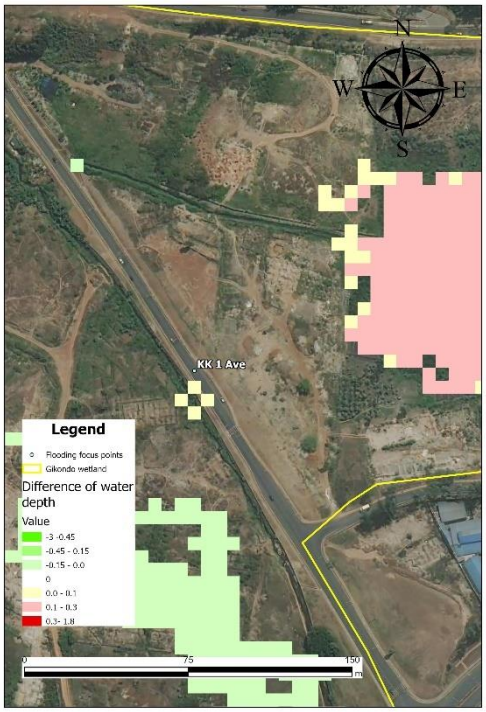
Hydraulic simulation results for baseline



Hydraulic simulation results with IBC / SGI actions



Hydraulic simulation results with IBC / SGI actions and YREC proposed infrastructure



Evolution of maximal water level with proposed rehabilitation actions
Yellow -red = increase / Green = decrease

FIGURE 6-27 COMPARISONS OF WATER LEVELS, BEFORE AND AFTER THE PROPOSED REHABILITATION IN KK 1 AVENUE

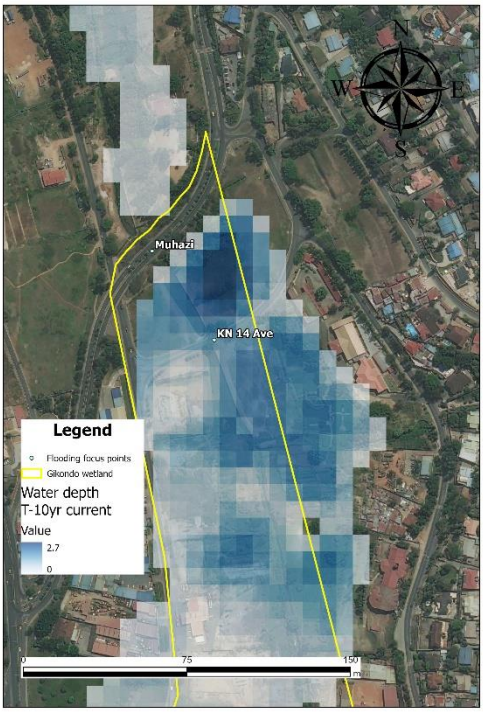
TABLE 6-18 WATER DEPTH FOR DIFFERENT SCENARIO FOR KK 1 AVENUE

Return Period	Land use	Climate Change	Proposed Rehabilitation IBC/SGI	Hotspots Rehabilitation (YREC)	Max water depth IBC/SGI [m]
10 Y	Current	Current	No	No	0.15
10 Y	Current	Current	Yes	No	0.00
10 Y	Current	Current	Yes	Yes	0.00

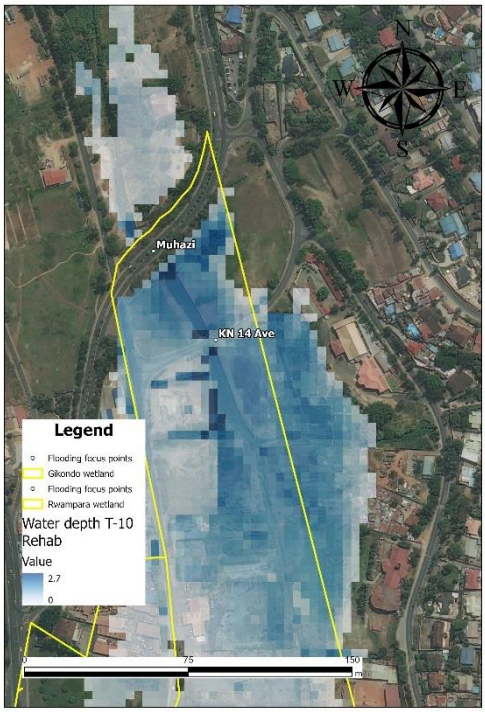
Observations and interpretations are the following:

- Wetland rehabilitation actions result in increasing water depth and flooded area upstream the point KK1 which is important to develop the actions G08 to G14
- Wetland rehabilitation actions combined with hotspot proposed infrastructure result in reducing the water depth at NR4 (as seen on the map at the bottom right) as well as reducing the flooding area and maximal water level for development of action G21 (Recreative area for Gikondo)
- As no more water flooding is remaining with wetland proposed rehabilitation actions, the hotspot infrastructure is not modifying the situation significantly

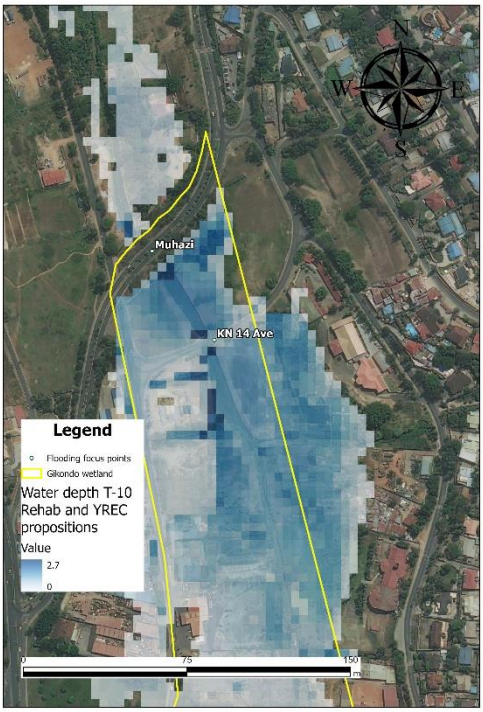
Flooding focus point: KN 14 Avenue



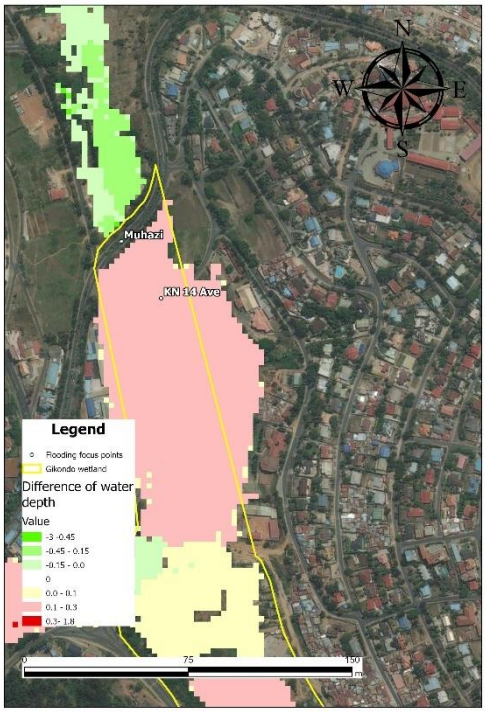
Hydraulic simulation results for baseline



Hydraulic simulation results with IBC / SGI actions



Hydraulic simulation results with IBC / SGI actions and YREC proposed infrastructure



Evolution of maximal water level with proposed rehabilitation actions
Yellow -red = increase / Green = decrease

FIGURE 6-28 COMPARISONS OF WATER LEVELS, BEFORE AND AFTER THE PROPOSED REHABILITATION IN KN 14 AVE

TABLE 6-19 WATER DEPTH FOR DIFFERENT SCENARIO FOR KN 14 AVE

Return Period	Land use	Climate Change	Proposed Rehabilitation IBC/SGI	Hotspots Rehabilitation (YREC)	Max water depth IBC/SGI [m]
10 Y	Current	Current	No	No	2.28
10 Y	Current	Current	Yes	No	1.71
10 Y	Current	Current	Yes	Yes	1.37

Observations and interpretations are the following:

- Wetland rehabilitation actions (especially G15) result in increasing water depth and flooded area upstream the point KN14 avenue which is important to develop the actions G15
- Wetland rehabilitation actions combined with hotspot proposed infrastructure result in reducing significantly the water depth at KN14 (as seen on the map at the bottom right) as well as reducing the flooding area and maximal water level for development of action G18 and G19 (Recreative area for Gikondo)

6.3.2.2 Rwampara

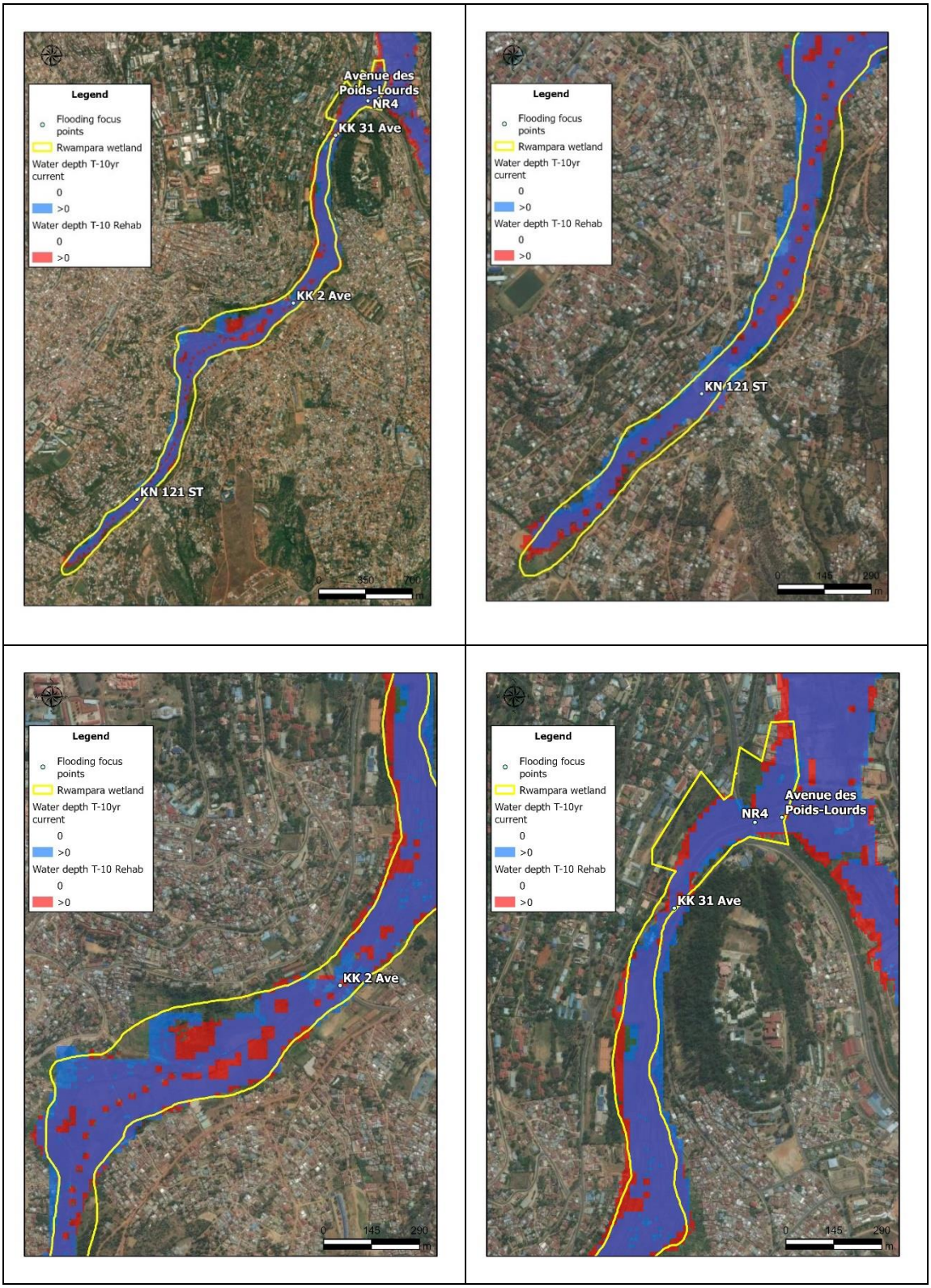
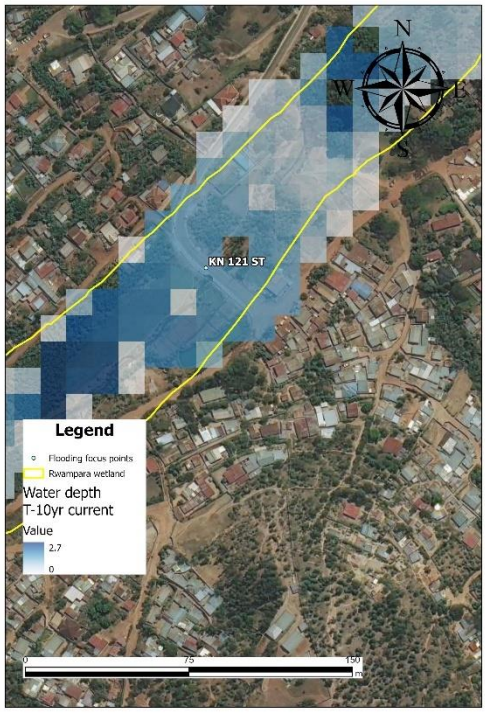


FIGURE 6-29 COMPARISONS OF FLOODED AREAS FOR RWAMPARA BEFORE AND AFTER THE REHABILITATION FOR THE CURRENT STATE

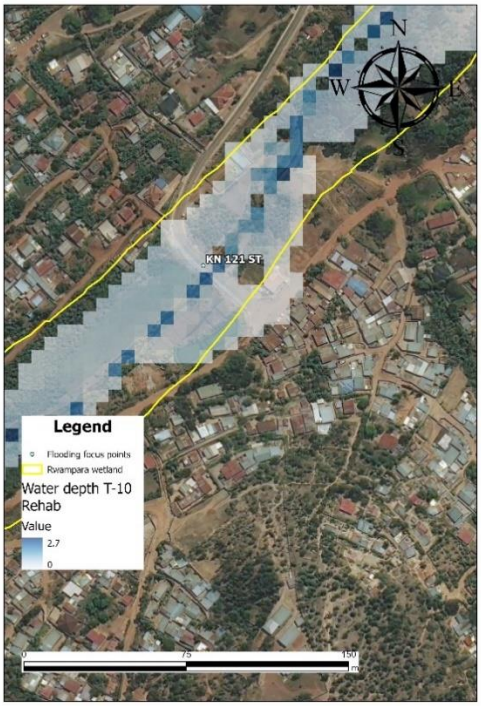
Observations and interpretations are the following:

- New peripheric areas are flooded (red) with proposed actions, which is consistent with the objective to increase the area of water inundation and reduce water level in specific points in the center (light blue)

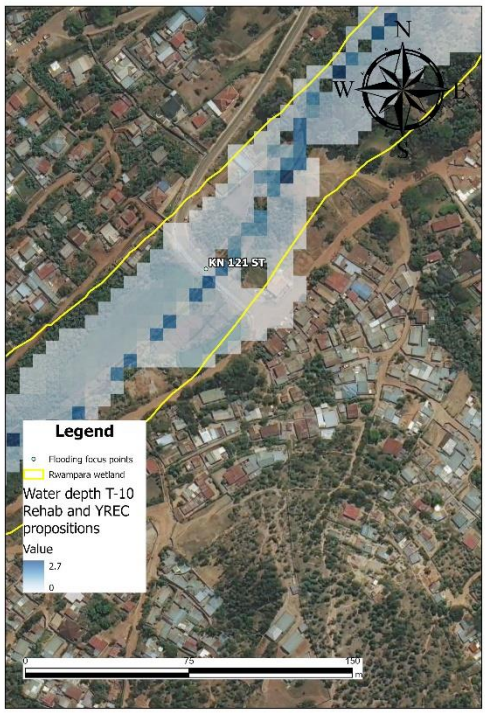
- Raise riverbed permits to slower the flows and reduce the discharge as described below
- **Flooding focus point: KN 121 St.**



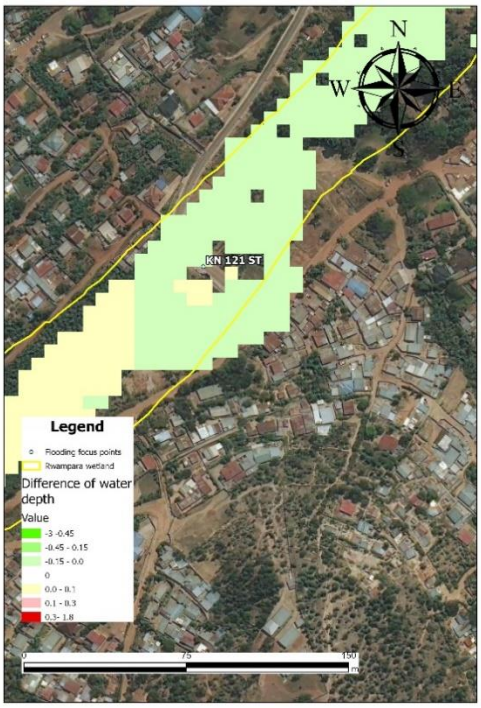
Hydraulic simulation results for baseline



Hydraulic simulation results with IBC / SGI actions



Hydraulic simulation results with IBC / SGI actions and YREC proposed infrastructure



Evolution of maximal water level with proposed rehabilitation actions
Yellow -red = increase / Green = decrease

FIGURE 6-30 COMPARISONS OF WATER LEVELS, BEFORE AND AFTER THE PROPOSED REHABILITATION IN KN 121 ST

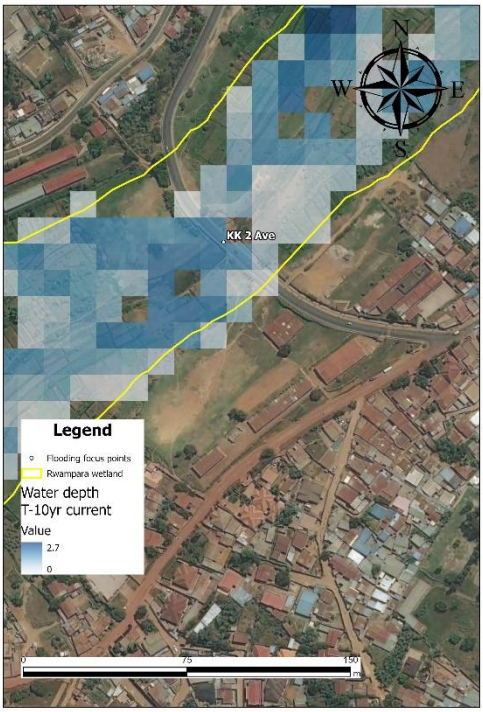
TABLE 6-20 WATER DEPTH FOR DIFFERENT SCENARIO FOR KN 121 ST

Return Period	Land use	Climate Change	Proposed Rehabilitation IBC/SGI	Hotspots Rehabilitation (YREC)	Max water depth IBC/SGI [m]
10 Y	Current	Current	No	No	1.06
10 Y	Current	Current	Yes	No	1.04
10 Y	Current	Current	Yes	Yes	1.04

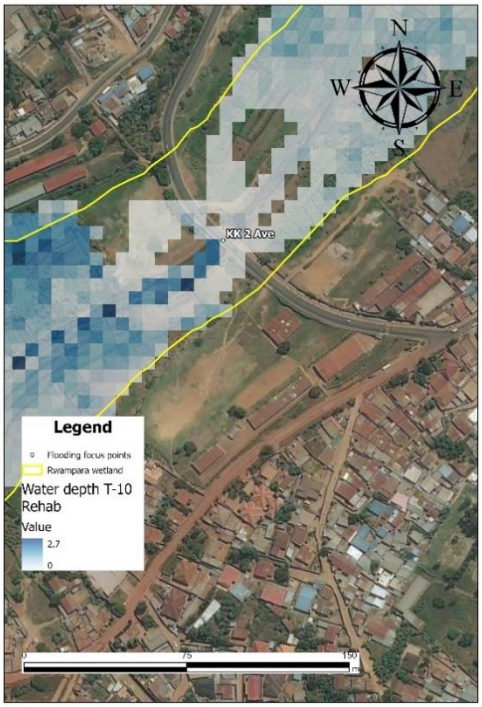
Observations and interpretations are the following:

- Wetland rehabilitation actions result in reducing flood water level downstream the point KN121
- The infrastructure for flood reduction will have to be modified taking into account the impact of the downstream actions RW02 to RW05 – not already defined.

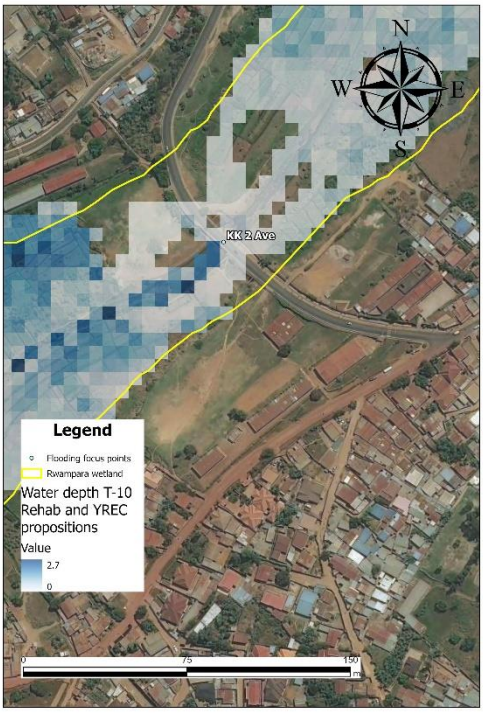
Flooding focus point: KK 2 Avenue



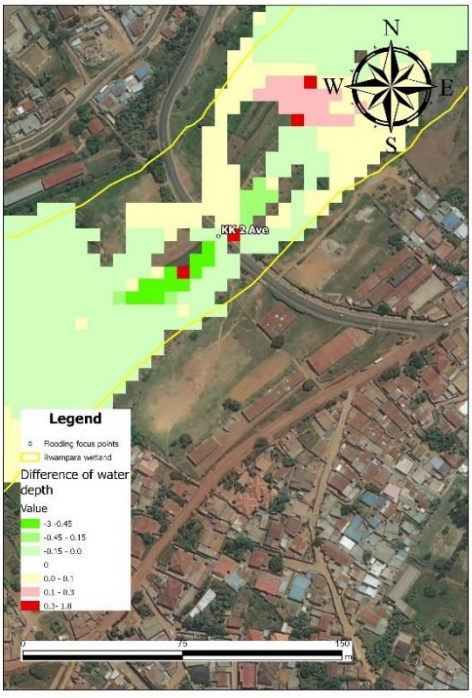
Hydraulic simulation results for baseline



Hydraulic simulation results with IBC / SGI actions



Hydraulic simulation results with IBC / SGI actions and YREC proposed infrastructure



Evolution of maximal water level with proposed rehabilitation actions
Yellow -red = increase / Green = decrease

FIGURE 6-31 COMPARISONS OF WATER LEVELS, BEFORE AND AFTER THE PROPOSED REHABILITATION IN KK 2 AVENUE

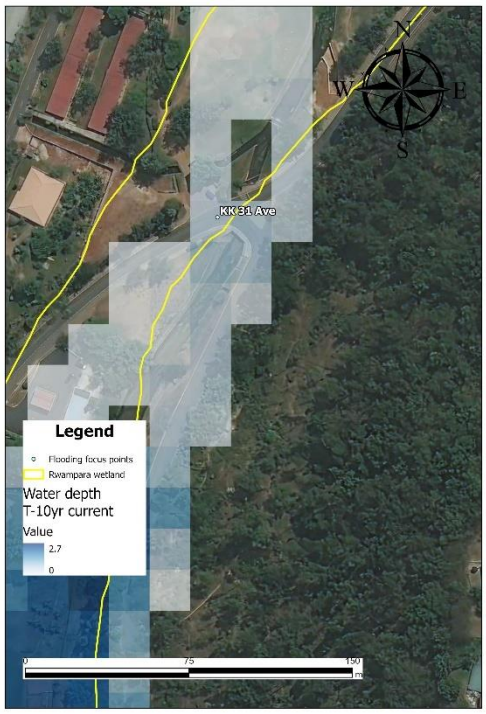
TABLE 6-21 WATER DEPTH FOR DIFFERENT SCENARIO FOR KK 2 AVENUE

Return Period	Land use	Climate Change	Proposed Rehabilitation IBC/SGI	Hotspots Rehabilitation (YREC)	Max water depth IBC/SGI [m]
10 Y	Current	Current	No	No	0.85
10 Y	Current	Current	Yes	No	0.02
10 Y	Current	Current	Yes	Yes	0.02

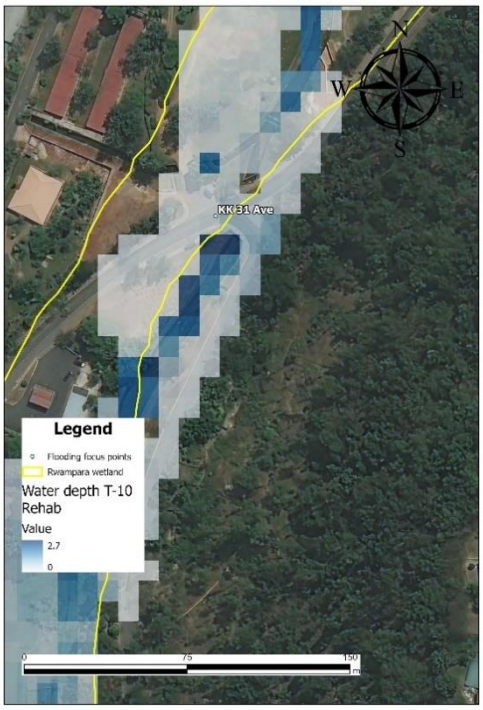
Observations and interpretations are the following:

- Increase of water depth before the point KK 2 and more area covered
- Reduce the water depth at KK 2, as seen on the map at the bottom right
- As no more water flooding is remaining with wetland proposed rehabilitation actions, the hotspot infrastructure is not modifying the situation significantly

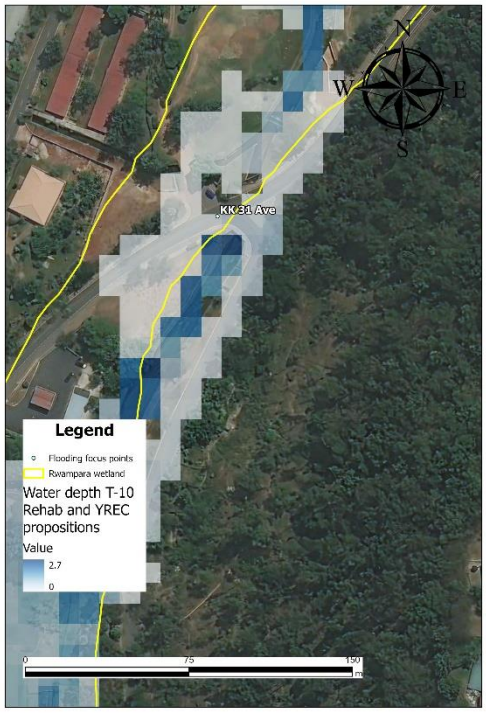
Flooding focus point: KK 31 Avenue



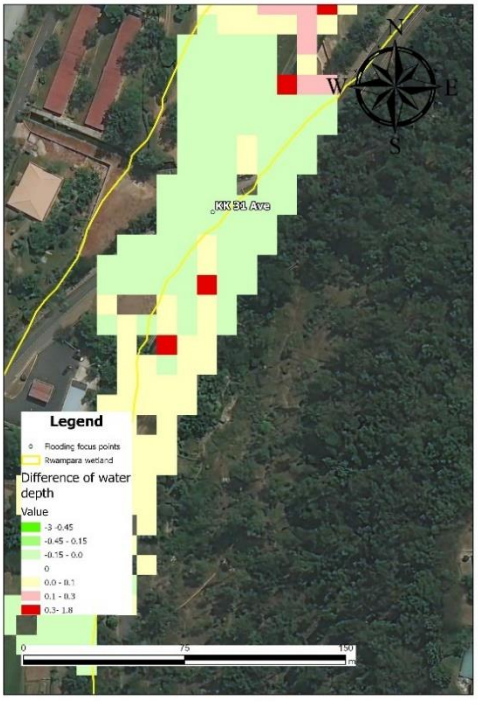
Hydraulic simulation results for baseline



Hydraulic simulation results with IBC / SGI actions



Hydraulic simulation results with IBC / SGI actions and YREC proposed infrastructure



Evolution of maximal water level with proposed rehabilitation actions
Yellow -red = increase / Green = decrease

FIGURE 6-32 COMPARISONS OF WATER LEVELS, BEFORE AND AFTER THE PROPOSED REHABILITATION IN KK 31 AVENUE

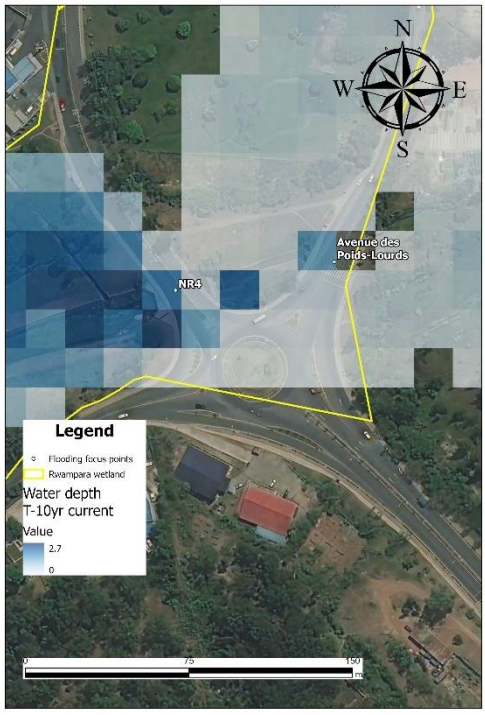
TABLE 6-22 WATER DEPTH FOR DIFFERENT SCENARIO FOR KK 31 AVENUE

Return Period	Land use	Climate Change	Proposed Rehabilitation IBC/SGI	Hotspots Rehabilitation (YREC)	Max water depth IBC/SGI [m]
10 Y	Current	Current	No	No	0.78
10 Y	Current	Current	Yes	No	0.36
10 Y	Current	Current	Yes	Yes	0.01

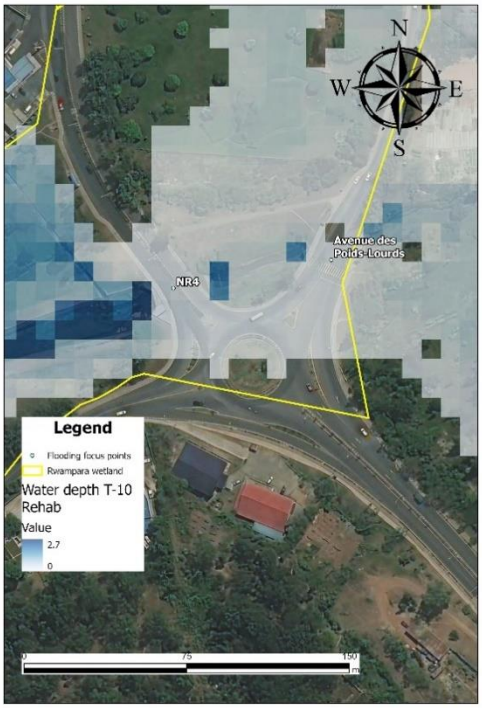
Observations and interpretations are the following:

- Wetland rehabilitation actions (especially Rw05) result in increasing water depth and flooded area upstream the point KK31
- Wetland rehabilitation actions combined with hotspot proposed infrastructure result in solving all the flood prblems at KK31 (as seen on the map at the bottom right) as well as reducing the flooding area and maximal water level downstream (Rugenge)

- **Flooding focus point: Avenue des Poids-Lourds, NR4**



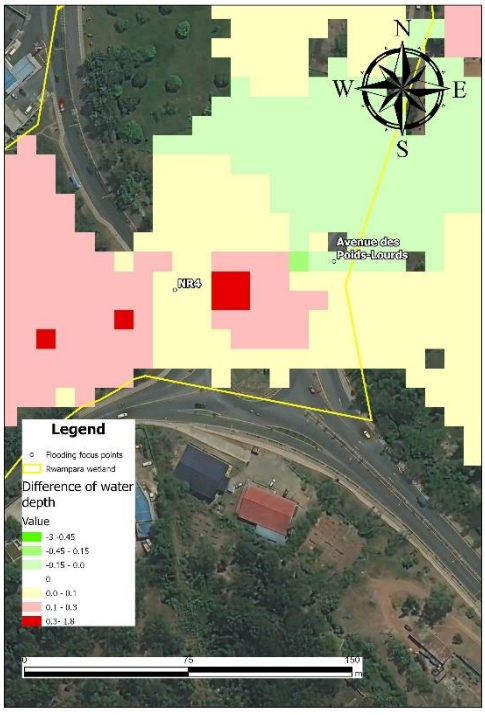
Hydraulic simulation results for baseline



Hydraulic simulation results with IBC / SGI actions



Hydraulic simulation results with IBC / SGI actions and YREC proposed infrastructure



Evolution of maximal water level with proposed rehabilitation actions
Yellow -red = increase / Green = decrease

FIGURE 6-33 COMPARISONS OF WATER LEVELS, BEFORE AND AFTER THE PROPOSED REHABILITATION IN AVENUE DES POIDS-LOURDS NR4

TABLE 6-23 WATER DEPTH FOR DIFFERENT SCENARIO FOR AVENUE DES POIDS-LOURDS NR4

Return Period	Land use	Climate Change	Proposed Rehabilitation IBC/SGI	Hotspots Rehabilitation (YREC)	Max water depth IBC/SGI [m]
10 Y	Current	Current	No	No	0.4
10 Y	Current	Current	Yes	No	0.17
10 Y	Current	Current	Yes	Yes	0.1

Observations and interpretations are the following:

- Wetland rehabilitation actions (especially Rw05) result in increasing water depth and flooded area upstream the point NR4
- Wetland rehabilitation actions combined with hotspot proposed infrastructure result in solving all the flood prblems at NR4 (as seen on the map at the bottom right) as well as reducing the flooding area and maximal water level downstream (Rugenge)

6.3.2.3 Kibumba

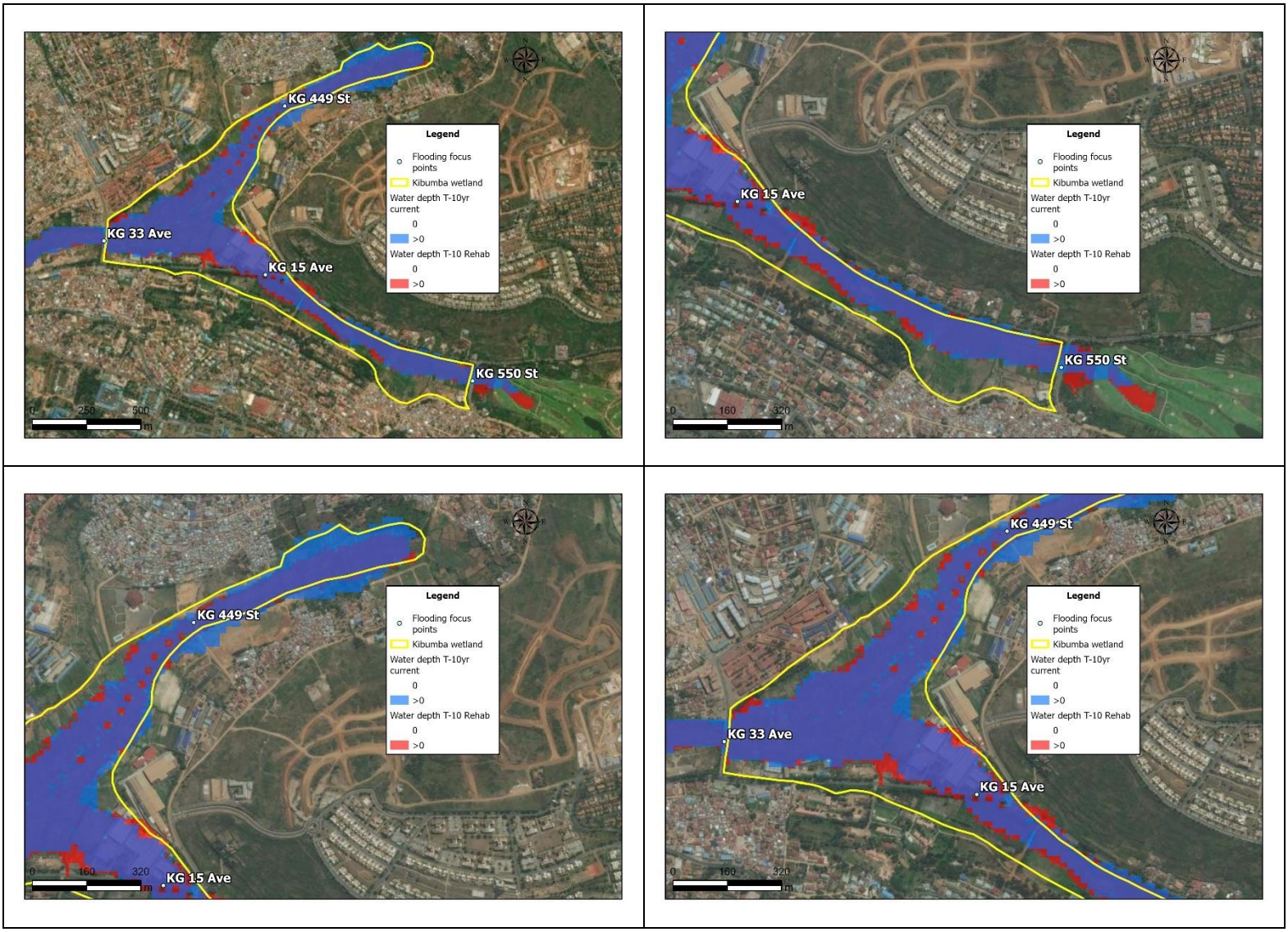
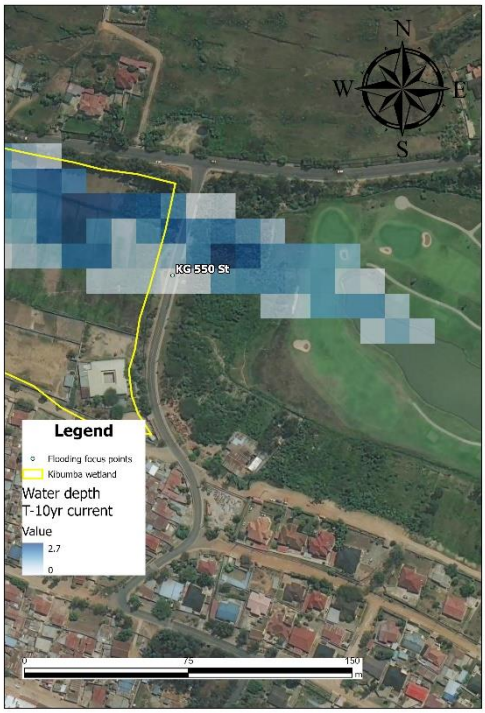


FIGURE 6-34 COMPARISONS OF FLOODED AREAS FOR KIBUMBA BEFORE AND AFTER THE REHABILITATION FOR THE CURRENT STATE

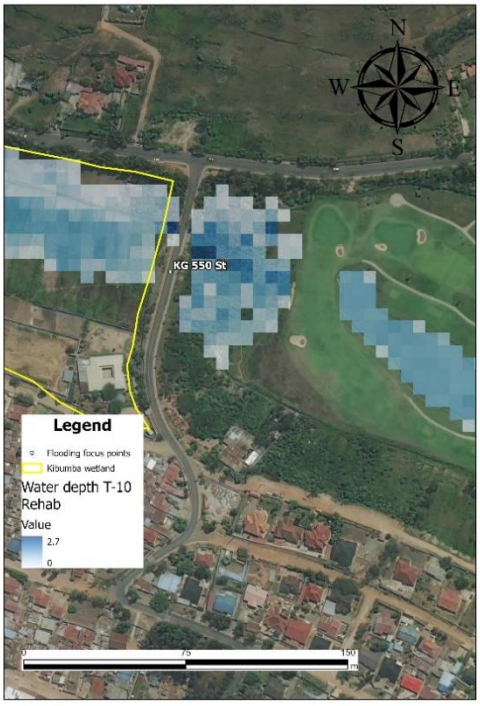
Observations and interpretations are the following:

- New peripheric areas are flooded (red) with proposed actions, which is consistent with the objective to increase the area of water inundation and reduce water level in specific points in the centre (light blue)
- Raise riverbed permits to slower the flows and reduce the discharge as described below

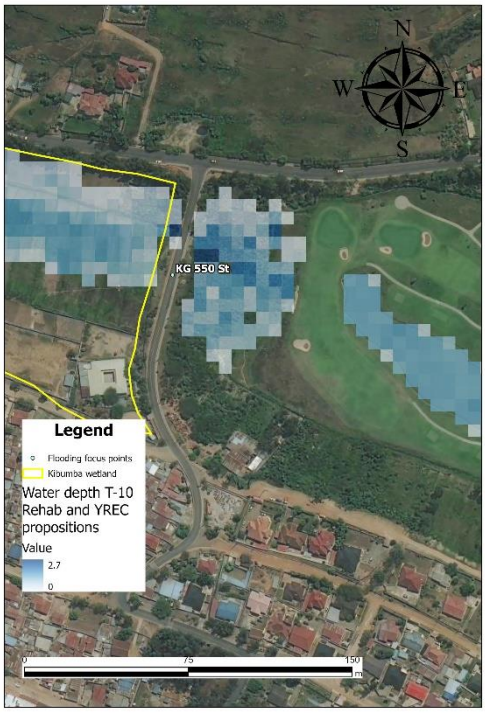
- **Flooding focus point: KG 550 St.**



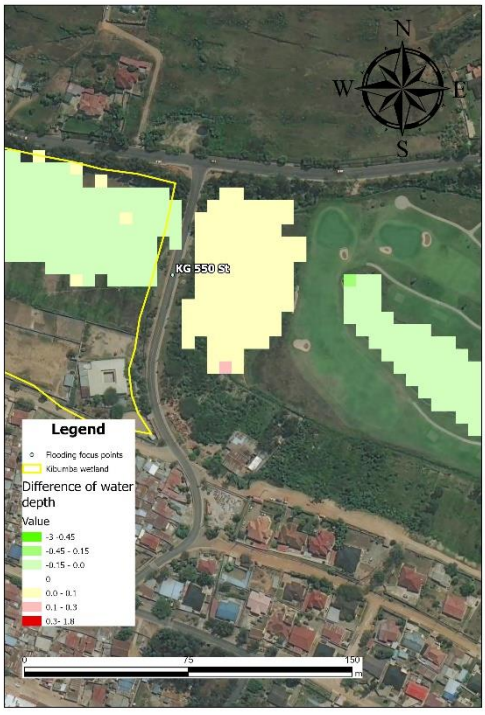
Hydraulic simulation results for baseline



Hydraulic simulation results with IBC / SGI actions



Hydraulic simulation results with IBC / SGI actions and YREC proposed infrastructure



Evolution of maximal water level with proposed rehabilitation actions
Yellow -red = increase / Green = decrease

FIGURE 6-35 COMPARISONS OF WATER LEVELS, BEFORE AND AFTER THE PROPOSED REHABILITATION IN KG 550 ST

TABLE 6-24 WATER DEPTH FOR DIFFERENT SCENARIO FOR KG 550 ST

Return Period	Land use	Climate Change	Proposed Rehabilitation IBC/SGI	Hotspots Rehabilitation (YREC)	Max water depth IBC/SGI [m]
10 Y	Current	Current	No	No	0.3
10 Y	Current	Current	Yes	No	0
10 Y	Current	Current	Yes	Yes	0

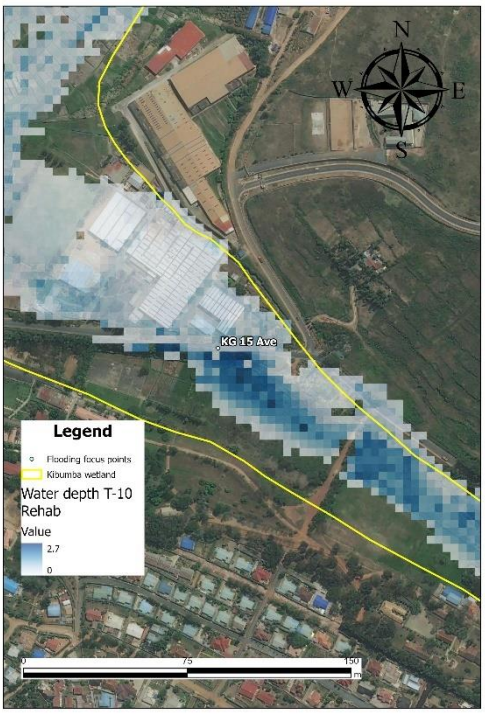
Observations and interpretations are the following:

- Wetland rehabilitation actions result in increasing water depth and flooded area upstream the point KG550 which is important to develop the actions K07
- As no more water flooding is remaining with wetland proposed rehabilitation actions, the hotspot infrastructure is not modifying the situation significantly. Flooding problems are solved.

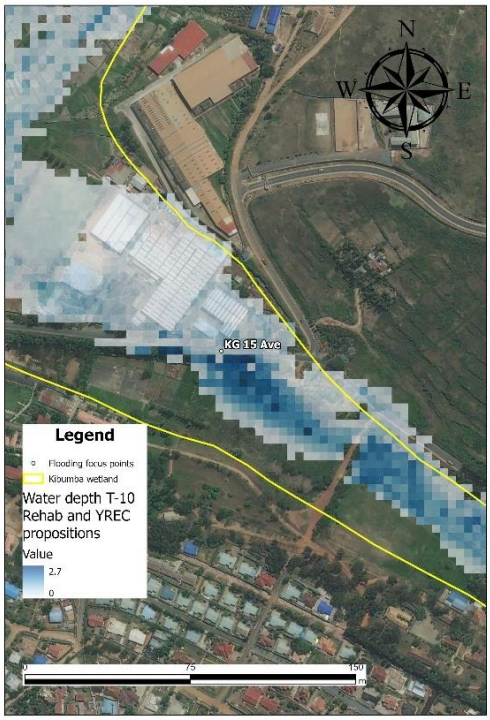
Flooding focus point: KG 15 Avenue



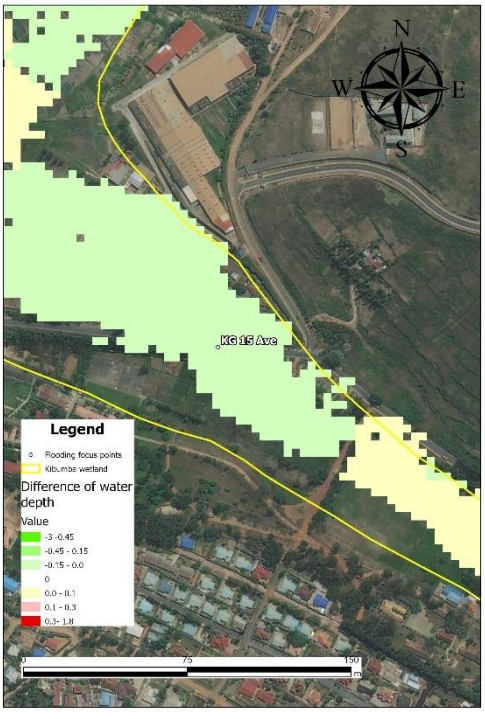
Hydraulic simulation results for baseline



Hydraulic simulation results with IBC / SGI actions



Hydraulic simulation results with IBC / SGI actions and YREC proposed infrastructure



Evolution of maximal water level with proposed rehabilitation actions
Yellow -red = increase / Green = decrease

FIGURE 6-36 COMPARISONS OF WATER LEVELS, BEFORE AND AFTER THE PROPOSED REHABILITATION KG 15 AVENUE

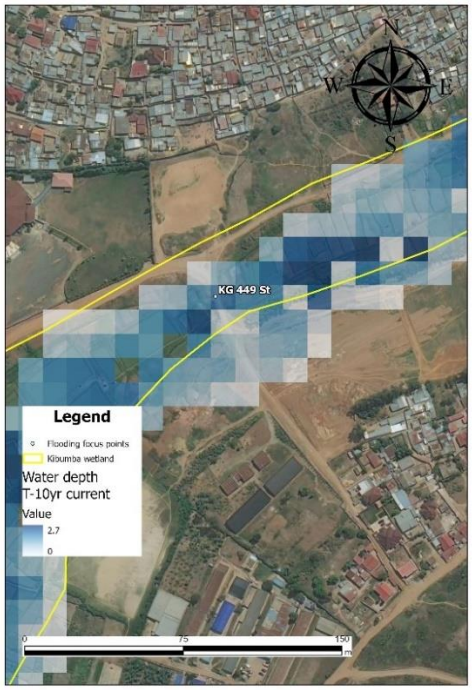
TABLE 6-25 WATER DEPTH FOR DIFFERENT SCENARIO FOR KG 15 AVENUE

Return Period	Land use	Climate Change	Proposed Rehabilitation IBC/SGI	Hotspots Rehabilitation (YREC)	Max water depth IBC/SGI [m]
10 Y	Current	Current	No	No	0.80
10 Y	Current	Current	Yes	No	0.48
10 Y	Current	Current	Yes	Yes	0.48

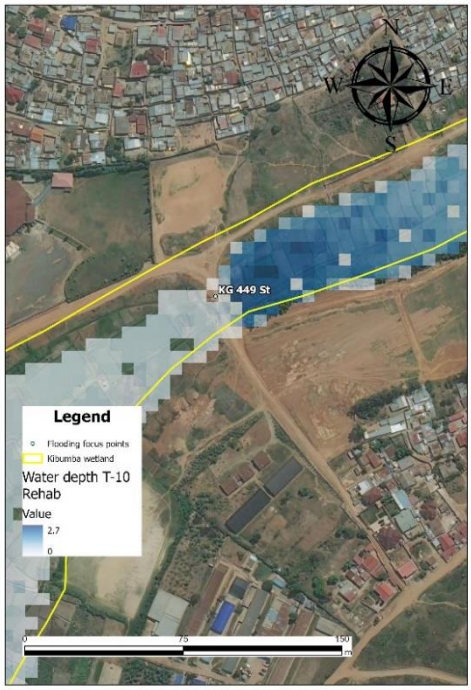
Observations and interpretations are the following:

- Increase of water depth before the point KG 15 and additional flooding area
- Reduction of water depth at KG 15 and downstream, as seen on the map at the bottom right
- As hotspots project did not propose any improvement in this sector and upstream, no additional change in water depth is observed. Flooded problems are only partially solved.

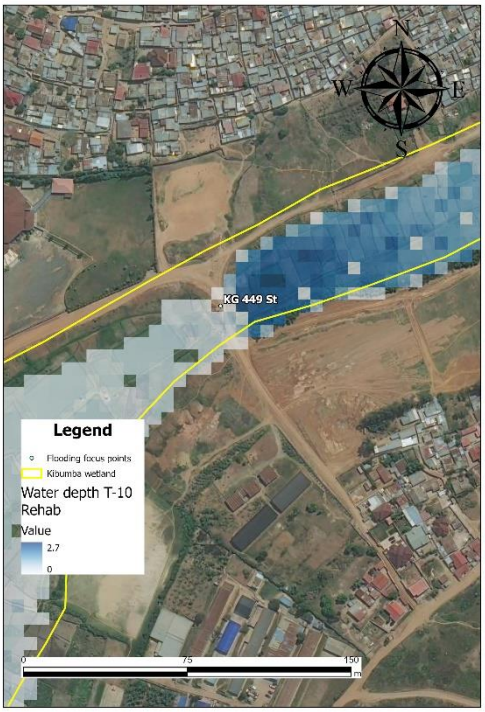
Flooding focus point: KG 449 St.



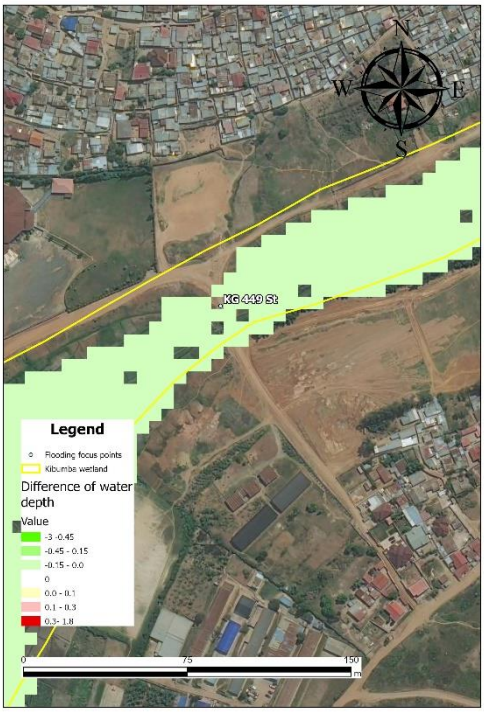
Hydraulic simulation results for baseline



Hydraulic simulation results with IBC / SGI actions



Hydraulic simulation results with IBC / SGI actions and YREC proposed infrastructure



Evolution of maximal water level with proposed rehabilitation actions
Yellow -red = increase / Green = decrease

FIGURE 6-37 COMPARISONS OF WATER LEVELS, BEFORE AND AFTER THE PROPOSED REHABILITATION IN KG 449 ST

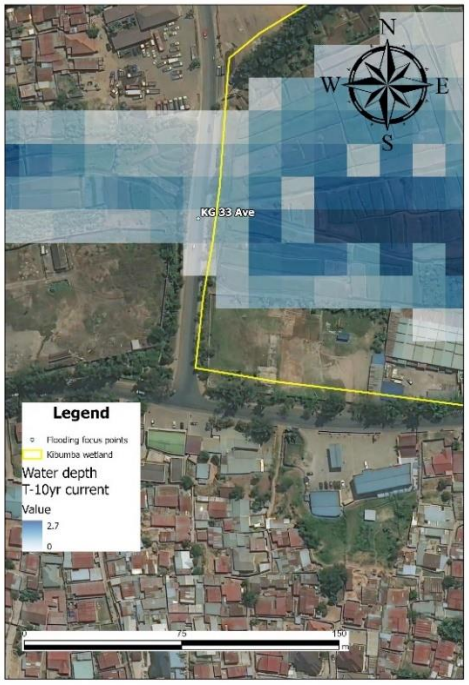
TABLE 6-26 WATER DEPTH FOR DIFFERENT SCENARIO FOR KG 449 ST

Return Period	Land use	Climate Change	Proposed Rehabilitation IBC/SGI	Hotspots Rehabilitation (YREC)	Max water depth IBC/SGI [m]
10 Y	Current	Current	No	No	0.62
10 Y	Current	Current	Yes	No	0.10
10 Y	Current	Current	Yes	Yes	0.10

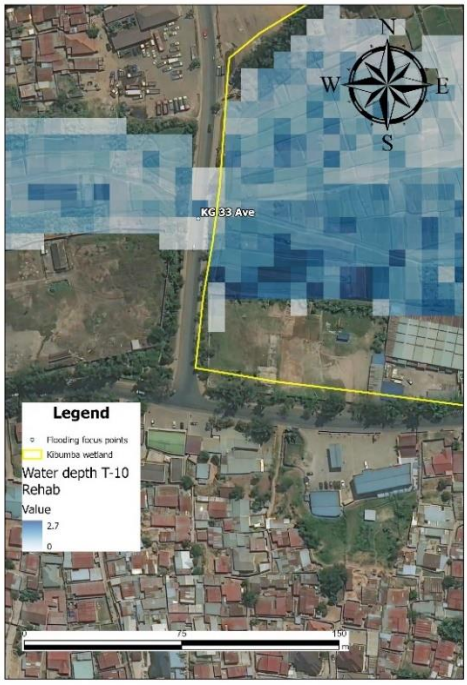
Observations and interpretations are the following:

- Wetland rehabilitation actions result in increasing water depth and flooded area upstream the point KG449 which is important to develop the actions K04
- Wetland rehabilitation actions result in reducing the water depth at NR4 (as seen on the map at the bottom right) as well as reducing the flooding area and maximal water level for development of action K02 and K03
- As hotspot project does not propose any improvement in this sector and upstream, no changes in water depth after the addition of proposals. Most of flooded problems are however solved.

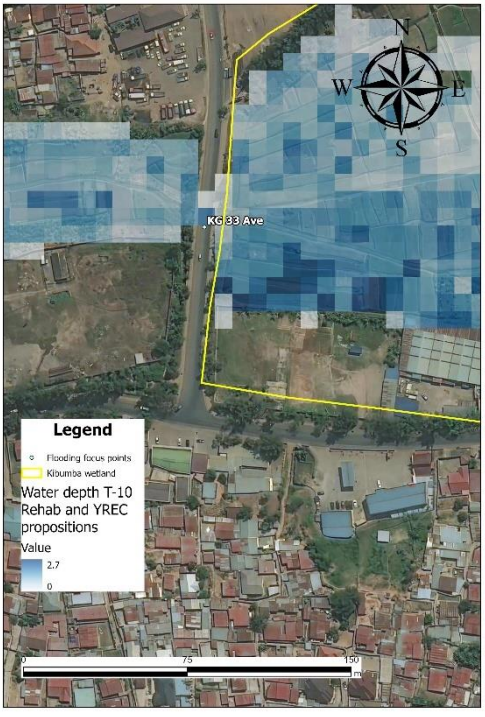
Flooding focus point: KG 33 Avenue



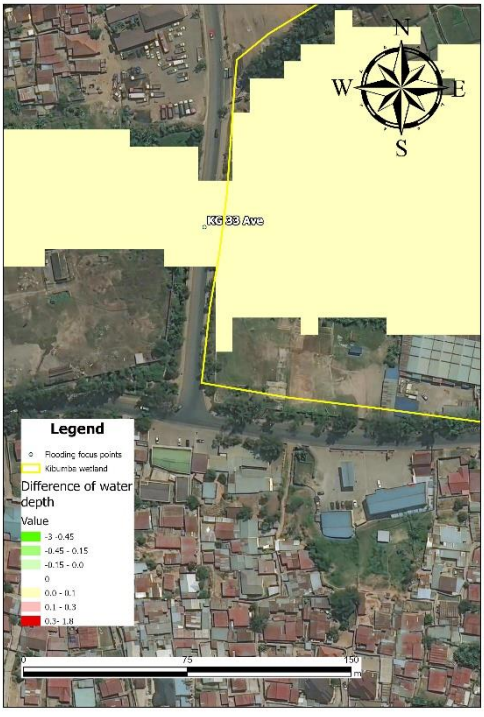
Hydraulic simulation results for baseline



Hydraulic simulation results with IBC / SGI actions



Hydraulic simulation results with IBC / SGI actions and YREC proposed infrastructure



Evolution of maximal water level with proposed rehabilitation actions
Yellow -red = increase / Green = decrease

FIGURE 6-38 COMPARISONS OF WATER LEVELS, BEFORE AND AFTER THE PROPOSED REHABILITATION IN KG 33 AVENUE

TABLE 6-27 WATER DEPTH FOR DIFFERENT SCENARIO FOR KG 33 AVENUE

Return Period	Land use	Climate Change	Proposed Rehabilitation IBC/SGI	Hotspots Rehabilitation (YREC)	Max water depth IBC/SGI [m]
10 Y	Current	Current	No	No	0.54
10 Y	Current	Current	Yes	No	0.04
10 Y	Current	Current	Yes	Yes	0.00

Observations and interpretations are the following:

- Wetland rehabilitation actions (especially K07, K06 and K03) result in increasing water depth and flooded area upstream the point KG33
- Wetland rehabilitation actions combined with hotspot proposed infrastructure result in solving all the flood prblems at NR4 (as seen on the map at the bottom right) as well as reducing the flooding area and maximal water level downstream (Rugenge)

6.3.2.4 Rugenge

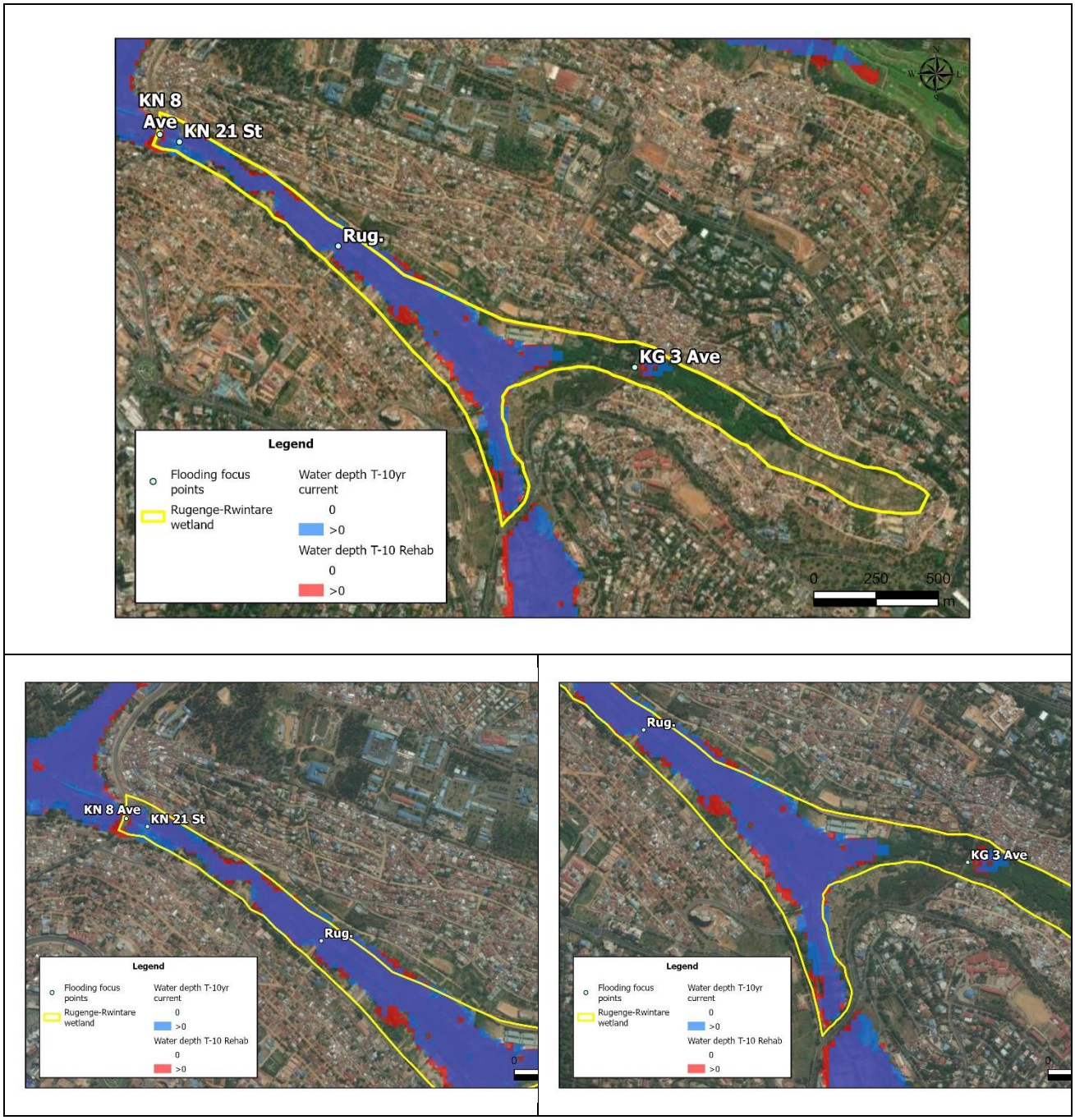
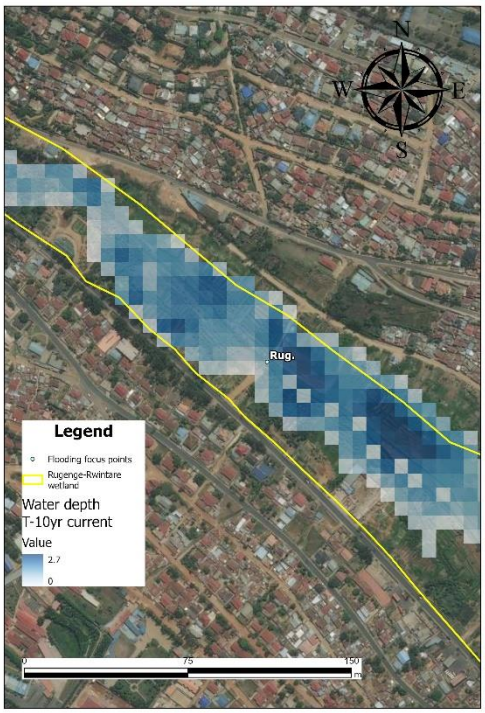


FIGURE 6-39 COMPARISONS OF FLOODED AREAS FOR RUGENGE BEFORE AND AFTER THE REHABILITATION FOR THE CURRENT STATE

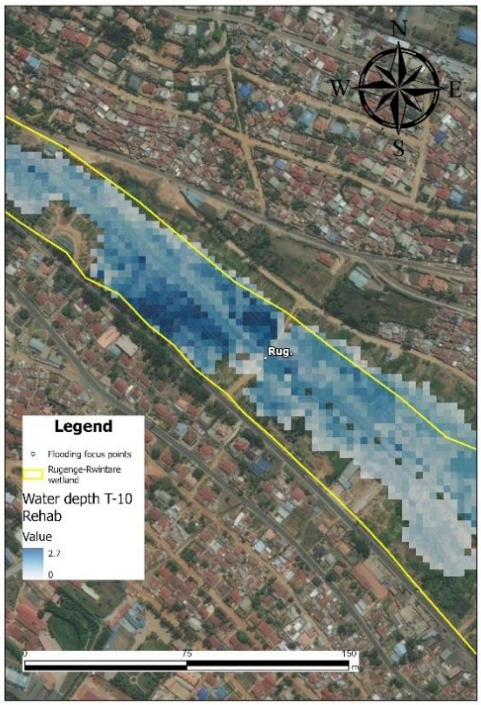
Observations and interpretations are the following:

- New peripheric areas are flooded (red) with proposed actions, which is consistent with the objective to increase the area of water inundation and reduce water level in specific points in the centre (light blue)
- Raise riverbed permits to slower the flows and reduce the discharge as described below

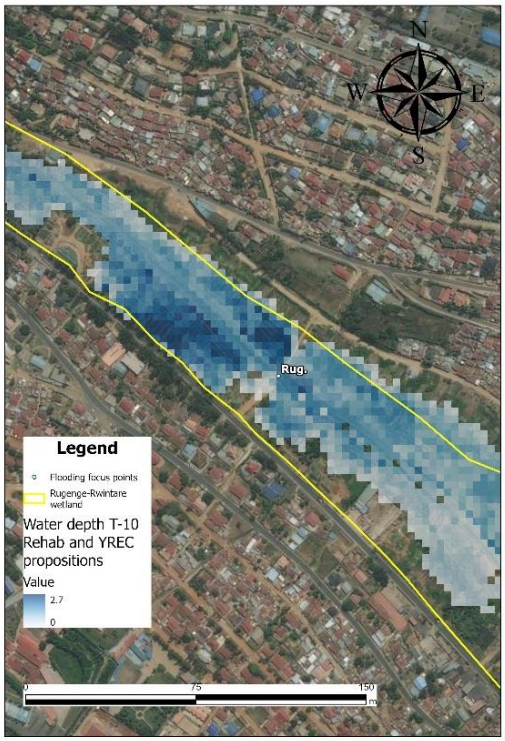
Flooding focus point: Rugenge road



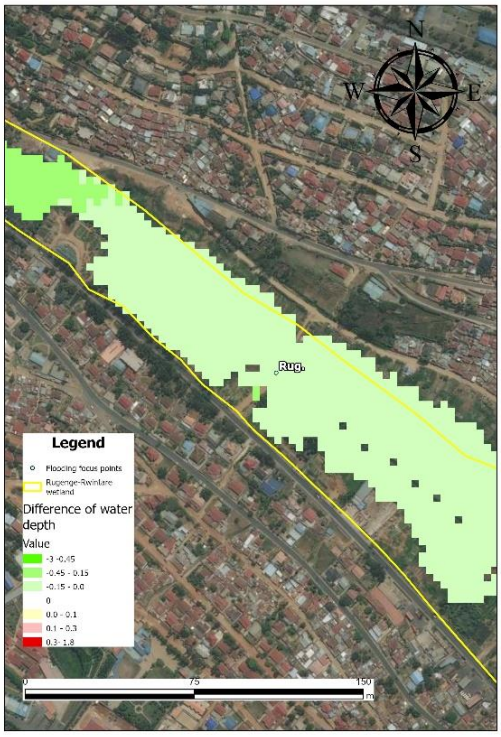
Hydraulic simulation results for baseline



Hydraulic simulation results with IBC / SGI actions



Hydraulic simulation results with IBC / SGI actions and YREC proposed infrastructure



Evolution of maximal water level with proposed rehabilitation actions
Yellow -red = increase / Green = decrease

FIGURE 6-40 COMPARISONS OF WATER LEVELS, BEFORE AND AFTER THE PROPOSED REHABILITATION IN RUGENGE ROAD

TABLE 6-28 WATER DEPTH FOR DIFFERENT SCENARIO FOR RUGENGE ROAD

Return Period	Land use	Climate Change	Proposed Rehabilitation IBC/SGI	Hotspots Rehabilitation (YREC)	Max water depth IBC/SGI [m]
10 Y	Current	Current	No	No	0.60
10 Y	Current	Current	Yes	No	0.20
10 Y	Current	Current	Yes	Yes	0.20

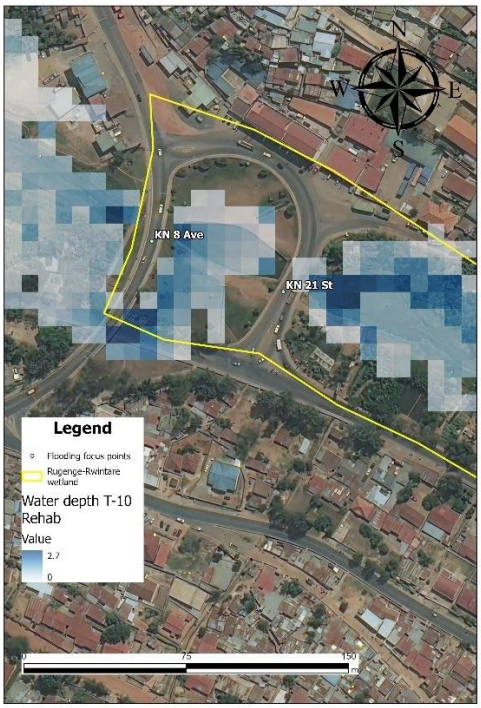
Observations and interpretations are the following:

- Wetland rehabilitation actions result in increasing water depth and flooded area upstream Rugenge road (action Ru 05)
- Wetland rehabilitation actions result in reducing the water depth at Rugenge Road (as seen on the map at the bottom right) as well as reducing the flooding area and maximal water level for development of action Ru 02
- As hotspot project does not propose any improvement in this sector and near to this point, no changes in water depth after the addition of proposals is observed. Most of flooded problems are however solved.

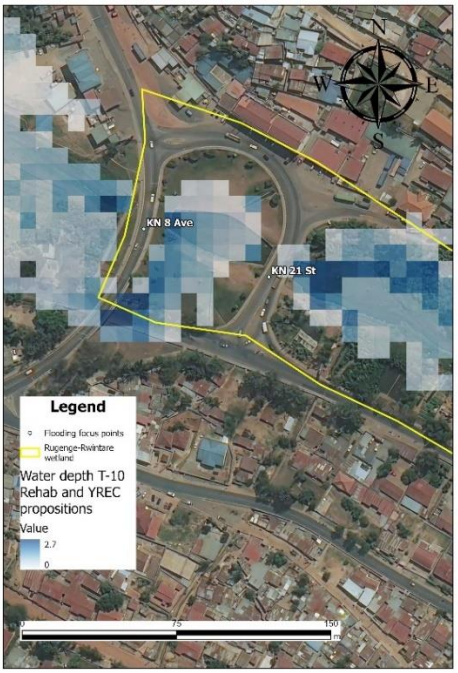
Flooding focus point: KN 21 St.



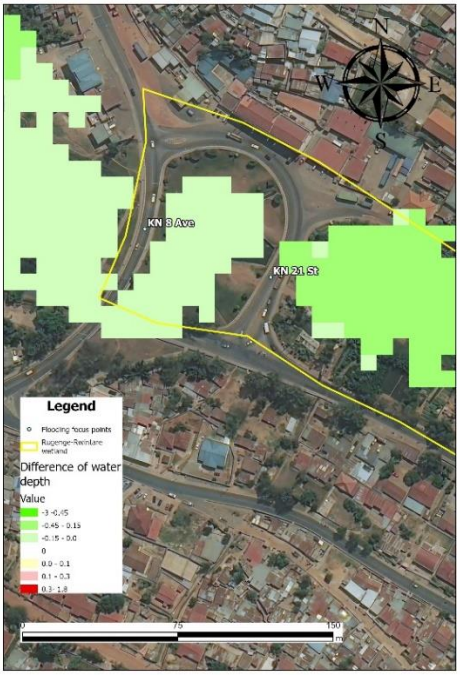
Hydraulic simulation results for baseline



Hydraulic simulation results with IBC / SGI actions



Hydraulic simulation results with IBC / SGI actions and YREC proposed infrastructure



Evolution of maximal water level with proposed rehabilitation actions
Yellow -red = increase / Green = decrease

FIGURE 6-41 COMPARISONS OF WATER LEVELS, BEFORE AND AFTER THE PROPOSED REHABILITATION IN KN 21

TABLE 6-29 WATER DEPTH FOR DIFFERENT SCENARIO FOR KN 21

Return Period	Land use	Climate Change	Proposed Rehabilitation IBC/SGI	Hotspots Rehabilitation (YREC)	Max water depth IBC/SGI [m]
10 Y	Current	Current	No	No	0.78
10 Y	Current	Current	Yes	No	0.00
10 Y	Current	Current	Yes	Yes	0.00

Observations and interpretations are the following:

- Wetland rehabilitation actions result in increasing water depth and flooded area upstream KN 21 road (action Ru 05)
- Wetland rehabilitation actions result in reducing the water depth at KN21 Road (as seen on the map at the bottom right) as well as reducing the flooding area and maximal water level for development of actions downstream
- As flooded problems are already solved by wetland rehabilitation actions, no modifications are to be considered through hotspot proposed infrastructure.

No analyse were done for KG3 as no flooding is observed for the baseline.

6.3.2.5 Nyabugogo

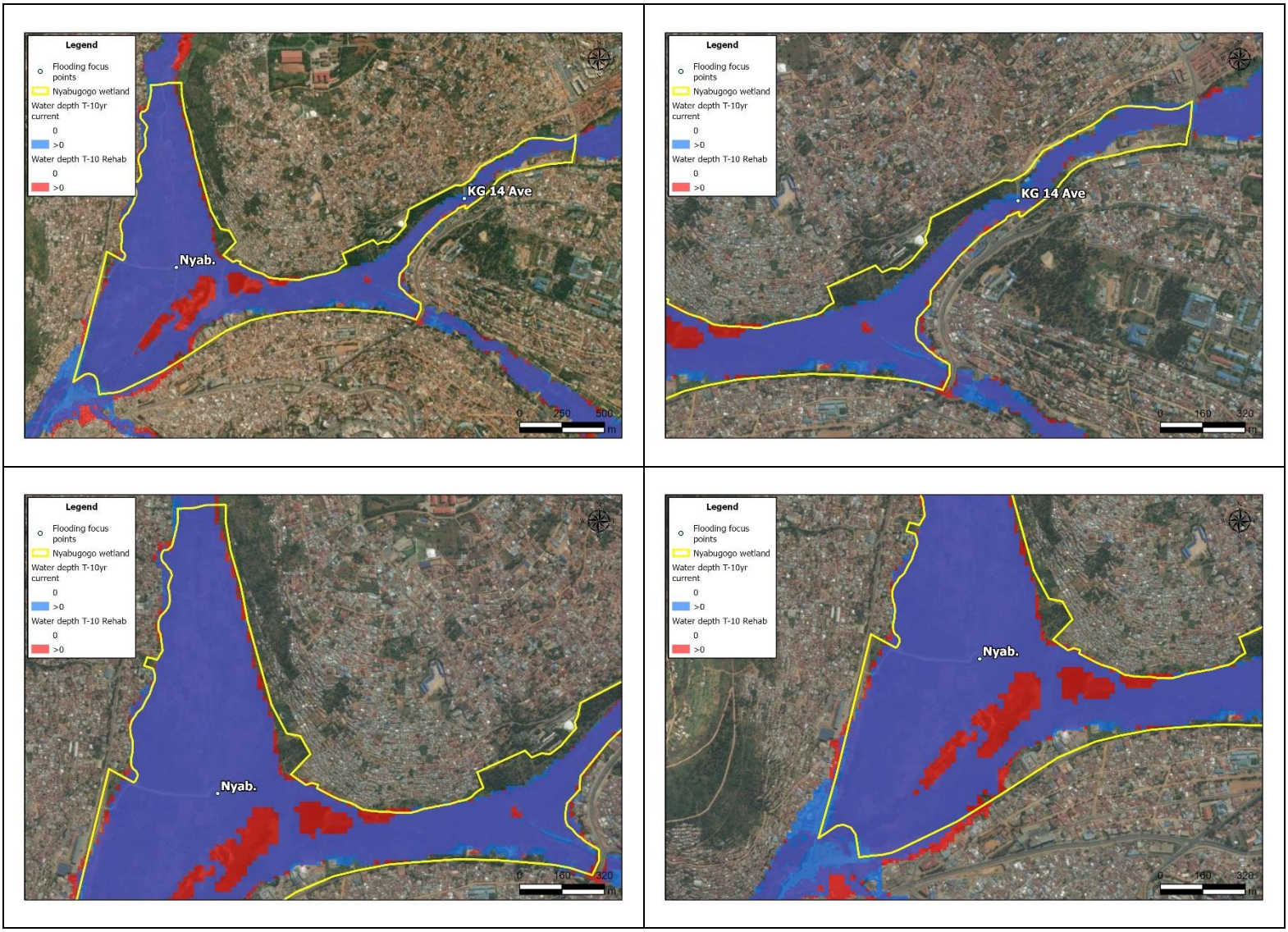
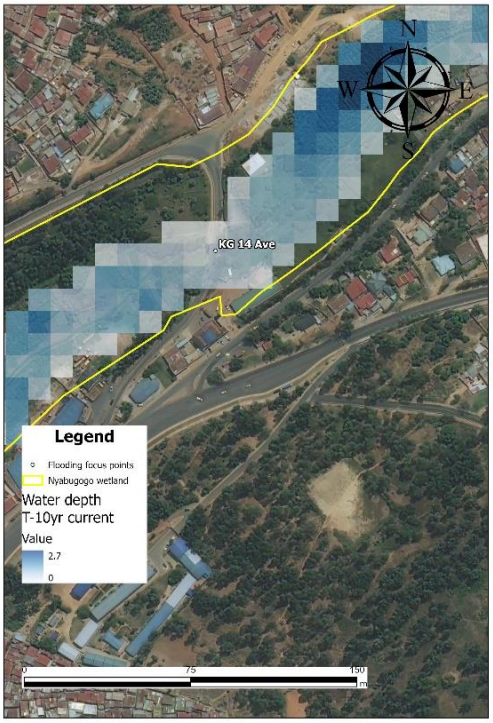


FIGURE 6-42 COMPARISONS OF FLOODED AREAS FOR NYABUGOGO BEFORE AND AFTER THE REHABILITATION FOR THE CURRENT STATE

Observations and interpretations are the following:

- New flooding areas are to be observed in the heart of Nyabugogo wetland (in red) which is very important to develop the
- Maximal water levels are decreasing downstream our study area
- Raise riverbed permits to slower the flows and reduce the discharge as described below

Flooding focus point: KG 14 Avenue



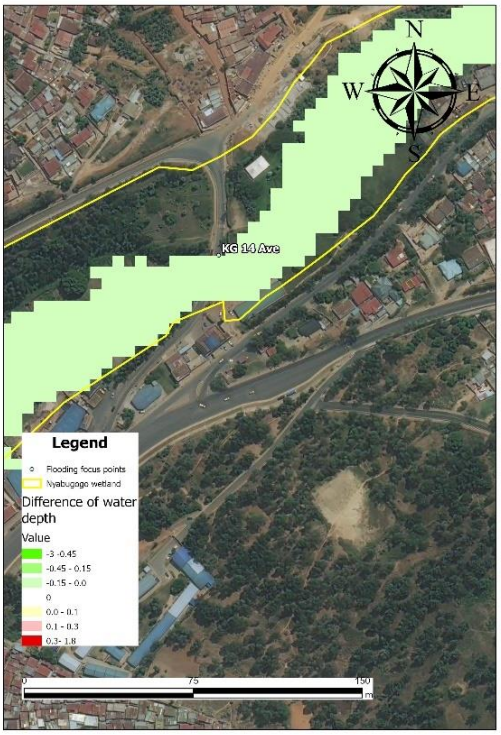
Hydraulic simulation results for baseline



Hydraulic simulation results with IBC / SGI actions



Hydraulic simulation results with IBC / SGI actions and YREC proposed infrastructure



Evolution of maximal water level with proposed rehabilitation actions
Yellow -red = increase / Green = decrease

FIGURE 6-43 COMPARISONS OF WATER LEVELS, BEFORE AND AFTER THE PROPOSED REHABILITATION IN KG 14 AVENUE

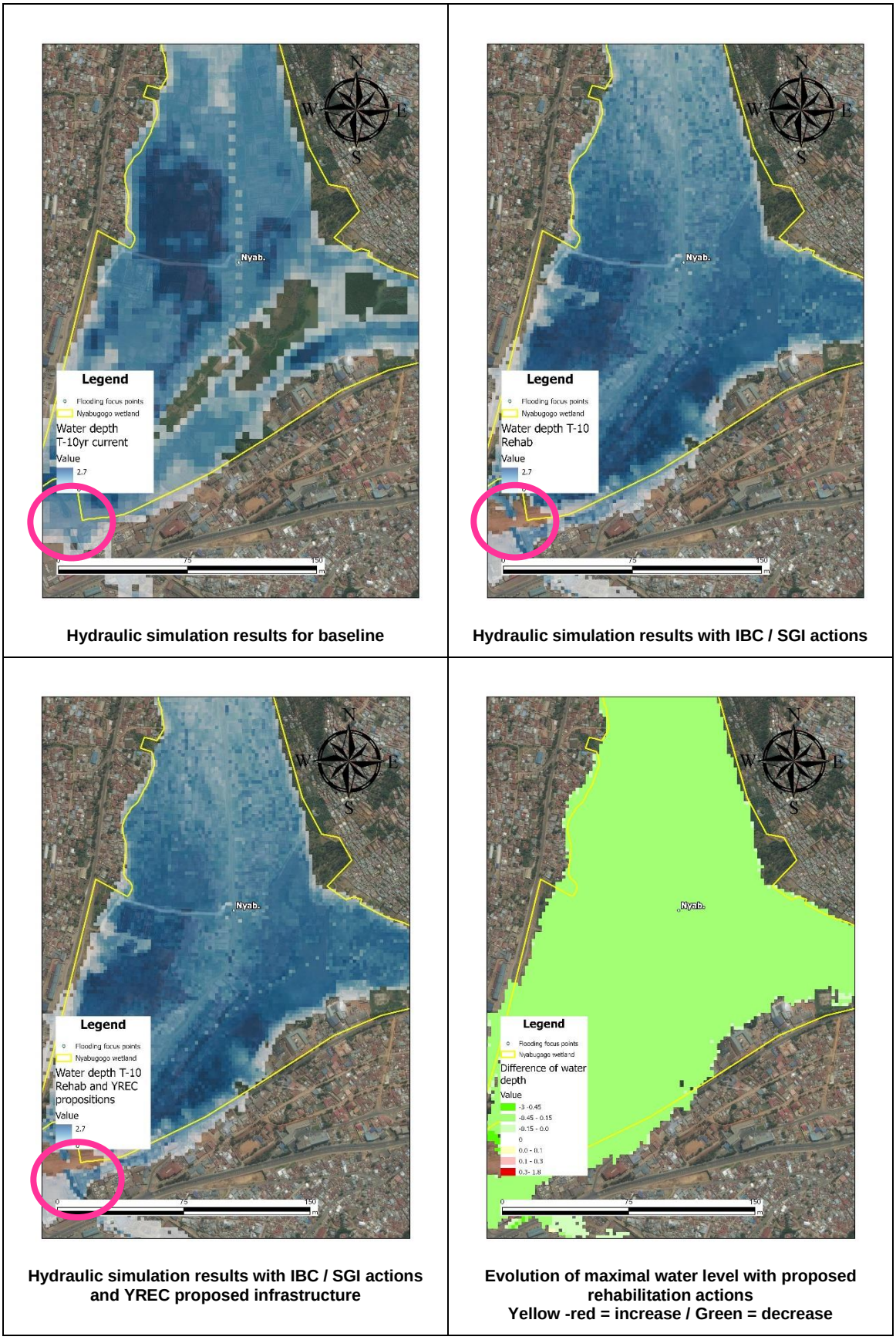
TABLE 6-30 WATER DEPTH FOR DIFFERENT SCENARIO FOR KG 14 AVENUE

Return Period	Land use	Climate Change	Proposed Rehabilitation IBC/SGI	Hotspots Rehabilitation (YREC)	Max water depth IBC/SGI [m]
10 Y	Current	Current	No	No	0.56
10 Y	Current	Current	Yes	No	0.00
10 Y	Current	Current	Yes	Yes	0.00

Observations and interpretations are the following:

- Wetland rehabilitation actions in Nyabugogo (N07) and upstream in Rugenge result in reducing the water depth at KN14 (as seen on the map at the bottom right) as well as reducing the flooding area and maximal water level for development of actions downstream.
- As flooded problems are already solved by wetland rehabilitation actions, no modifications are to be considered through hotspot proposed infrastructure.

Flooding focus point: Nyabugogo



Hydraulic simulation results for baseline

Hydraulic simulation results with IBC / SGI actions

Hydraulic simulation results with IBC / SGI actions and YREC proposed infrastructure

Evolution of maximal water level with proposed rehabilitation actions
Yellow -red = increase / Green = decrease

FIGURE 6-44 COMPARISONS OF WATER LEVELS, BEFORE AND AFTER THE PROPOSED REHABILITATION IN NYABUGOGO

TABLE 6-31 WATER DEPTH FOR DIFFERENT SCENARIO FOR NYABUGOGO

Return Period	Land use	Climate Change	Proposed Rehabilitation IBC/SGI	Hotspots Rehabilitation (YREC)	Max water depth IBC/SGI [m]
10 Y	Current	Current	No	No	2.44
10 Y	Current	Current	Yes	No	1.98
10 Y	Current	Current	Yes	Yes	1.98

Observations and interpretations are the following:

- Actions proposed for wetland rehabilitation (N06) have a positive impact for flood control but only partially solve flooding problems in Nyabugogo centre point.
- This point is not so sensitive in terms of existing infrastructure, the objective is to reduce the flooding problems downstream and it is observed (see pink circles)
- The west part of Nyabugogo wetland is to be considered separately as it is related to the Nyaruruma hotspot and the upper part of the Nyabugogo river.

6.3.3 Results for variant 2

The objective of variant 2 in terms of flood control is twofold:

- to create artificial lakes with dams construction for part of the wetlands more suitable and
- to keep other parts of the wetland with the proposed actions for variant 1.

The following sections present:

- For each wetland, a map comparing the flooded area and maximum water level:
  - For baseline situation (in blue).
  - With the proposed actions of variant 2
  - The difference of maximal water level (new flooded areas in red)
  - The impact of hotspots proposed infrastructure for this variant

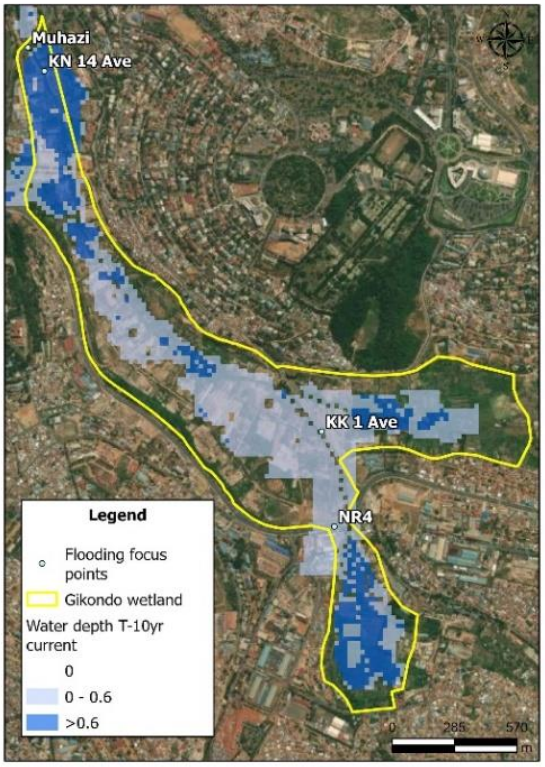
The following observations are detailed in the following chapters, and they are quite logical:

- Increase of the water level for area concerned by lake creation
- Decrease of the discharge downstream the lake
- Additional decrease in the riverbed for sensitive points with hotspot proposed infrastructure
- Decrease of maximum water level for the actions downstream the lakes

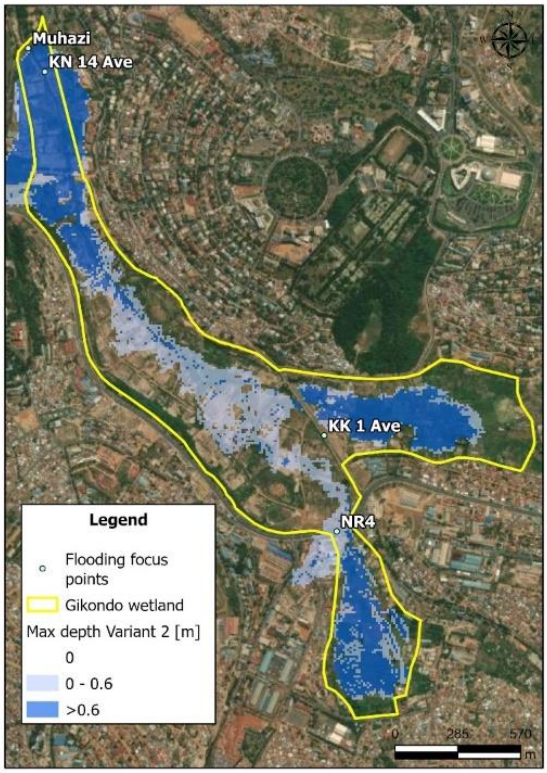
All values presented below are for:

- Return period event: 10 years
- Climate change: Current
- Land use: Current

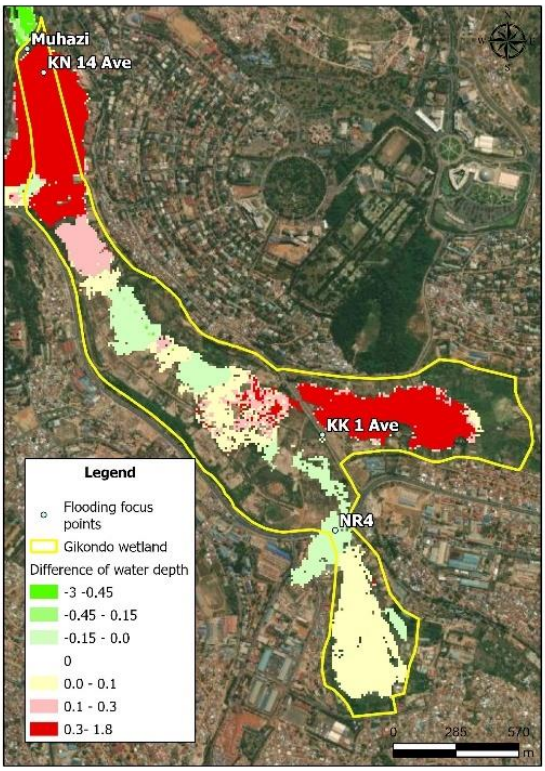
6.3.3.1 Gikondo



Hydraulic simulation results for baseline



Hydraulic simulation results with actions of variant 2



Evolution of maximal water level with proposed rehabilitation actions
Yellow -red = increase / Green = decrease

FIGURE 6-45 COMPARISON OF CURRENT STATE AND VARIANT 2 FOR GIKONDO

TABLE 6-32 TABLE COMPARING THE MAX. WATER DEPTH BEFORE AND AFTER THE IMPLEMENTING OF THE VARIANT 2 FOR GIKONDO

Name of flooding point	Max. water depth current state [m]	Max. water depth after modifications [m]
NR4	0.04	0.01
KK 1 Ave	0.15	0.00
KN 14 Ave	2.28	10 - 12

TABLE 6-33 TABLE COMPARING THE MAX. WATER DEPTH BEFORE AND AFTER THE IMPLEMENTING OF THE VARIANT 2 FOR GIKONDO

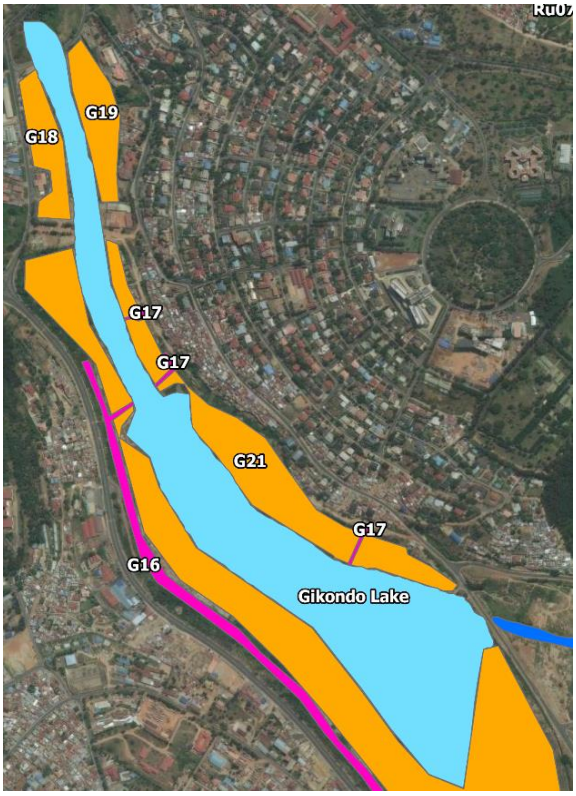
Name of flooding point	Impact of hotspot infrastructure
NR4	Already solved by wetland rehabilitation actions – no additional modification
KK 1 Ave	Already solved by wetland rehabilitation actions – no additional modification
KN 14 Ave	Flooded – included in the area foreseen for the future lake

According to the hydrologic and hydraulic calculation, the characteristics of the lake are the following.

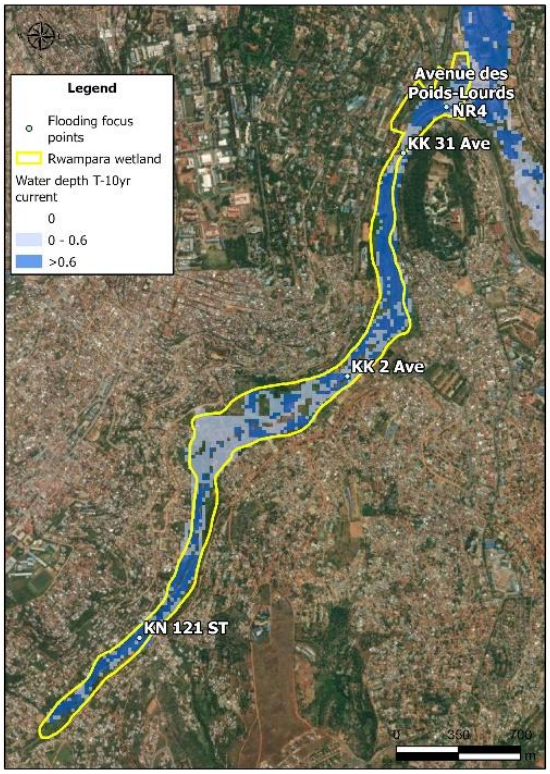
Creation of a lake in Gikondo	Average surface of the lake in ha	38
Characteristics of the dam	H - Height in m	16
	L – Approximative length in m	370
	Maximal overflow to ensure annual renewal of the lake (m3/s)	0.21
	% of annual average flow	88%

The following graphic shows the water level (in m) of the lake during 2 consecutive years.

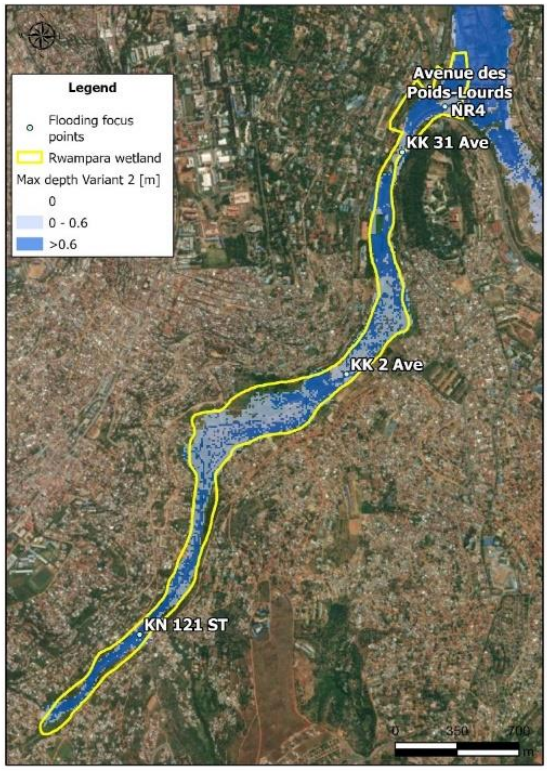




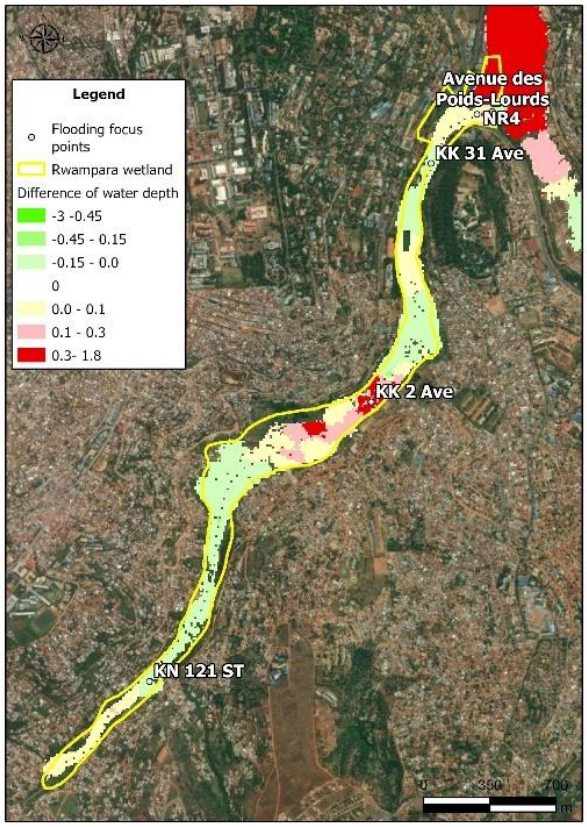
6.3.3.2 Rwampara



Hydraulic simulation results for baseline



Hydraulic simulation results with actions of variant 2



Evolution of maximal water level with proposed rehabilitation actions
Yellow -red = increase / Green = decrease

FIGURE 6-46 COMPARISON OF CURRENT STATE AND VARIANT 2 FOR RWAMPARA

TABLE 6-34 TABLE COMPARING THE MAX. WATER DEPTH BEFORE AND AFTER THE IMPLEMENTING OF THE VARIANT 2 FOR RWAMPARA

Name of flooding point	Max. water depth current state [m]	Max. water depth after modifications [m]
KN 121 ST	1.06	1.04
KK 2 Ave	0.85	6 - 8
KK 31 Ave	0.78	0.32
Poids-Lourds, NR4	0.4	0.20

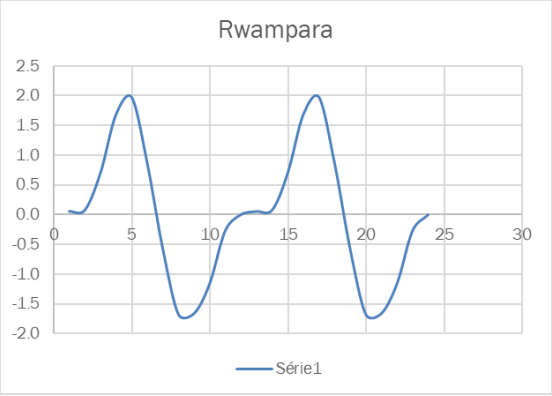
TABLE 6-35 TABLE COMPARING THE MAX. WATER DEPTH BEFORE AND AFTER THE IMPLEMENTING OF THE VARIANT 2 FOR RWAMPARA

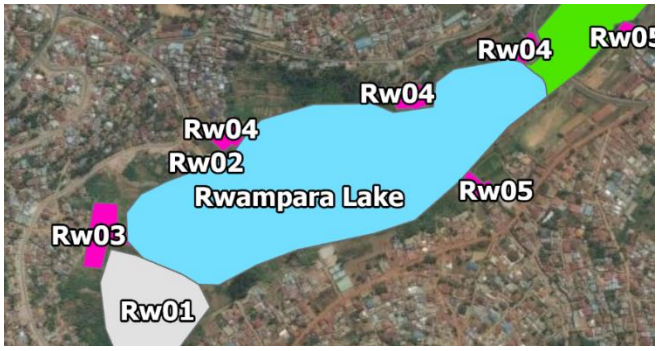
Name of flooding point	Impact of hotspot infrastructure
KN 121 ST	No real impact – no action proposed upstream
KK 2 Ave	Flooded – included in the area foreseen for the future lake
KK 31 Ave	Totally solved with combination of wetland rehabilitation actions and hotspots proposed infrastructure
Poids-Lourds, NR4	Totally solved with combination of wetland rehabilitation actions and hotspots proposed infrastructure

According to the hydrologic and hydraulic calculation, the characteristics of the lake are the following.

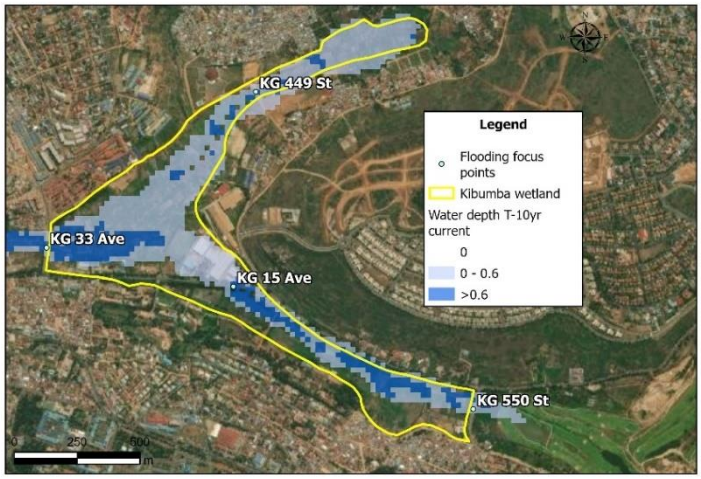
Creation of a lake in Rwampara	Average surface of the lake in ha	18
Characteristics of the dam	H - Height in m	10
	L – Approximative length in m	215
	Maximal overflow to ensure annual renewal of the lake (m3/s)	0.19
	% of annual average flow	92%

The following graphic shows the water level (in m) of the lake during 2 consecutive years.

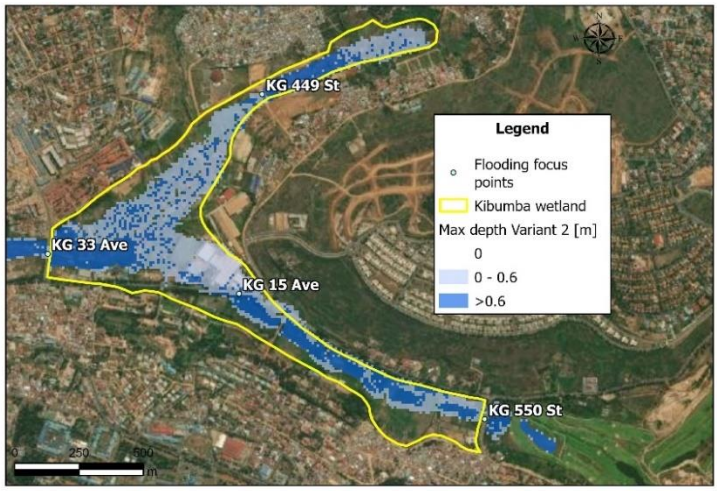




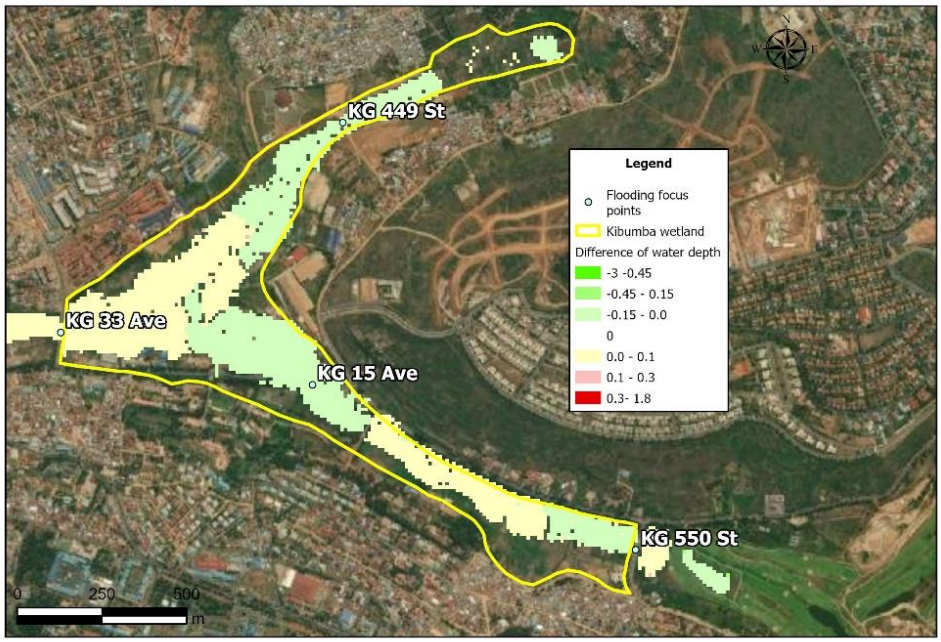
6.3.3.3 Kibumba



Hydraulic simulation results for baseline



Hydraulic simulation results with actions of variant 2



Evolution of maximal water level with proposed rehabilitation actions
Yellow -red = increase / Green = decrease

FIGURE 6-47 COMPARISON OF CURRENT STATE AND VARIANT 2 FOR KIBUMBA

TABLE 6-36 TABLE COMPARING THE MAX. WATER DEPTH BEFORE AND AFTER THE IMPLEMENTING OF THE VARIANT 2 FOR KIBUMBA

Name of flooding point	Max. water depth current state [m]	Max. water depth after modifications [m]
KG 550 St	0.3	0.00
KG 15 Ave	0.8	0.25
KG 449 St	0.62	3.5 - 5
KG 33 Ave	0.54	0.03

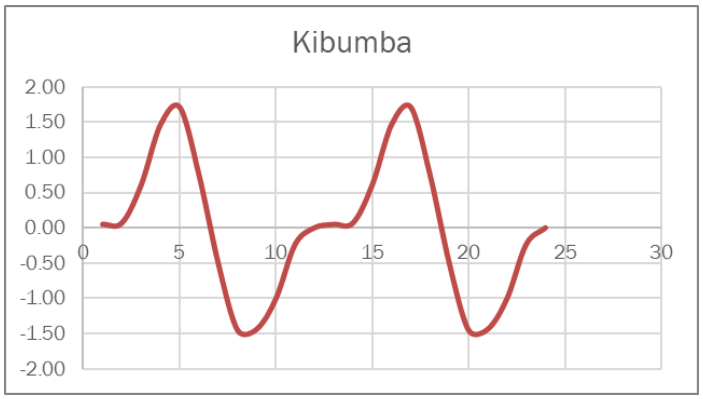
TABLE 6-37 TABLE COMPARING THE MAX. WATER DEPTH BEFORE AND AFTER THE IMPLEMENTING OF THE VARIANT 2 FOR KIBUMBA

Name of flooding point	Impact of hotspot infrastructure
KG 550 St	Totally solved with combination of wetland rehabilitation actions and hotspots proposed infrastructure
KG 15 Ave	Partially solved – better than with variant 1
KG 449 St	Flooded – included in the area foreseen for the future lake
KG 33 Ave	Totally solved with combination of wetland rehabilitation actions and hotspots proposed infrastructure

According to the hydrologic and hydraulic calculation, the characteristics of the lake are the following.

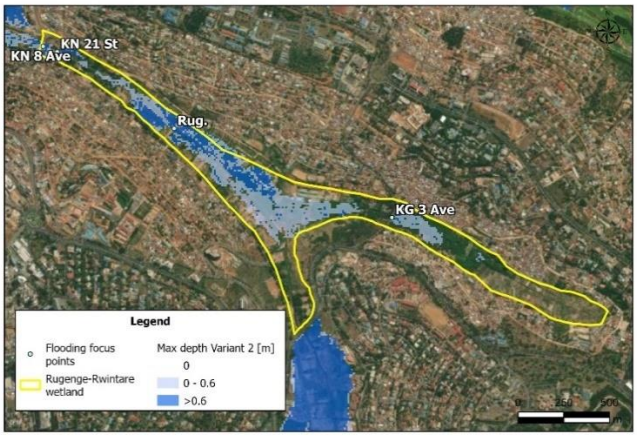
Creation of a lake in Kibumba	Average surface of the lake in ha	19
Characteristics of the dam	H - Height in m	7
	L – Approximative length in m	220
	Maximal overflow to ensure annual renewal of the lake (m3/s)	0.13
	% of annual average flow	90%

The following graphic shows the water level (in m) of the lake during 2 consecutive years.

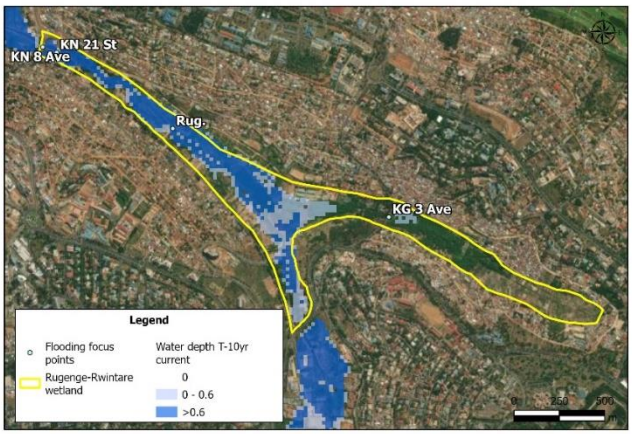




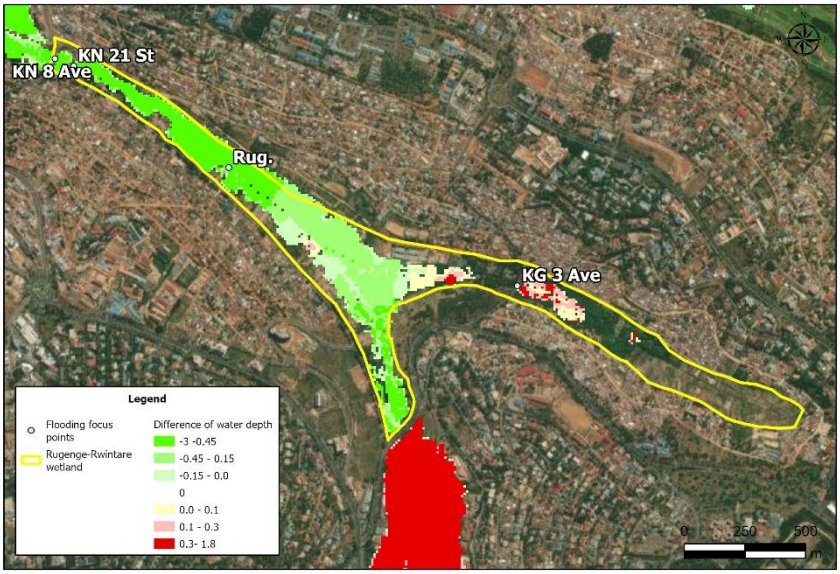
6.3.3.4 Rugenge



Hydraulic simulation results for baseline



Hydraulic simulation results with actions of variant 2



Evolution of maximal water level with proposed rehabilitation actions
Yellow -red = increase / Green = decrease

FIGURE 6-48 COMPARISON OF CURRENT STATE AND VARIANT 2 FOR RUGENGE

TABLE 6-38 TABLE COMPARING THE MAX. WATER DEPTH BEFORE AND AFTER THE IMPLEMENTING OF THE VARIANT 2 FOR RUGENGE

Name of flooding point	Max. water depth current state [m]	Max. water depth after modifications [m]
Rug.	0.6	0.00
KN 21 St	0.78	0.00

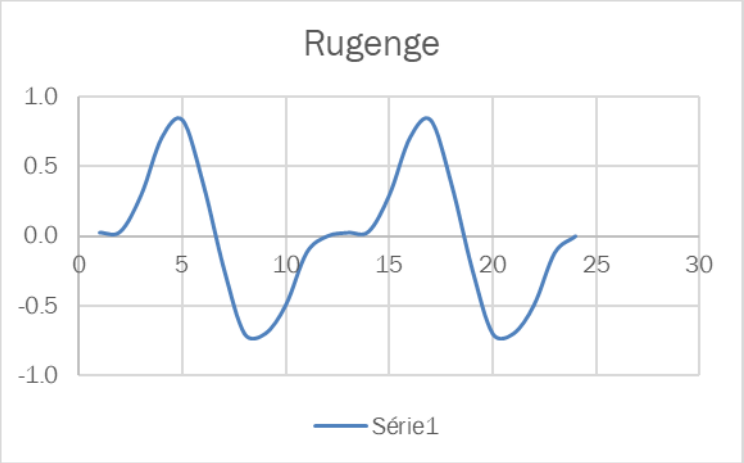
TABLE 6-39 TABLE COMPARING THE MAX. WATER DEPTH BEFORE AND AFTER THE IMPLEMENTING OF THE VARIANT 2 FOR RUGENGE

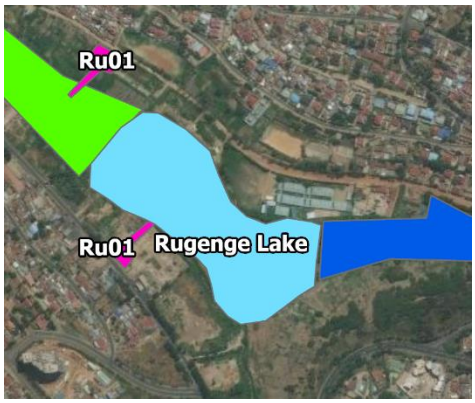
Name of flooding point	**Impact of hotspot infrastructure**
Rug.	Totally solved by lake creation
KN 21 St	Totally solved by lake creation and hotspot infrastructure construction

According to the hydrologic and hydraulic calculation, the characteristics of the lake are the following.

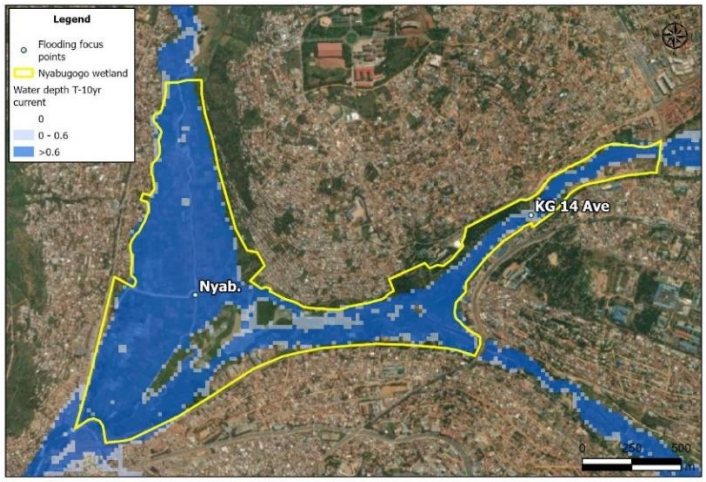
Creation of a lake in Rugenge	Average surface of the lake in ha	10
Characteristics of the dam	H - Height in m	3
	L – Approximative length in m	250
	Maximal overflow to ensure annual renewal of the lake (m3/s)	0.05
Very low!	% of annual average flow	12%

The following graphic shows the water level (in m) of the lake during 2 consecutive years.

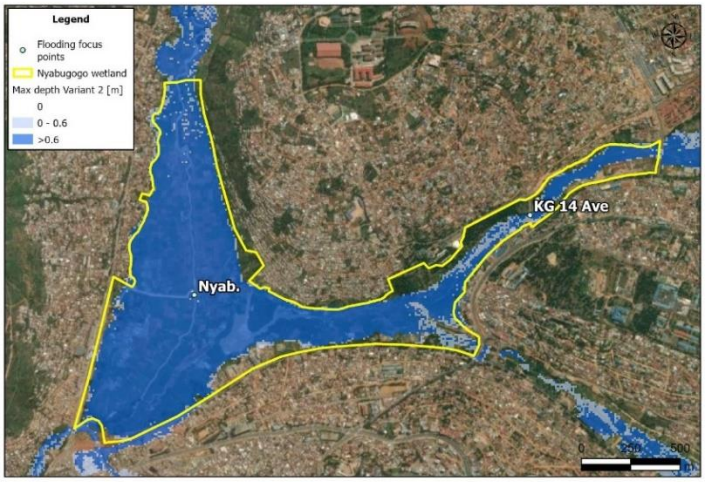




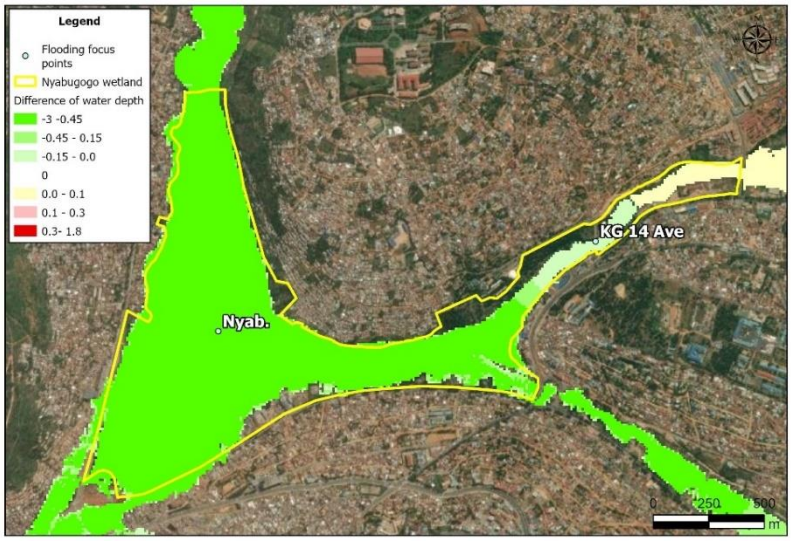
6.3.3.5 Nyabugogo



Hydraulic simulation results for baseline



Hydraulic simulation results with actions of variant 2



Evolution of maximal water level with proposed rehabilitation actions
Yellow -red = increase / Green = decrease

FIGURE 6-49 COMPARISON OF CURRENT STATE AND VARIANT 2 FOR NYABUGOGO

TABLE 6-40 TABLE COMPARING THE MAX. WATER DEPTH BEFORE AND AFTER THE IMPLEMENTING OF THE VARIANT 2 FOR NYABUGOGO

Name of flooding point	Max. water depth current state [m]	Max. water depth after modifications [m]
Nyab.	2.44	1.73
KG 14 Ave	0.56	0.00

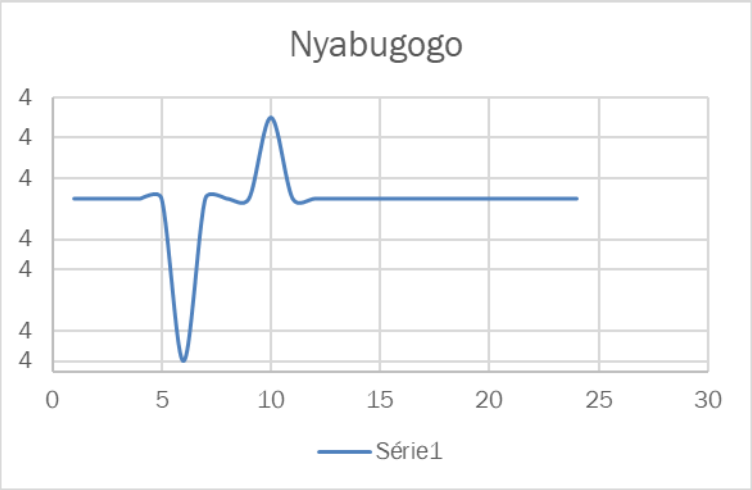
TABLE 6-41 TABLE COMPARING THE MAX. WATER DEPTH BEFORE AND AFTER THE IMPLEMENTING OF THE VARIANT 2 FOR NYABUGOGO

Name of flooding point	Impact of hotspot infrastructure
Nyab.	To be confirmed through new analysis
KG 14 Ave	Totally solved by lake creation

According to the hydrologic and hydraulic calculation, the characteristics of the lake are the following.

Creation of a lake in Nyabugogo	Average surface of the lake in ha	33
Characteristics of the dam	H - Height in m	4
	L – Approximative length in m	250
	Maximal overflow to ensure annual renewal of the lake (m3/s)	19.7
	% of annual average flow	97%

The following graphic shows the water level (in m) of the lake during 2 consecutive years.





6.3.4 Results for variant 3

The objective of variant 3 in terms of flood control is twofold:

- to create successive retention zones by weirs on the sides of the wetlands and
- to keep other parts of the wetland with the proposed actions for variant 1.

The following sections present:

- For each wetland, maps and tables comparing the flooded area and maximum water level:
  - For baseline situation (in blue).
  - With the proposed actions of variant 3
  - The difference of maximal water level (new flooded areas in red)
  - The impact of hotspots proposed infrastructure for this variant

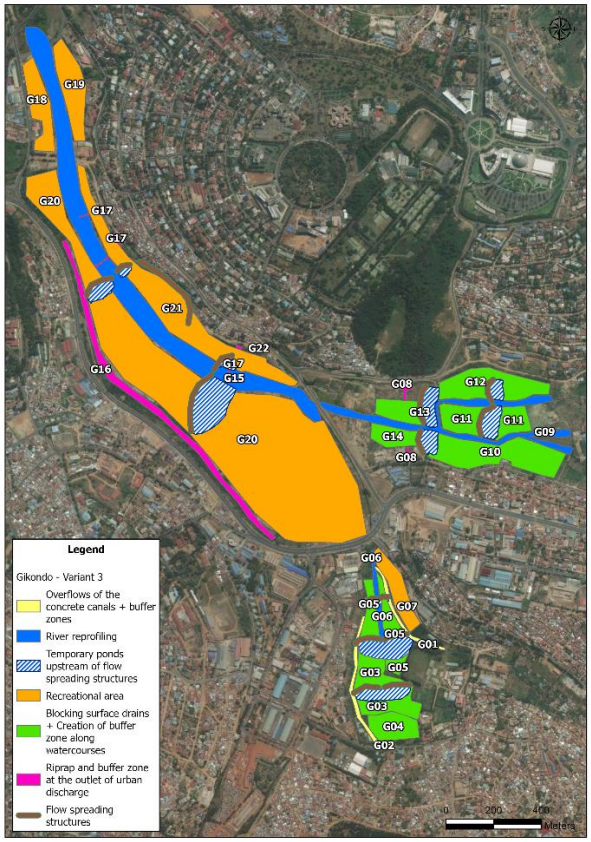
The following observations are detailed in the following chapters, and they are quite logical:

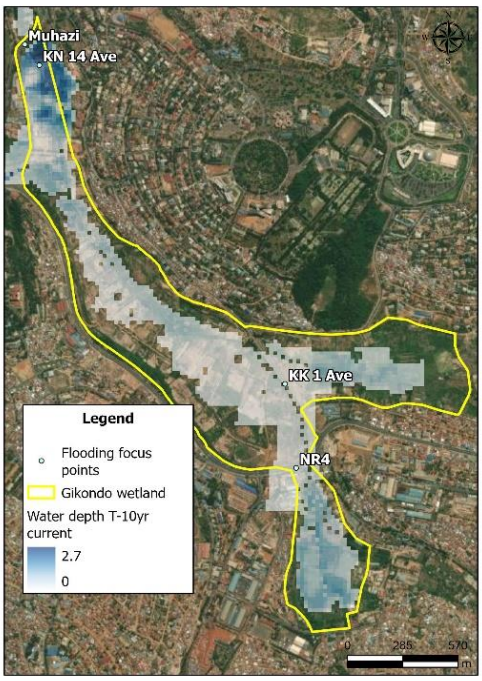
- Increase of the water level for area concerned by new weirs
- Creation of new flooding areas (in yellow and red)
- Decrease of the discharge downstream the lake
- Additional decrease in the riverbed for sensitive points with hotspot proposed infrastructure
- Decrease of maximum water level for the actions downstream the lakes

All values presented below are for:

- Return period event: 10 years
- Climate change: Current
- Land use: Current

6.3.4.1 Gikondo

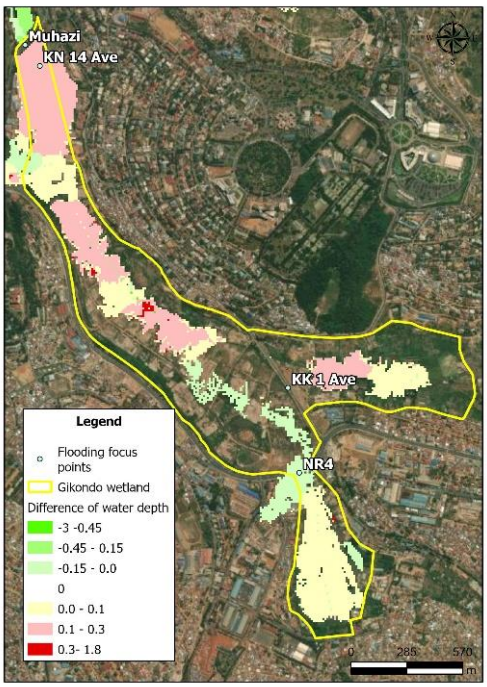




Hydraulic simulation results for baseline



Hydraulic simulation results with actions of variant 3



Evolution of maximal water level with proposed rehabilitation actions
Yellow -red = increase / Green = decrease

FIGURE 6-50 COMPARISON OF CURRENT STATE AND VARIANT 3 FOR GIKONDO

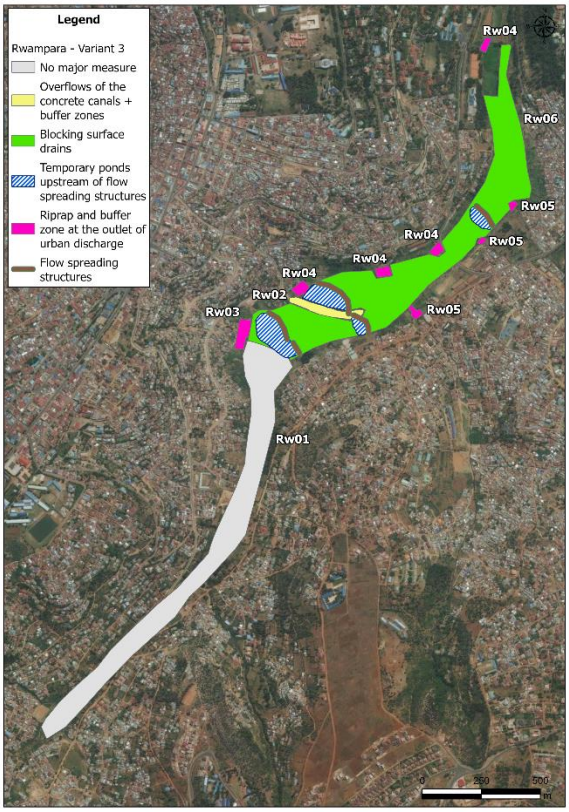
TABLE 6-42 TABLE COMPARING THE MAX. WATER DEPTH BEFORE AND AFTER THE IMPLEMENTING OF THE VARIANT 3 FOR GIKONDO

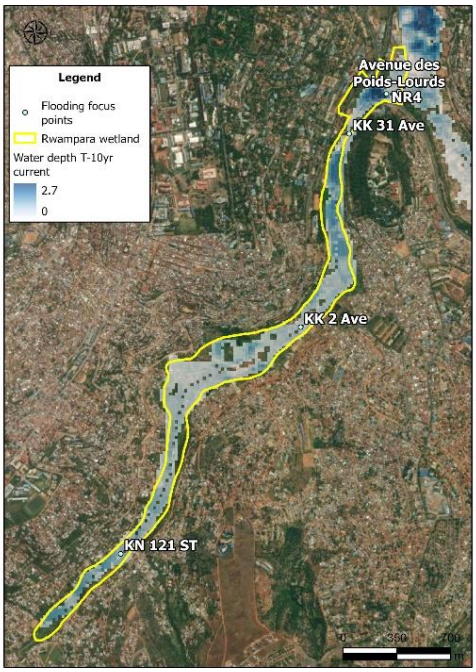
Name of flooding point	Max. water depth current state [m]	Max. water depth after modifications [m]
NR4	0.04	0.01
KK 1 Ave	0.15	0.00
KN 14 Ave	2.28	1.67

TABLE 6-43 TABLE COMPARING THE MAX. WATER DEPTH BEFORE AND AFTER THE IMPLEMENTING OF THE VARIANT 3 FOR GIKONDO

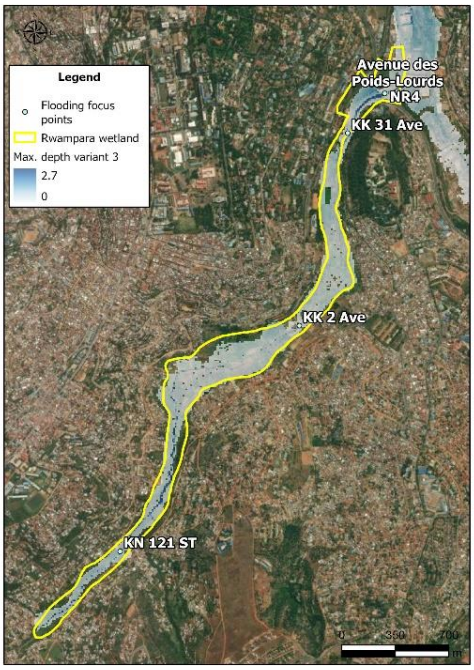
Name of flooding point	Impact of hotspot infrastructure
NR4	Totally solved with rehabilitation actions
KK 1 Ave	Totally solved with rehabilitation actions
KN 14 Ave	Into the new flooded area

6.3.4.2 Rwampara

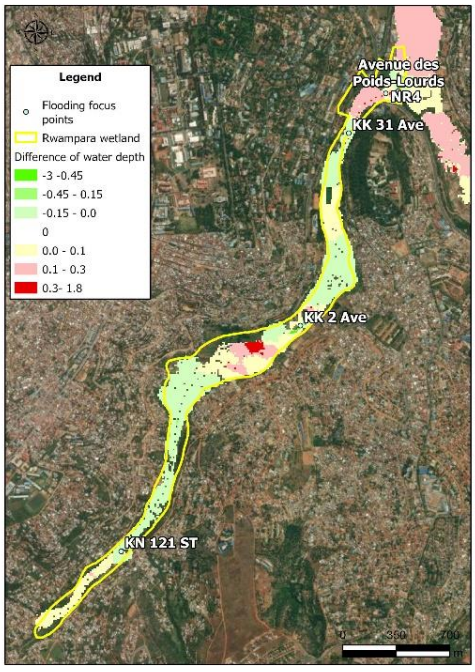




Hydraulic simulation results for baseline



Hydraulic simulation results with actions of variant 3



Evolution of maximal water level with proposed rehabilitation actions
Yellow -red = increase / Green = decrease

FIGURE 6-51 COMPARISON OF CURRENT STATE AND VARIANT 3 FOR RWAMPARA

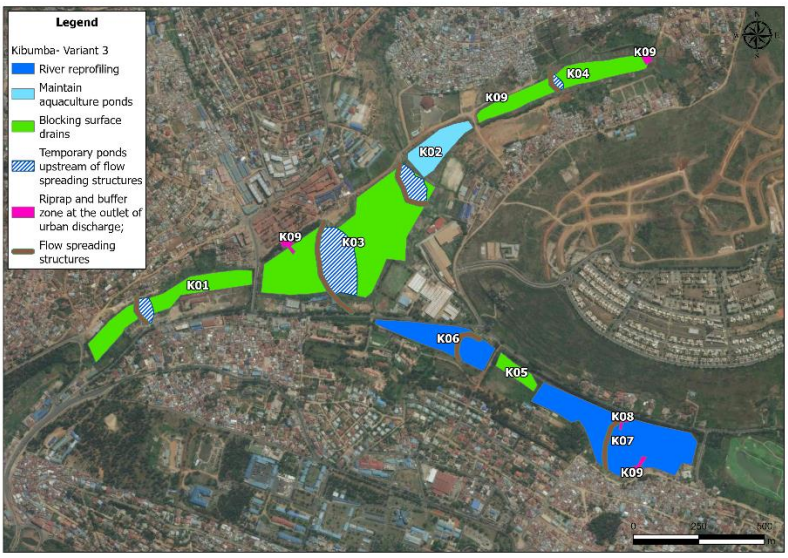
TABLE 6-44 TABLE COMPARING THE MAX. WATER DEPTH BEFORE AND AFTER THE IMPLEMENTING OF THE VARIANT 3 FOR RWAMPARA

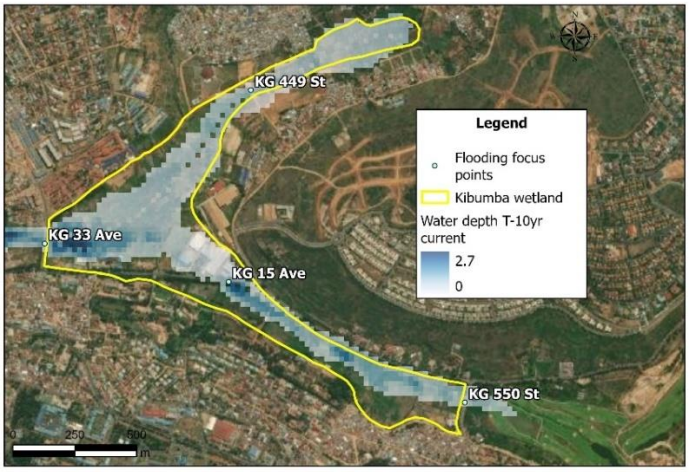
Name of flooding point	Max. water depth current state [m]	Max. water depth after modifications [m]
KN 121 ST	1.06	1.04
KK 2 Ave	0.85	0.10
KK 31 Ave	0.78	0.45
Poids-Lourds, NR4	0.40	0.30

TABLE 6-45 TABLE COMPARING THE MAX. WATER DEPTH BEFORE AND AFTER THE IMPLEMENTING OF THE VARIANT 3 FOR RWAMPARA

Name of flooding point	Impact of hotspot infrastructure
KN 121 ST	Residual flooding - No actions upstream
KK 2 Ave	Totally solved with rehabilitation actions but residual water level according to the new action
KK 31 Ave	Totally solved with combination of Wetland rehabilitation actions and hotspot proposed infrastructure
Poids-Lourds, NR4	Totally solved with combination of Wetland rehabilitation actions and hotspot proposed infrastructure

6.3.4.3 Kibumba

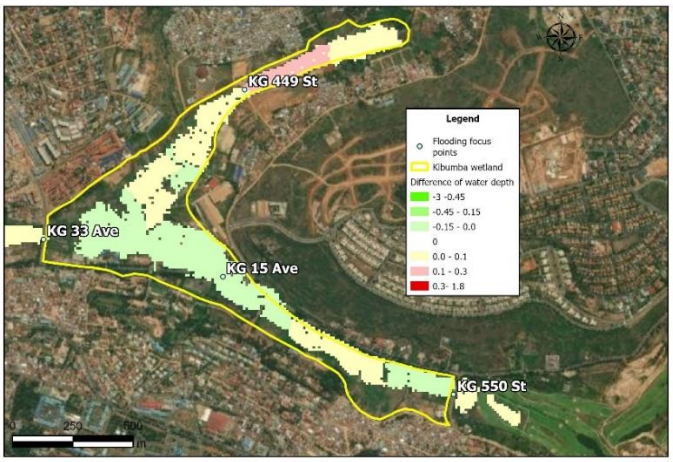




Hydraulic simulation results for baseline



Hydraulic simulation results with actions of variant 3



Evolution of maximal water level with proposed rehabilitation actions
Yellow -red = increase / Green = decrease

FIGURE 6-52 COMPARISON OF CURRENT STATE AND VARIANT 3 FOR KIBUMBA

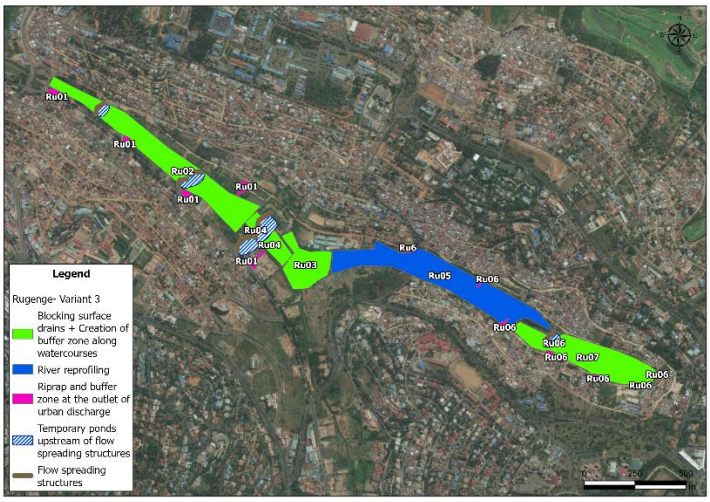
TABLE 6-46 TABLE COMPARING THE MAX. WATER DEPTH BEFORE AND AFTER THE IMPLEMENTING OF THE VARIANT 3 FOR KIBUMBA

Name of flooding point	Max. water depth current state [m]	Max. water depth after modifications [m]
KG 550 St	0.3	0.00
KG 15 Ave	0.80	0.26
KG 449 St	0.62	0.10
KG 33 Ave	0.54	0.03

TABLE 6-47 TABLE COMPARING THE MAX. WATER DEPTH BEFORE AND AFTER THE IMPLEMENTING OF THE VARIANT 3 FOR KIBUMBA

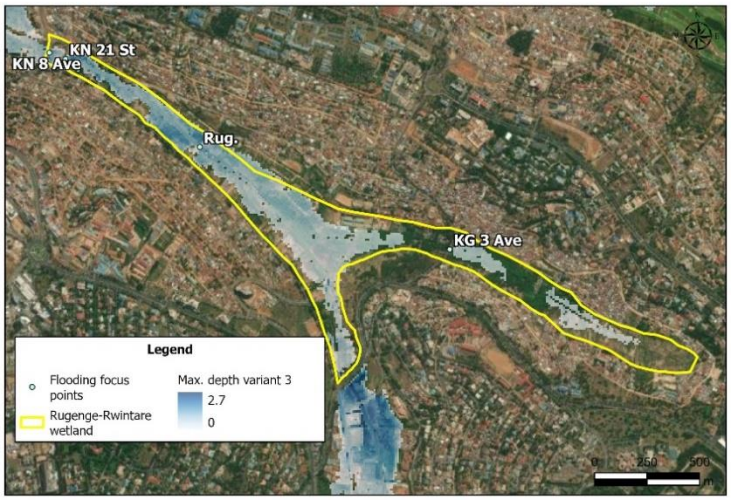
Name of flooding point	Impact of hotspot infrastructure
KG 550 St	Totally solved with wetland rehabilitation actions
KG 15 Ave	Residual flooding - No actions upstream
KG 449 St	Totally solved with wetland rehabilitation actions
KG 33 Ave	Totally solved with combination of Wetland rehabilitation actions and hotspot proposed infrastructure

6.3.4.4 Rugenge

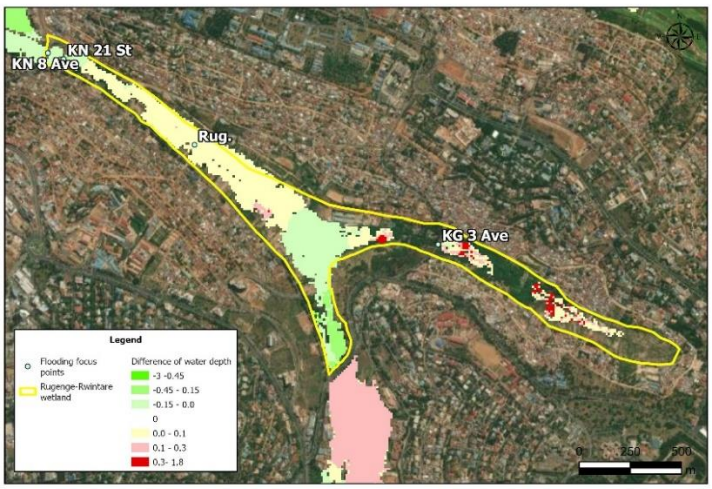




Hydraulic simulation results for baseline



Hydraulic simulation results with actions of variant 3



Evolution of maximal water level with proposed rehabilitation actions
Yellow -red = increase / Green = decrease

FIGURE 6-53 COMPARISON OF CURRENT STATE AND VARIANT 3 FOR RUGENGE

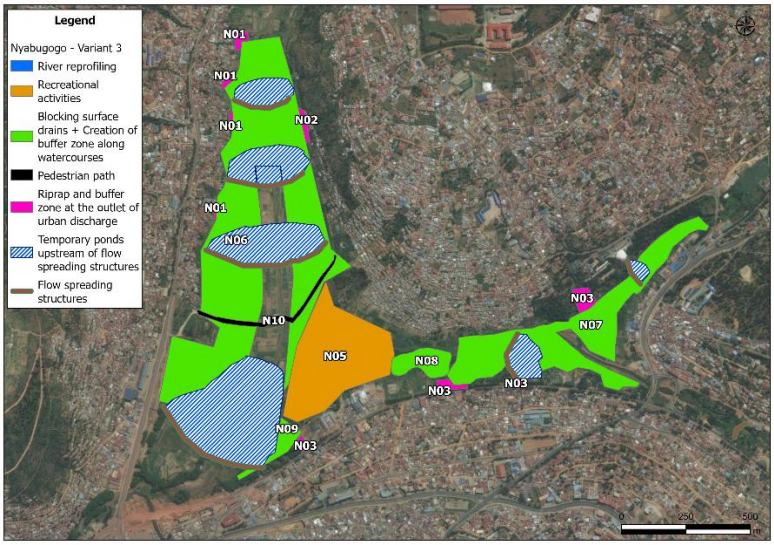
TABLE 6-48 TABLE COMPARING THE MAX. WATER DEPTH BEFORE AND AFTER THE IMPLEMENTING OF THE VARIANT 3 FOR RUGENGE

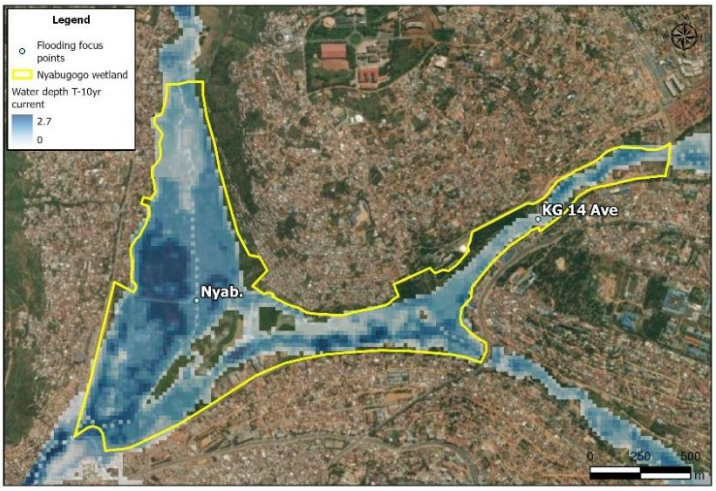
Name of flooding point	Max. water depth current state [m]	Max. water depth after modifications [m]
Rug.	0.60	0.34
KN 21 St	0.78	0.00

TABLE 6-49 TABLE COMPARING THE MAX. WATER DEPTH BEFORE AND AFTER THE IMPLEMENTING OF THE VARIANT 3 FOR RUGENGE

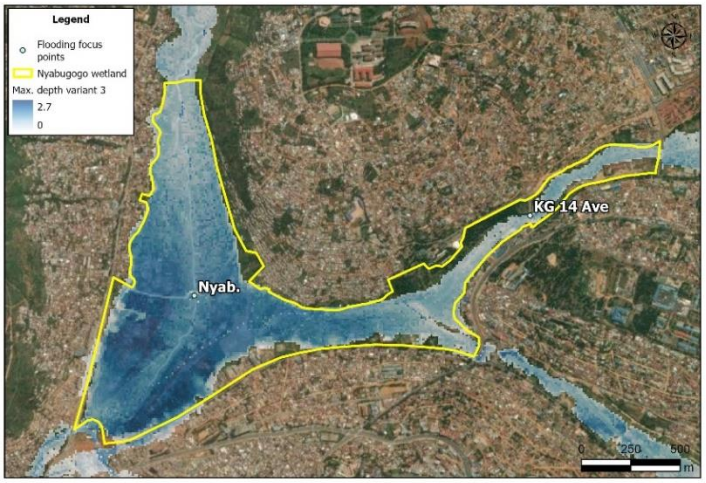
Name of flooding point	Impact of hotspot infrastructure
Rug.	Totally solved with rehabilitation actions but residual water level according to the new action
KN 21 St	Totally solved with rehabilitation actions

6.3.4.5 Nyabugogo

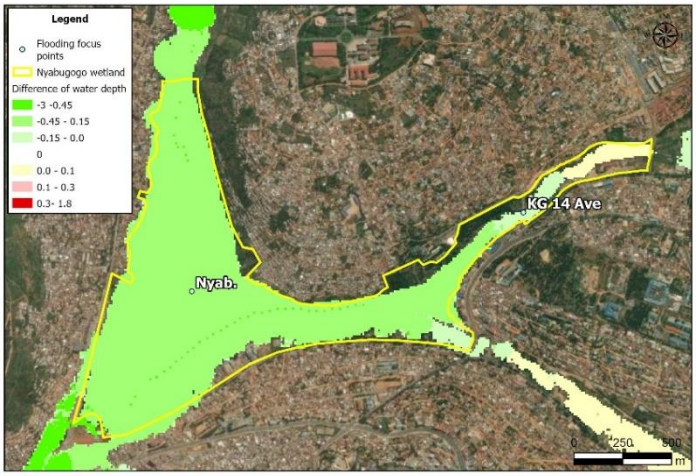




Hydraulic simulation results for baseline



Hydraulic simulation results with actions of variant 3



Evolution of maximal water level with proposed rehabilitation actions
Yellow -red = increase / Green = decrease

FIGURE 6-54 COMPARISON OF CURRENT STATE AND VARIANT 3 FOR NYABUGOGO

TABLE 6-50 TABLE COMPARING THE MAX. WATER DEPTH BEFORE AND AFTER THE IMPLEMENTING OF THE VARIANT 3 FOR NYABUGOGO

Name of flooding point	Max. water depth current state [m]	Max. water depth after modifications [m]
Nyab.	2.44	2.00
KG 14 Ave	0.56	0.00

TABLE 6-51 TABLE COMPARING THE MAX. WATER DEPTH BEFORE AND AFTER THE IMPLEMENTING OF THE VARIANT 3 FOR NYABUGOGO

Name of flooding point	Impact of hotspot infrastructure
Nyab.	Partially reduced with new actions To be confirmed through new analysis
KG 14 Ave	Totally solved by proposed rehabilitation actions

- **CONCLUSION ON IMPACT OF FLOOD HOTSPOT PROJECT PROPOSED INFRASTRUCTURE**

Based on information given in August 2022:

- The construction of the proposed infrastructure should have an impact on rehabilitation actions: some overlapping actions to be discussed and increment of downstream flows to be taken into consideration for definition of our actions
- According to the verifications we made, the actions proposed for wetland rehabilitation actions are however still relevant, but will have to be resized precisely during detailed design phase
- For many cases the two project actions are complementary in order to fully resolve flooding problems at sensitive points
- It is to be reminded that the time return period is not the same one : hotspots infrastructure are to be sized for intense events (50 year to 100 years) whereas main wetland rehabilitation actions are to be sized for 2 to 10 year events.

7. COMPARISON OF DEVELOPMENT SCENARIOS FOR THE CHOSEN VARIANT

Variant 1 is proposed as the preferred variant. It is recommended to implement this variant in phases:

- Priority 1 actions: these are short term action to be implemented by 2025. They represent the most urgent actions to allow the wetlands to be partially rehabilitated.
- Priority 2 actions: these are the medium-term action to be implemented by 2035. They represent the second most urgent actions to allow the wetlands to be partially rehabilitated
- Priority 3 actions: these are the long-term actions to be implemented by 2050. They represent the least urgent rehabilitation activities.

The rationale of this phased implementation is as follow:

- Phasing interventions will allow to gain return of experience, especially on the topic of re-vegetation. As past studies on the wetland rehabilitation considered that costs can be reduced thanks to naturally occurring vegetation which would be able to rapidly colonize disturbed sites. However, given the presence of invasive species, it is more prudent to test natural re-colonization in pilot sectors (as described under Action 6).
- Phase interventions will allow to gain return of experience on O&M as explained in the criteria "Convenience of operation and maintenance requirements of the scenario". It would also allow to gain experience in park governance, strategic planning, and communication and to hire necessary staff for park operations and maintenance. Rehabilitating 500 ha of wetland is quite a challenge, as this is a large area (for comparison, Walthamstow Wetlands in London cover 210 hectares and Central Park in New York covers 341 hectares).
- Phasing interventions would allow to mobilize funds, as rehabilitation of 500 ha of wetlands is quite a large area to cover. The success of priority 1 actions would be strong incentives to attract businesses for the second and third phases.

7.1 DEFINITION OF SCENARIOS

The mapping of scenarios is defined according to the priorities previously detailed in the table for Variant 1 definition. The following maps are given hereafter.

The three types of actions define the various scenarios for Variant 1 that we propose:

- An optimum scenario: with all three actions.
- A short and medium-term alternative scenario with all actions 1 and 2.
- A priority scenario with short-term actions 1.

The next table shows the priority levels for each sector of the 5 wetlands and takes into account the collected comments from stakeholders.

7.1.1 Gikondo

Order of priorities for Gikondo follows the recommendations of stakeholders to prioritize upstream interventions in the area that starts from the flood prone areas (at the Southern branch). Some measures are therefore implemented as first priority upstream and third priority downstream.

TABLE 7-1 PRIORITIES FOR GIKONDO

Location	Comprehensive list of actions	Priority 1	Priority 2	Priority 3
	Southern branch			
G01	Action 1: Raising the water level in the outfalls or the river.	X		

Location	Comprehensive list of actions	Priority 1	Priority 2	Priority 3
G02	Action 2: Creation of overflows on the two concrete canals to ensure overflow of water into the wetland during rainfall (*destruction of canals*)	X		
	Action 3: Creation of buffer zones (filtering wetlands) at the right of the overflows to ensure the treatment of the polluted water before overflowing into the wetland and then the river.	X		
G03 G04 G05	Action 4: Removal of existing backfills.	X		
	Action 5: Blocking of surface drains (agriculture ditch) to limit the lowering of the groundwater and increase the residence time of the water in the wetland.	X		
	Action 6: Planting of native plant species adapted to the wetland environment (based on the plant species surveyed in the existing natural area in the center of the wetland).	X		
	Action 34: Installation of flow spreading structures made of gabions	Action not maintained, not part of Variant 1		
G06	Action 1: Raising the water level of the river in order to limit the lowering of the groundwater and to favour flooding of the river on the riparian areas.	X		
	Action 7: Re-profiling of the river with the creation of meanders and banks with different levels.	X		
	Action 8: Filling of the old minor bed of the watercourse.	X		
	Action 9: Planting the banks with native plant species according to the water level and their tolerance for wetness.	X		
	Action 20: Stream protection zone with a vegetated riparian buffer.	X		
G07	See common action for the Gikondo eco-valley (G21, G20, G19, G18, G07)	X		
Northern Branch				
G08	Action 11: Riprap at the outlet of urban discharges.		X	
	Action 12: Constructed wetland will act as buffer zones at urban discharges, sized for qualitative and quantitative water management (sizing according to the catchment area and water quality).		X	
	Action 13: Reprofiling of the hydraulic outlets from the discharges (creation of banks with different levels) and reconnection with the river.		X	
G9	Action 1: Raising the water level of the river in order to limit the lowering of the groundwater and to favour flooding of the river on the riparian areas.		X	
	Action 7: Re-profiling of the river with the creation of meanders and banks with different levels.		X	

Location	Comprehensive list of actions	Priority 1	Priority 2	Priority 3
	Action 8: Filling of the old minor bed of the watercourse.		X	
	Action 9: Planting the banks with local plant species according to the water level and tolerance to wetness.		X	
	Action 20: Stream protection zone with a vegetated riparian buffer.		X	
G10 G11 G12	Action 5: Blocking of surface drains (agriculture ditches) to limit the lowering of the groundwater and increase the residence time of the water in the wetland.		X	
	Action 6: Planting of native plant species adapted to the wetland environment (based on the plant species found in the existing natural area in the center of the wetland).		X	
	Action 34: Installation of flow spreading structures made of gabions	Action no maintained, not part of Variant 1		
G13 G14	Action 5: Blocking of surface drains		X	
	Action 14: Differentiated management according to natural habitats.		X	
Main branch				
G15	Action 1: Raising the water level of the river in order to limit the lowering of the groundwater and to favour the flooding of the river on the riparian plots.	X upstream		X downstream
	Action 7: Re-profiling of the Rugenge river with the creation of meanders and banks with different levels.	Action not maintained based on stakeholders' recommendation		
	Action 8: Filling of the old minor bed of the watercourse.	X upstream		X downstream
	Action 9: Planting the banks with local plant species according to the water level and tolerance to wetness.	X upstream		X downstream
	Action 15: Clearance over a large width to facilitate the overflow of the river during flood periods.	X		
	Action 20: Stream protection zone with a vegetated riparian buffer.	X upstream		X downstream
	Action 29: Creation of a lake in Gikondo	X		
	Action 34: Installation of flow spreading structures made of gabions.	Action no maintained, not part of Variant 1		
G16 G17	Action 11: Riprap at the outlet of urban discharges.	X upstream		X downstream

Location	Comprehensive list of actions	Priority 1	Priority 2	Priority 3
	Action 12: Constructed wetland will act as buffer zones at urban discharges, sized for qualitative and quantitative water management (sizing according to the catchment area and water quality).	X upstream		X downstream
	Action 13: Reprofiling of the hydraulic outlets from the discharges (creation of banks with different levels) and reconnection with the river.	X upstream		X downstream
G18 G19 G20 G21	Action 16: Ground levelling and vegetation to create an urban green space (recreational area) that can be flooded in times of high water.	X upstream		X downstream
	Action 10-G: Development of an Eco-valley	X upstream		X downstream

The following map show the priority level.

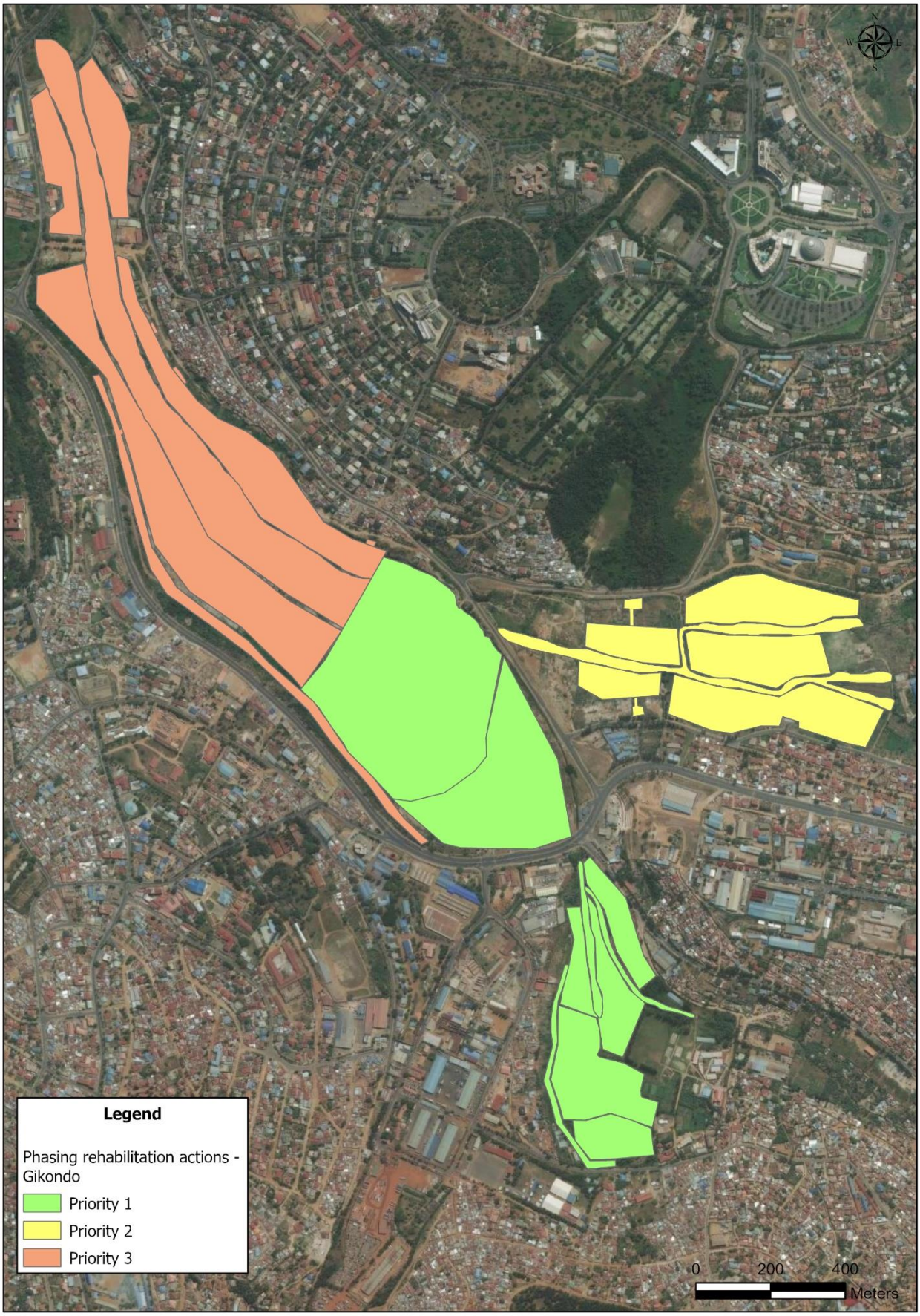


FIGURE 7-1 ACTIONS BY ORDER OF PRIORITIES IN GIKONDO

7.1.2 Rwampara

Rwampara priority is to implement action in the central part of the wetland, as this area hold the best potential for rehabilitation. In addition, stakeholders recommended to implement actions in priority in upstream areas.

TABLE 7-2 PRIORITIES FOR RWAMPARA

Sector	Comprehensive list of actions	Priority 1	Priority 2	Priority 3
Rw01*	Action 1: Raising the water level in the outfalls or the river.			X
	Action 7: On the downstream part of the area, reprofiling of the Rwampara River with the creation of meanders and banks with different levels.			X
	Action 8: Filling of the old minor bed of the watercourse.			X
	Action 9: Planting the banks with native plant species according to the water level and tolerance to wetness.			X
	Action 11: Riprap at the outlet of urban discharges.			X
	Action 12: Creation of buffer zones at urban discharges, sized for qualitative and quantitative water management (sizing according to the catchment area and water quality).			X
	Action 20: Stream protection zone with a vegetated riparian buffer.			X
Rw02	Action 1: Raising the water level in the outfalls or the river.	X		
	Action 2: Creation of overflows on the concrete canal to ensure overflow of water into the wetland during rainfall (*destruction of canal*).	X		
	Action 3: Creation of buffer zones at the right of the overflows to ensure the treatment of the water before overflowing into the wetland and then the river.	X		
Rw03 Rw04 Rw04 Rw05	Action 11: Riprap at the outlet of urban discharges.	X upstream	X downstream	
	Action 12: Constructed wetland will act as buffer zones at urban discharges, sized for qualitative and quantitative water management (sizing according to the catchment area and water quality).	X upstream	X downstream	
	Action 13 : Reprofiling of the hydraulic outlets from the discharges (creation of banks with different levels) and reconnection with the Rwampara River.	X upstream	X downstream	
Rw06	Action 5: Blocking of surface drains to limit the lowering of the groundwater and increase the residence time of the water in the wetland.	X along the River	X in other areas	

Sector	Comprehensive list of actions	Priority 1	Priority 2	Priority 3
	Action 6: Planting of local plant species adapted to the wetland environment.	X along the River	X in other areas	
	Action 7 : Reprofiling of the Rwampara River with the creation of meanders and banks with different levels.	X along the River	X in other areas	
	Action 8 : Filling of the old minor bed of the watercourse.	X along the River	X in other areas	
	Action 9 : Planting the banks with local plant species according to the water level.	X along the River	X in other areas	
	Action 18: Creation of a depression disconnected from the Rwampara river which will be fed by flood water and the groundwater.	X along the River	X in other areas	
	Action 19: Diversification of natural habitats typical of wetlands through the creation of a mosaic of depressions.	X along the River	X in other areas	
	Action 20: Stream protection zone with a vegetated riparian buffer.	X along the River	X in other areas	
	Action 30: Creation of a lake in Rwampara	Action not maintained, not part of Variant 1		
	Action 34: Installation of flow spreading structures made of gabions	Action no maintained, not part of Variant 1		
Rw06 See presentation sheets	Action 28: Creation of a circuit of pedestrian/cycling routes	X in downstream areas		X in upstream areas

***** During stakeholder consultations, it was required to provide more explanation on the reason why Rw01 is a challenge in terms of rehabilitation and why interventions in this area would be in third priority and limited to the downstream part of Rw01. The following paragraph provides additional explanations.

The upstream part of the Rwampara wetland presents a valley with a strongly incised cross-section. This incision is due to the nature and erosion of the soil. Indeed, the increasing urbanization/soiling of the watershed and the lack of stormwater management have strongly contributed to the current state of the wetland. The stream has a minor bed with a depth varying from two meters to more than ten meters.

This erosion has resulted in :

- Removal of the soil layer necessary to maintain/develop natural habitats typical of wetlands.
- Lowering the water table that accompanies the watercourse, causing the permanent drying up of the riparian plots.

Restoration actions would be possible, but these would incur huge restoration costs with an uncertain long-term success rate if no stormwater management measures are put in place upstream:

- If "ecological restoration" is the objective: filling of the incised valley with quality inputs, raising of the minor bed over a length of more than 1.5 kilometers and revegetation of the restored area.
- If the restoration objective is "civil engineering": installation of several hydraulic dams with heights of up to ten meters.

Considering the current state of this upstream part and the technical problems, the choice of the restoration was focused on the downstream zones of Rw01 where the economic investment and the environmental gains will be better controlled.

TABLE 7-3 PRIORITIES FOR RWAMPARA

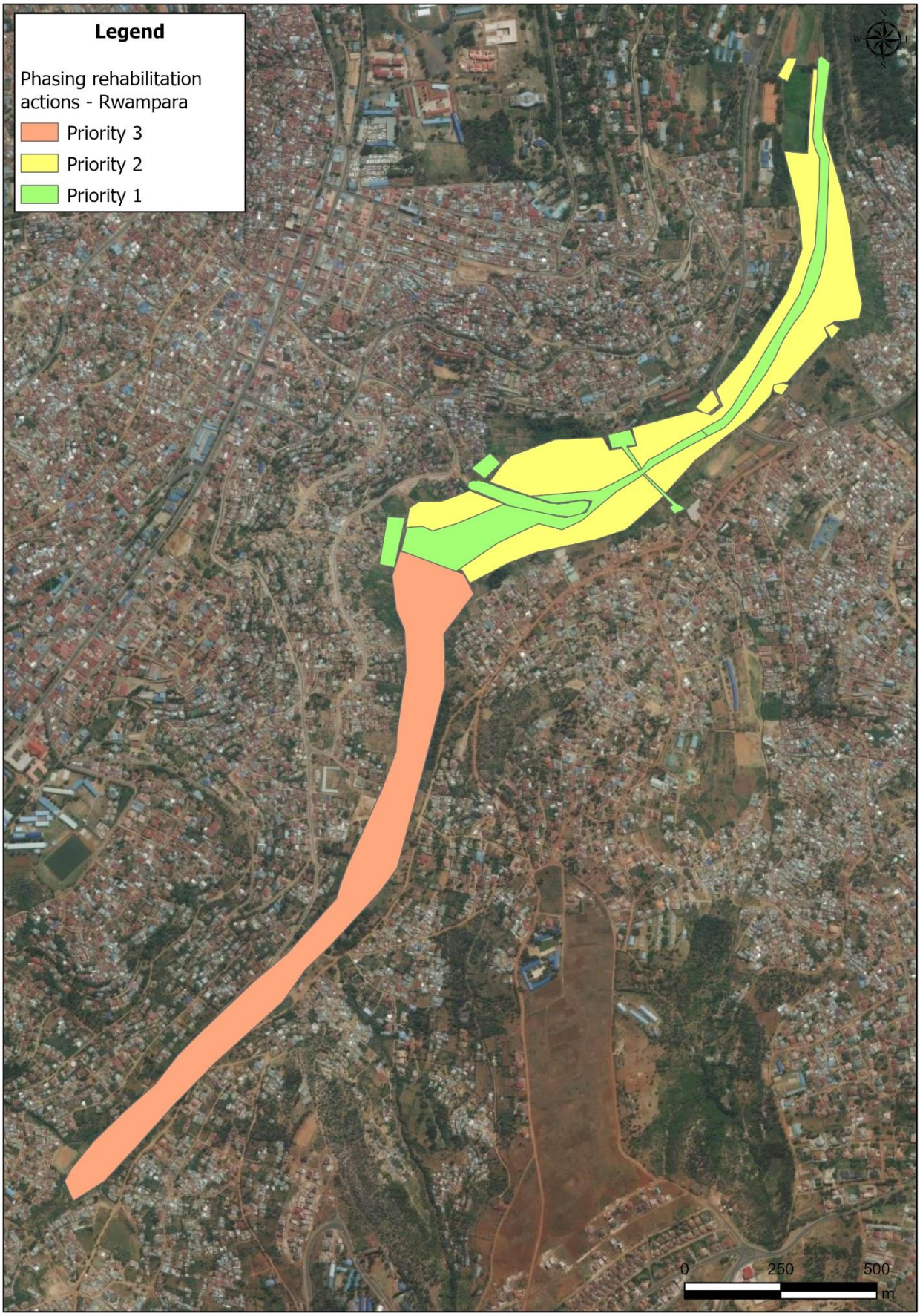


FIGURE 7-2 ACTION BY ORDER OF PRIORITIES IN RWAMPARA

7.1.3 Rugenge-Rwintare

Rugenge-Rwintare priority is to implement action in the upstream part of the wetland, as this area hold the best potential for rehabilitation. In addition, stakeholders recommended to implement actions in priority in upstream areas.

TABLE 7-4 PRIORITIES FOR RUGENGE-RWINTARE

Location	Comprehensive list of actions	Priority 1	Priority 2	Priority 3
Ru01	Action 11: Riprap at the outlet of urban discharges.		X	
	Action 12: Constructed wetland will act as buffer zones at urban discharges, sized for qualitative and quantitative water management (sizing according to the catchment area and water quality).		X	
	Action 13: Reprofiling of the hydraulic outlets from the discharges (creation of banks with different levels) and reconnection with the river.		X	
Ru02	Action 5: Blocking of surface drains to limit the lowering of the groundwater and increase the residence time of the water in the wetland.		X along the river	X in other areas
	Action 6: Planting of native plant species adapted to the wetland environment (based on the plant species found in the existing natural area in the center of the wetland).		X along the river	X in other areas
	Action 18: Creation of a depression disconnected from the river which will be fed by flood water and the groundwater.		X along the river	X in other areas
	Action 19: Diversification of natural habitats typical of wetlands through the creation of a mosaic of depressions.		X along the river	X in other areas
	Action 34: Installation of flow spreading structures made of gabions.	Action not maintained, not part of Variant 1		
Ru03	Action 5: Blocking of surface drains to limit the lowering of the groundwater and increase the residence time of the water in the wetland.	X		
	Action 7: Reprofiling of the river with the creation of meanders and banks with different levels.			
	Action 8: Filling of the old minor bed of the watercourse.	X		
	Action 9: Planting the banks with local plant species according to the water level.	X		
	Action 20: Stream protection zone with a vegetated riparian buffer.	X		
	Action 34: Installation of flow spreading structures made of gabions	Action not maintained, not part of Variant 1		
	Action 31: Creation of a lake in Rugenge-Rwintare (common to Ru03 and Ru04)	Action not maintained, not part of Variant 1		

Location	Comprehensive list of actions	Priority 1	Priority 2	Priority 3
Ru04	Action 5: Blocking of surface drains to limit the lowering of the groundwater and increase the residence time of the water in the wetland.		X	
	Action 7: Reprofiling of the river with the creation of meanders and banks with different levels.		X	
	Action 8: Filling of the old minor bed of the watercourse.		X	
	Action 9: Planting the banks with local plant species according to the water level.		X	
	Action 20: Stream protection zone with a vegetated riparian buffer.		X	
	Action 34: Installation of flow spreading structures made of gabions	Action not maintained, not part of Variant 1		
Ru05	Action 1: Raising the water level in the outfalls or the river.	X		
	Action 7: Reprofiling of the river with the creation of meanders and banks with different levels.	X		
	Action 8: Filling of the old minor bed of the watercourse.	X		
	Action 9: Planting the banks with local plant species according to the water level (based on the plant species found in the existing natural area in the center of the wetland at Ru04).	X		
Ru06	Action 11: Riprap at the outlet of urban discharges.	X		
	Action 12: Constructed wetland will act as buffer zones at urban discharges, sized for qualitative and quantitative water management (sizing according to the catchment area and water quality).	X		
	Action 13: Reprofiling of the hydraulic outlets from the discharges (creation of banks with different levels) and reconnection with the river.	X		
Ru07	Action 5: Blocking of surface drains to limit the lowering of the groundwater and increase the residence time of the water in the wetland.	X		
	Action 6: Planting of local plant species adapted to the wetland environment (based on the plant species found in the existing natural area in the center of the wetland).	X		
	Action 21: Natural weirs in cascade to limit floods (located at urban drains).	X		
	Action 34: Installation of flow spreading structures made of gabions	Action not maintained, not part of Variant 1		
See presentation sheets	Action 28: Creation of a circuit of pedestrian/cycling routes	X upstream		X downstream

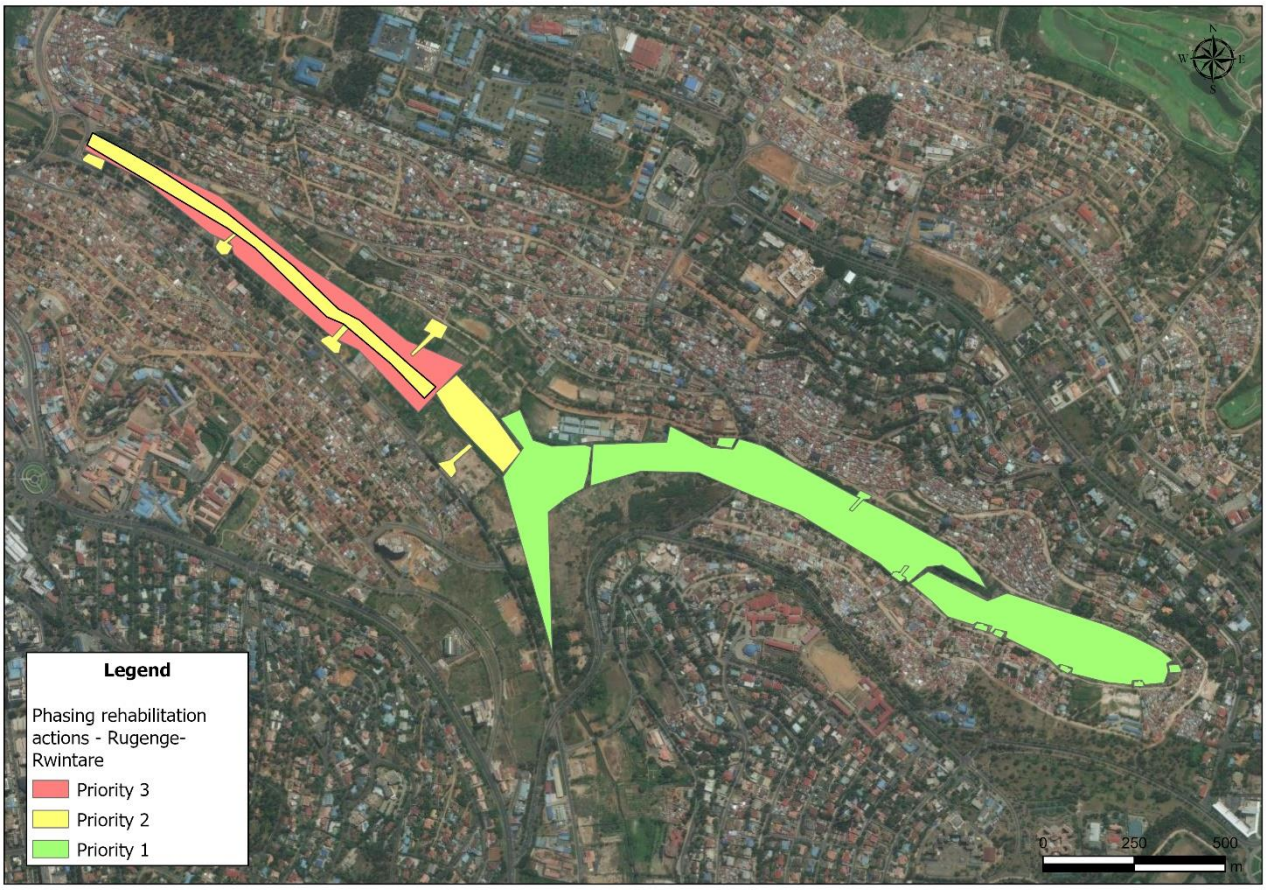


FIGURE 7-3 ACTIONS BY ORDER OF PRIORITIES IN RUGENGE-RWINTARE

7.1.4 Kibumba

The central part of the wetland will be included in priority 1 as this area holds good potential for rehabilitation.

TABLE 7-5 PRIORITIES FOR KIBUMBA

Location	Comprehensive list of actions	Priority 1	Priority 2	Priority 3
K01	Action 5: Blocking of surface drains to limit the lowering of the groundwater and increase the residence time of the water in the wetland.		X along the river	X in other areas
	Action 6: Planting of native plant species adapted to the wetland environment (based on the plant species found in the existing natural area in the southeast of the wetland).		X along the river	X in other areas
	Action 18: Creation of a depression disconnected from the river which will be fed by flood water and the groundwater.		X along the river	X in other areas
	Action 19: Diversification of natural habitats typical of wetlands through the creation of a mosaic of depressions.		X along the river	X in other areas
	Action 34: Installation of flow spreading structures made of gabions	Action not maintained, not part of Variant 1		

Location	Comprehensive list of actions	Priority 1	Priority 2	Priority 3
K02	Action 22: Modify the banks of aquaculture ponds by creating levels according to the water level.	X		
	Action 23: Diversification of natural habitats to make these water bodies more ecologically attractive.	X		
K03	Action 1: Raising the water level in the outfalls or the river.	X along the river	X in other areas	
	Action 5: Blocking of surface drains to limit the lowering of the groundwater and increase the residence time of the water in the wetland.	X along the river	X in other areas	
	Action 6: Planting of local plant species adapted to the wetland environment (based on the plant species found in the existing natural area in the southeast of the wetland).	X along the river	X in other areas	
	Action 7: Reprofiling of the Rugenge River with the creation of meanders and banks with different levels.	Not maintained at this location and replaced by Action 15		
	Action 8: Filling of the old minor bed of the watercourse.	X along the river	X in other areas	
	Action 9: Planting the banks with native plant species according to the water level and tolerance to wetness.	X along the river	X in other areas	
	Action 15: Clearance over a large width to facilitate the overflow of the river during flood periods is covering all the main branch	X along the river	X in other areas	
	Action 20: Stream protection zone with a vegetated riparian buffer.	X along the river	X in other areas	
	Action 32: Creation of a lake in Kibumba	Action not maintained, not part of Variant 1		
	Action 34: Installation of flow spreading structures made of gabions	Action not maintained, not part of Variant 1		
K04	Action 5: Blocking of surface drains to limit the lowering of the groundwater and increase the residence time of the water in the wetland.			X
	Action 6: Planting of native plant species adapted to the wetland environment (based on the plant species found in the existing natural area in the center of the wetland).			X
	Action 21: Natural weirs in cascade to limit floods.			X
	Action 34: Installation of flow spreading structures made of gabions	Action not maintained, not part of Variant 1		
K05	Action 5: Blocking of surface drains.	X		
	Action 14: Differentiated management according to natural habitats.	X		

Location	Comprehensive list of actions	Priority 1	Priority 2	Priority 3
	Action 24: Protection and conservation of typical wetland habitats.	X		
K06	Action 6: Planting of native plant species adapted to the wetland environment (based on the plant species found in the existing natural area in the southeast of the wetland).	X		
	Action 7: Reprofiling of the river with the creation of meanders and banks with different levels.	X		
	Action 8: Filling of the old minor bed of the watercourse.	X		
	Action 9: Planting the banks with local plant species according to the water level.	X		
	Action 20: Stream protection zone with a vegetated riparian buffer.	X		
	Action 25: Diversion of the river into the original flow (thalweg bottom) with potential to upgrade the existing wetland (with good potential), restoring and meandering the old channel to create a small delta).	X		
	Action 34: Installation of flow spreading structures made of gabions.	Action not maintained, not part of Variant 1		
K07	Action 5: Blocking of surface drains to limit the lowering of the groundwater and increase the residence time of the water in the wetland.	X		
	Action 6: Planting of local plant species adapted to the wetland environment (based on the plant species found in the existing natural area in the southeast of the wetland).	X		
	Action 7: Reprofiling of the river with the creation of meanders and banks with different levels.	X		
	Action 8: Filling of the old minor bed of the watercourse.	X		
	Action 9: Planting the banks with local plant species according to the water level.	X		
	Action 20: Stream protection zone with a vegetated riparian buffer.	X		
	Action 25: Diversion of the river into its original flow (thalweg bottom) with potential to upgrade the existing wetland (with good potential), restoring and meandering the old channel to create a small delta.	X		
	Action 34: Installation of flow spreading structures made of gabions.	Action not maintained, not part of Variant 1		
K08	Action 11: Riprap at the outlet of urban discharges.	X		
	Action 12: Constructed wetland will act as buffer zones at urban discharges, sized for qualitative and	X		

Location	Comprehensive list of actions	Priority 1	Priority 2	Priority 3
	quantitative water management (sizing according to the catchment area and water quality).			
	Action 13: Reprofiling of the hydraulic outlets from the discharges (creation of banks with different levels) and reconnection with the river.	X		
K09	Action 11: Riprap at the outlet of urban discharges.	X for areas close to K03 and K07		X for the area close to K04
	Action 12: Constructed wetland will act as buffer zones at urban discharges, sized for qualitative and quantitative water management (sizing according to the catchment area and water quality).	X for areas close to K03 and K07		X for the area close to K04
	Action 13: Reprofiling of the hydraulic outlets from the discharges (creation of banks with different levels) and reconnection with the river.	X for areas close to K03 and K07		X for the area close to K04
See presentation sheets	Action 28: Creation of a circuit of pedestrian/cycling routes	X except for the downstream part and northern branch		X for the downstream part and northern branch

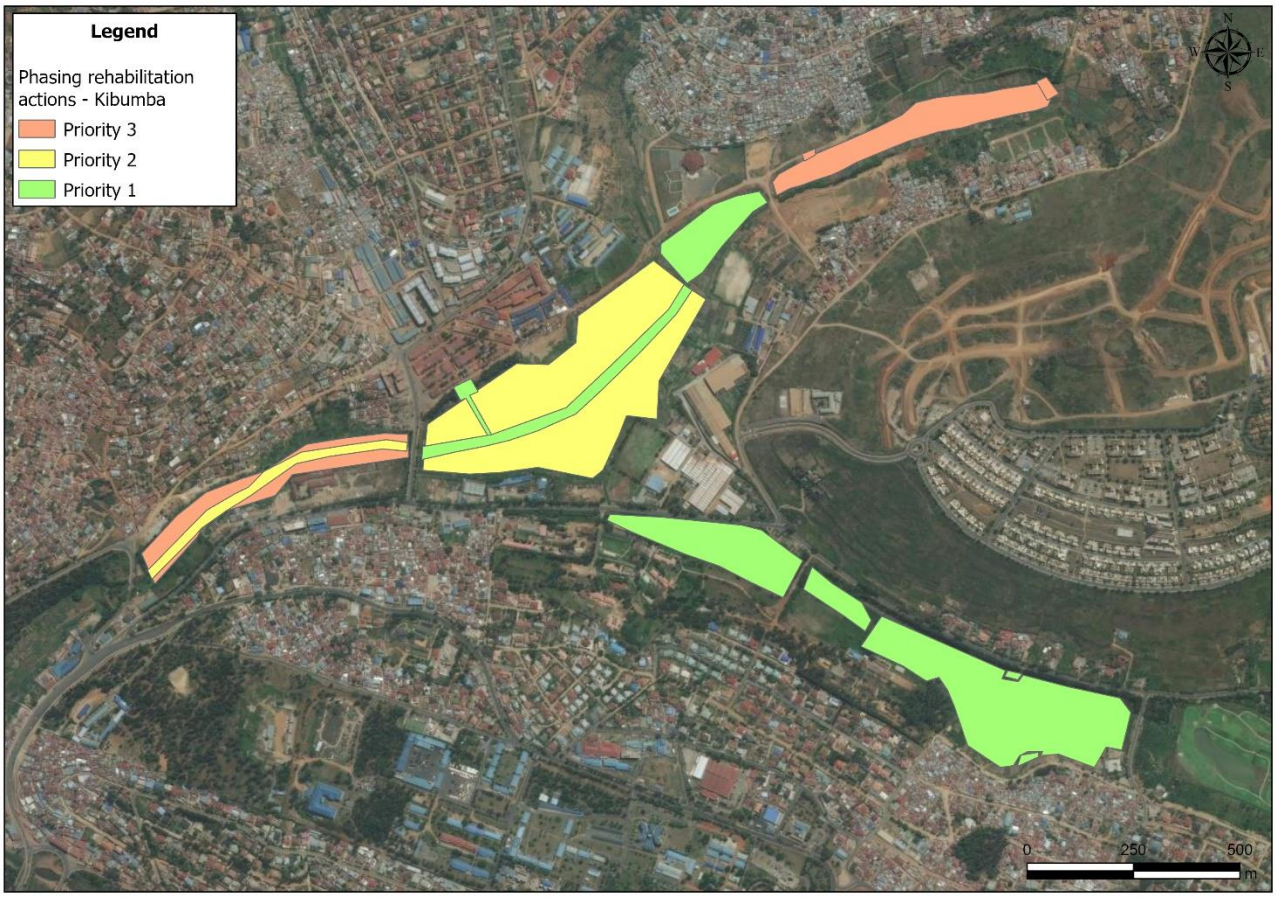


FIGURE 7-4 ACTIONS BY ORDER OF PRIORITIES IN KIBUMBA

7.1.5 Nyabugogo Lower

The upstream parts of the wetland are in priority while downstream areas are in second and third priority.

Location	Comprehensive list of actions	Priority 1	Priority 2	Priority 3
N01 N02 N03	Action 11: Riprap at the outlet of urban discharges.	**X**		
	Action 12: Constructed wetland will act as buffer zones at urban discharges, sized for qualitative and quantitative water management (sizing according to the catchment area and water quality).	X		
	Action 13: Reprofiling of the hydraulic outlets from the discharges (creation of banks with different levels) and reconnection with the Nyabugogo River and its natural channels.	X		
N04	Action 1: Raising the water level of the river in order to limit the lowering of the groundwater and to favour the flooding of the river on the riparian plots.	X		
	Action 7: Reprofiling of the Nyabugogo River with the creation of meanders and banks with different levels.	X		
	Action 8: Filling of the old minor bed of the watercourse.	X		
	Action 9: Planting the banks with native plant species according to the water level and tolerance to wetness.	X		
	Action 20: Stream protection zone with a vegetated riparian buffer.	X		
	Action 26: Creation of a delta before the confluence of the Nyabugogo River and its right bank tributary (Rwenzagoro River).			X
	Action 33: Creation of a lake in Nyabugogo	Action not maintained, not part of Variant 1		
	Action 34: Installation of flow spreading structures made of gabions.	Action not maintained, not part of Variant 1		
	Action 27: Management to limit the expansion of water hyacinth and increase of the size of the existing lake.	X		
N05	Action 10-N: Development of Nyabugogo Wetland Centre.	X		
N06	Action 5: Blocking of surface drains (agriculture ditches) to limit the lowering of the groundwater and increase the residence time of the water in the wetland.		X	
	Action 6: Planting of local plant species adapted to the wetland environment (based on the plant species found in the existing natural area in the center of the wetland Papyrus).		X	
	Action 18: Creation of a depression disconnected from the river which will be fed by flood water and the groundwater.		X	
	Action 19: Diversification of natural habitats typical of wetlands through the creation of a mosaic of depressions.		X	

Location	Comprehensive list of actions	Priority 1	Priority 2	Priority 3
	Action 34: Installation of flow spreading structures made of gabions.	Action not maintained, not part of Variant 1		
N07	Action 5: Blocking of surface drains to limit the lowering of the groundwater and increase the residence time of the water in the wetland.	X along the river	X in other areas	
	Action 6: Planting of native plant species adapted to the wetland environment (based on the plant species found in the existing natural area in the center of the wetland such as Papyrus).	X along the river	X in other areas	
	Action 15: Clearance over a large along the river width to facilitate the overflow of the river during flood periods.	X		
	Action 34: Installation of flow spreading structures made of gabions.	Action not maintained, not part of Variant 1		
N08 N09	Action 5: Blocking of surface drains (if any).	X		
	Action 14: Differentiated management according to natural habitats.	X		
	Action 24: Protection and conservation of typical wetland habitats.	X		
N11	Action 28: Creation of a circuit of pedestrian/cycling routes	X		

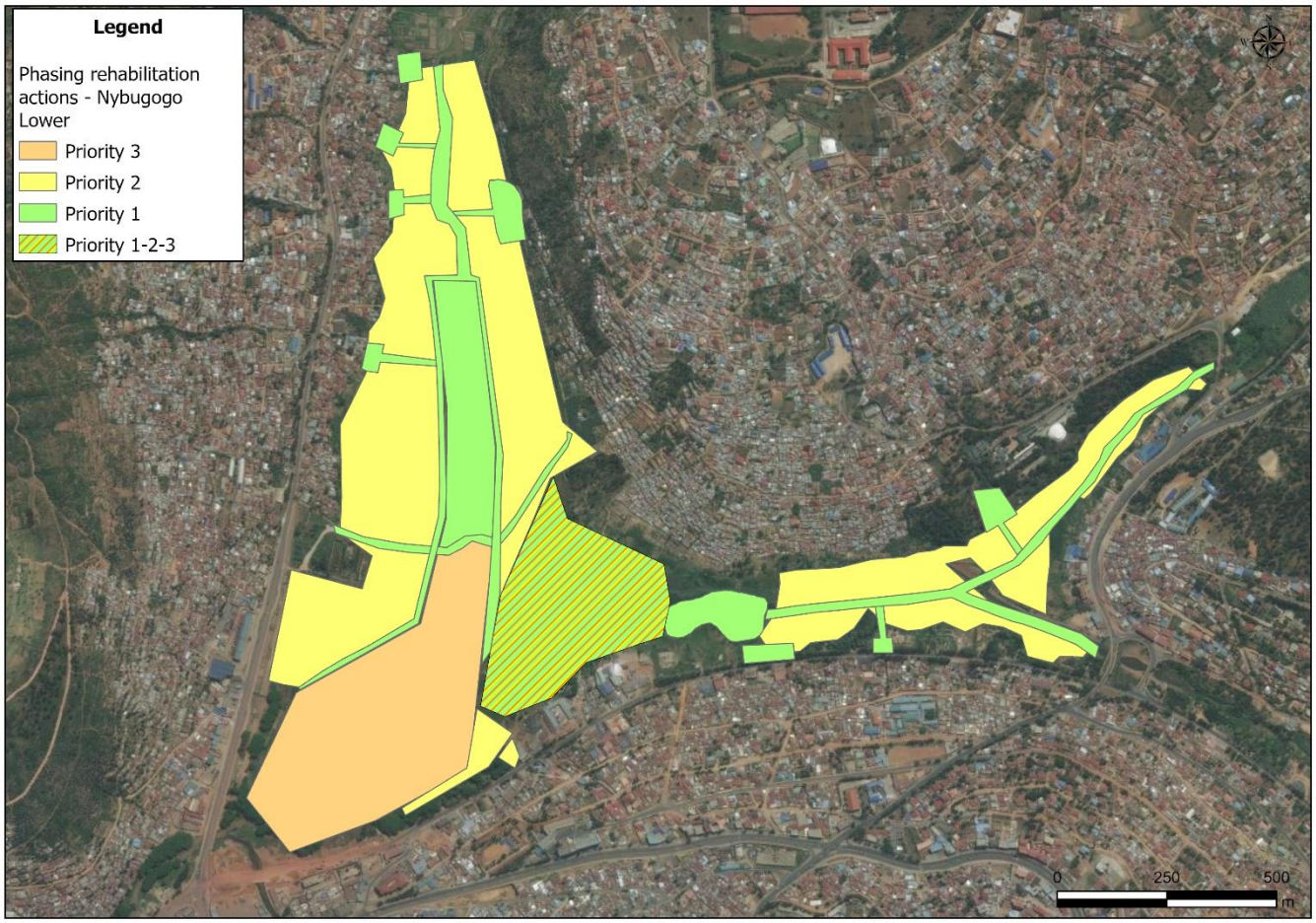


FIGURE 7-5 ACTIONS BY ORDER OF PRIORITIES IN NYABUGOGO LOWER

8. PRELIMINARY PROPOSED REHABILITATION DESIGN OF PREFERRED OPTIONS

The preferred option is the **Priority scenario under Variant 1**.

This chapter develops preliminary designs for the **priority 1 actions** sufficiently for preliminary costing and cost benefit analyses.

8.1 GENERAL APPROACH

8.1.1 Objectives and priority definition

The objective of this chapter is to summarize and detail all the actions that will enable the scenarios described to be implemented.

As a reminder, scenarios have been defined taking into account the degree of priority of the actions to be implemented.

- Baseline scenarios: no action is required; it is the no-go scenario.
- Optimum scenarios: all the action with priorities 1, 2 and 3
- Alternative scenario: actions with priorities 1 and 2 only
- Priority scenario: actions with priority 1 only

The comparison of the scenarios is well described in the previous chapters.

The general approach is to define realistic degrees of priority according to the development constraints identified, in particular the presence of agriculture, and the actual development potential of the various sectors.

8.1.2 Cost estimate

The costs have been estimated taking into account:

- current ratios observed for traditional civil engineering works (earthworks, backfill, aggregate inputs, concreting, etc.)
- cost estimates for similar projects in other countries for vegetation-based actions
- similar developments for recreational areas

It is important to mention that following items are included in our cost estimate:

- necessity to divert / rebuilt the existing pipes
- demolition of old foundations and presence of blocks
- maintenance costs during 10 years (including dredging of sediment)
- monitoring of action implementation

Details of costs will be provided in the Detailed Design.

8.1.3 Action sheets

To allow the actors to perceive the stakes and the characteristics of the works to be built and the plant arrangements to be set up, the preliminary design are presented in the form of action sheets which summarize all the information necessary for the detailed studies to be carried out during the next steps of the project.

Actions sheets were defined for each type of action and for each wetland, with the following information:

- Type of action
- Action target: whether flood control, biodiversity enhancement, water filtration or recreational and landscape.
- Precise location of the action
- Technical characteristics and descriptive plan
- Justification of the interest of the action and possible associated actions
- Summary estimate of costs and degrees of priority

8.2 PRELIMINARY DESIGNS FOR EACH WETLAND

8.2.1 Gikondo

8.2.1.1 Priorities

The following figure shows the actions by order of priority.

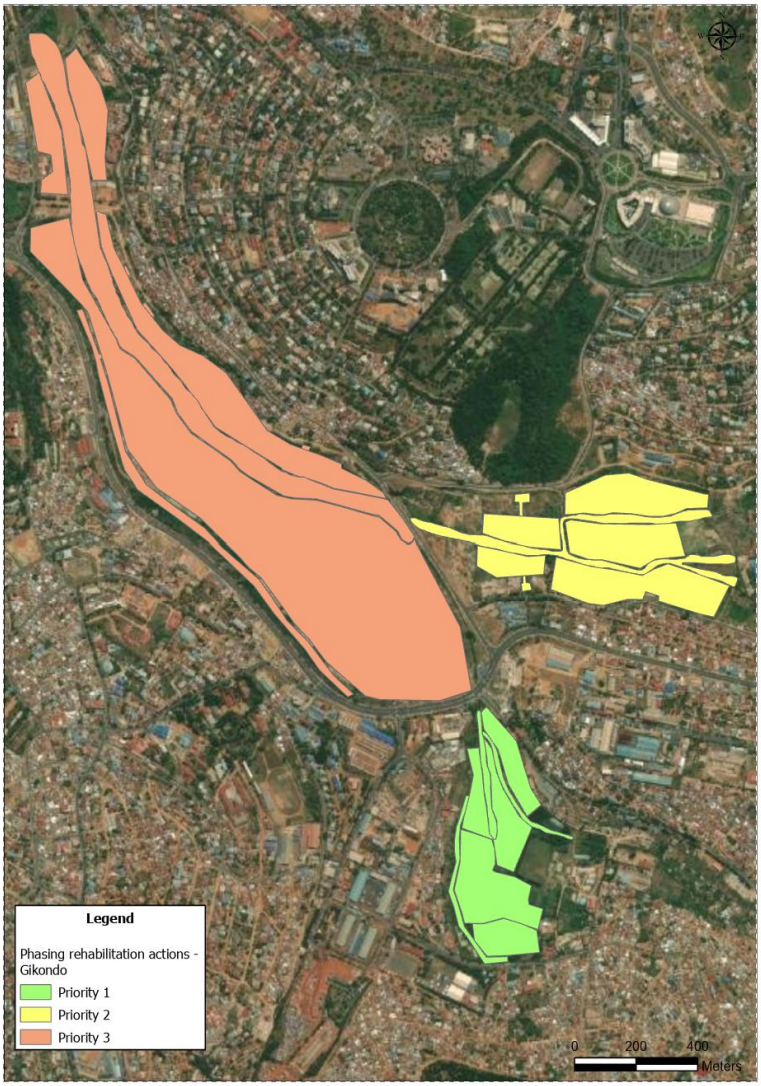


FIGURE 8-1 GIKONDO-ACTIONS BY ORDER OF PRIORITY

Gikondo is considered as a strategic wetland for creation of a touristic zone in the downstream part of the wetland (the main branch) – see the landscape sheet for “Gikondo Eco Valley”. The landscaping will be broken down into 3 distinct levels of priority for this area and will only concern pedestrian / cycling circuits for the 2 upstream sectors of the wetlands (southern branch and northern branch).

It is logical to consider that developments linked to the watercourse and biodiversity (reprofiling, recharge, plantations) should be carried out as a priority for this central area (the main branch), simultaneously with landscaping. In addition, based on outcomes of stakeholder workshops, the Southern branch (upstream area) is also treated as a first level priority, especially for its role in flood mitigation.

The eastern branch is defined as priority 2.

8.2.1.2 Action sheets

The action sheets for the wetland are presented at appendix 5.

8.2.2 Rwampara

8.2.2.1 Priorities

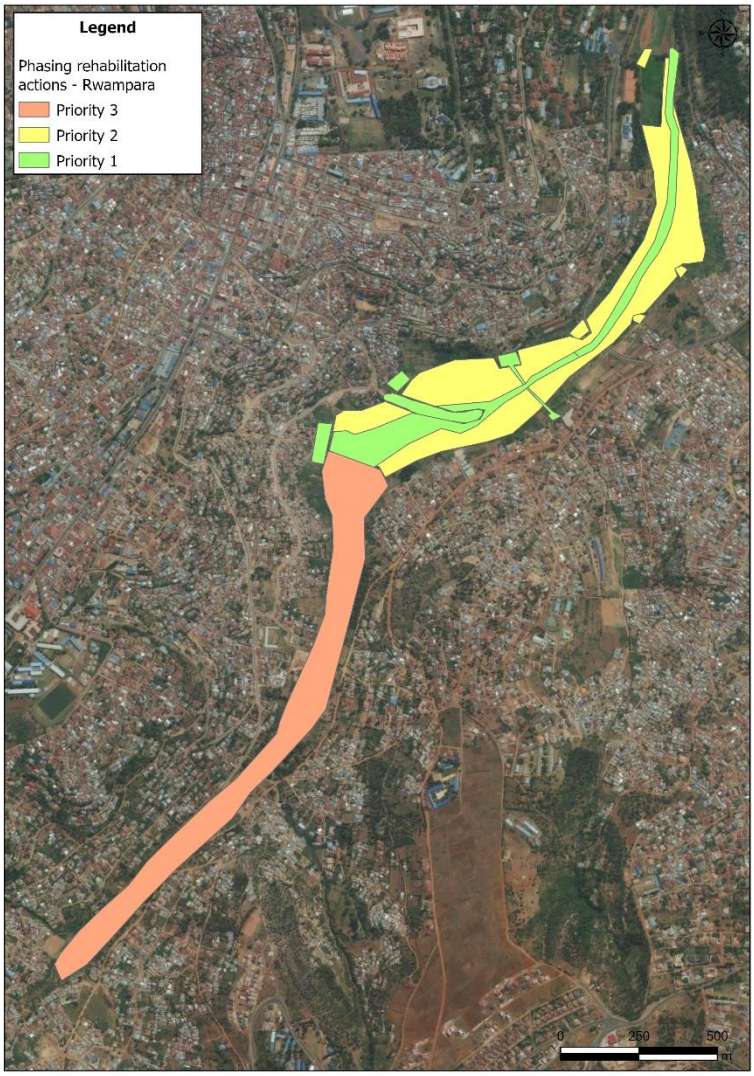


FIGURE 8-2 RWAMPARA-ACTIONS BY ORDER OF PRIORITY

The upstream sector of Rwampara presents very important erosions which make the developments very difficult and less relevant than for the rest of the sectors. Priority 3 has been maintained in this sector.

The central zone presents more important hydraulic opportunities (recharge, weirs) which could be carried out in the short term.

Finally, the downstream area presents a classic configuration for which the buffer zones around the river can be carried out in priority 1 together with the drains to be connected, while the peripheral zones will have to be carried out in priority 2.

Recreational activities are divided in 3 priorities according to the description given into the specific drawing but will only concern the central part of the wetland.

8.2.2.2 Action sheets

The action sheets for the wetland are presented at appendix 5.

8.2.3 Rugenge-Rwintare

8.2.3.1 Priorities

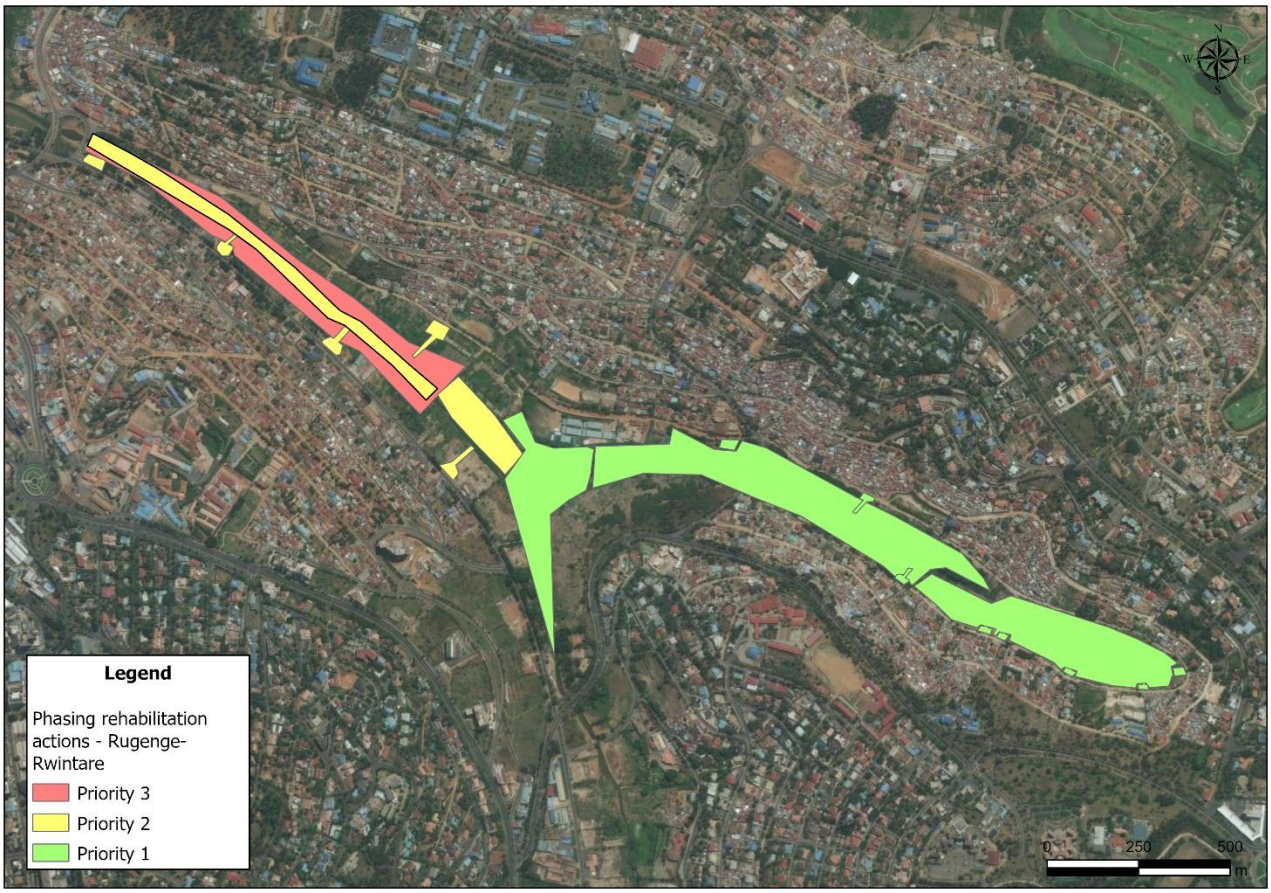


FIGURE 8-3 RUGENGE-RWINTARE-ACTIONS BY ORDER OF PRIORITY

The upstream part of Rugenge-Rwintare presents important development constraints due to the presence of agriculture. However, based on outcomes from the stakeholder workshops, it was decided to move to first priority.

For the central part (Ru04), the development possibilities are relevant, and the the works can be done in the medium term (priority 2).

Finally, the downstream area presents a classic configuration for which the buffer zones around the river can be carried out in priority 2 together with the drains to be connected, while the peripheral zones will have to be carried out in priority 3.

Recreational activities are concerning main infrastructure divided in 3 priorities according to the description given into the specific landscape sheet, with some infrastructure to be constructed in a second time for the east part of the wetland.

8.2.3.2 Action sheets

The action sheets for the wetland are presented at appendix 5.

8.2.4 Kibumba

8.2.4.1 Priorities

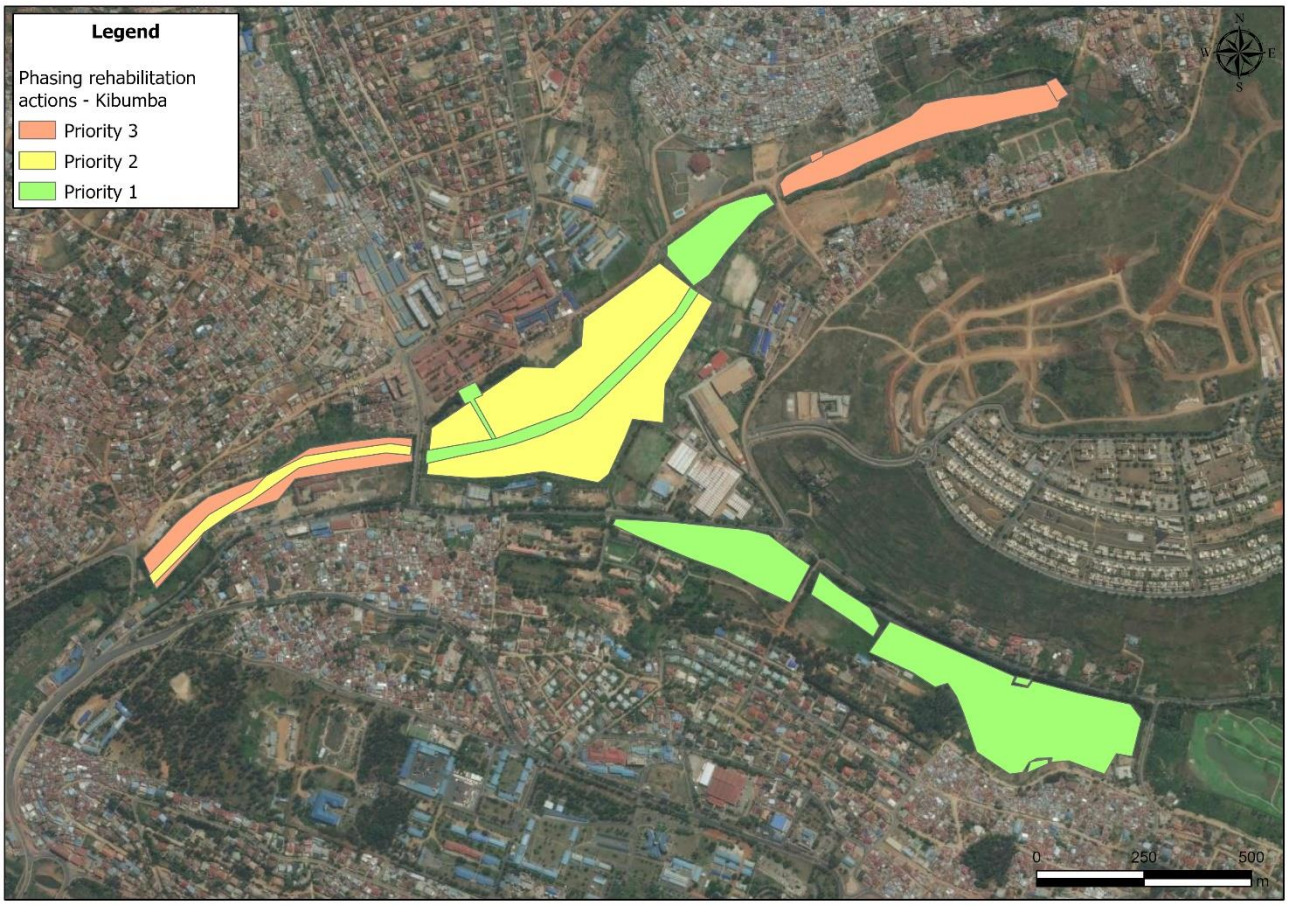


FIGURE 8-4 KIBUMBA-ACTIONS BY ORDER OF PRIORITY

The south-western sector of Kibumba is one of the sectors with the greatest opportunity for enhancement of the city (being close to the golf course and the new residential development Vision 2000), both hydraulically and ecologically, and is defined as priority 1. The central part represents interesting potential to develop a large wetland and was identified as a first priority by stakeholders during the workshops.

The northern sector has been given priority 3 in line with the existing occupation constraints. The downstream part does not present any major interest, the priority is level 2 around the river and 3 in peripheral zones.

Landscape infrastructure is mainly present in the south-eastern and central sectors as described in detail in the landscape sheet.

8.2.4.2 Action sheets

The action sheets for the wetland are presented at appendix 5.

8.2.5 Nyabugogo Lower

8.2.5.1 Priorities

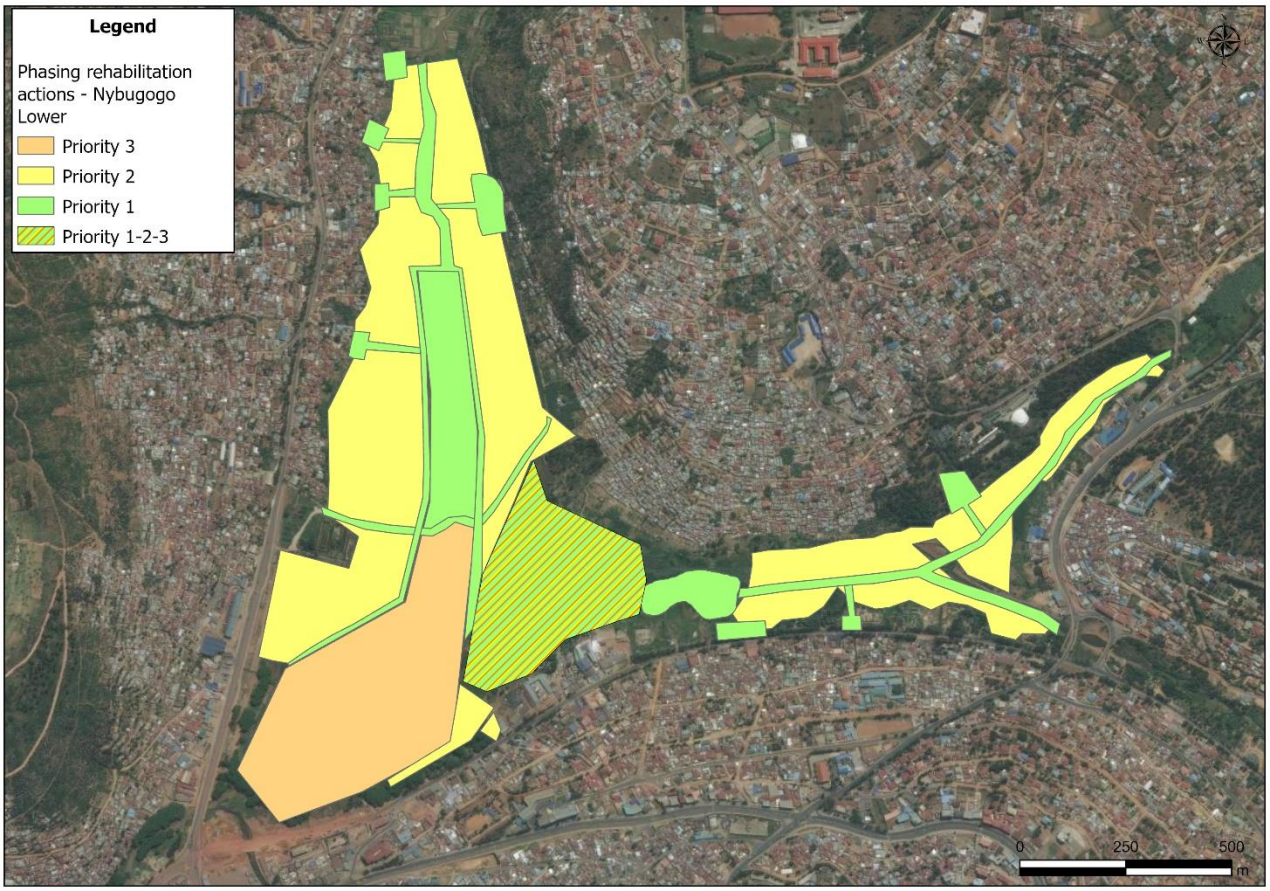


FIGURE 8-5 NYABUGOGO-ACTIONS BY ORDER OF PRIORITY

The central part of the wetland is of major interest in terms of landscaping for the tourism development of the area (around the existing pond). These developments are divided into 3 priorities as described in the dedicated drawings. It has been decided to develop this central area hydraulically (re-meddling) and ecologically (protection and differentiated management of the habitat) – priority 1.

Concerning the upstream area (eastern part), it was decided to consider as priority 1 only the developments related to the establishment of a buffer zone on both sides of the river and the connection form the drains, the rest of the sector being given priority 2 in relation to the existing constraints.

The other area (western sector) is of lesser value for development and has many occupancy constraints, particularly related to agriculture. The centre of the area and the development of the drains has been defined as priority 1, the rest being left as priority 2. The downstream area, the inland delta will be implemented as a third priority.

Landscape infrastructure is mainly present in the south-eastern and central sectors as described in detail in the landscape sheet – consistent with the priority defined.

8.2.5.2 Action sheets

The action sheets for the wetland are presented at appendix 5.

8.3 COST ESTIMATE SUMMARY

The following table summarizes the costs for each category of action. These are adapted to local costs and were adjusted based on return of experience from the Nyandungu wetland restoration activities (in the City of Kigali).

		Cost to build the scenario (including 10 years maintenance)	Cost to operate and maintain (per year after 10 years)
Gikondo	priority 1	2,450,250 USD	29,564 USD
	priority 2	2,426,936 USD	21,202 USD
	priority 3	3,222,990 USD	42,827 USD
	TOTAL	**8,100,176 USD**	**93,594 USD**
Kibumba	priority 1	3,516,988 USD	39,351 USD
	priority 2	1,761,328 USD	29,957 USD
	priority 3	1,250,190 USD	29,144 USD
	TOTAL	**6,528,506 USD**	**98,451 USD**
Rugenge	priority 1	2,603,205 USD	44,929 USD
	priority 2	1,057,723 USD	12,726 USD
	priority 3	939,724 USD	13,522 USD
	TOTAL	**4,600,652 USD**	**71,177 USD**
Rwampara	priority 1	3,865,645 USD	56,432 USD
	priority 2	2,848,472 USD	42,863 USD
	priority 3	4,365,968 USD	61,947 USD
	TOTAL	**11,080,085 USD**	**161,242 USD**
Nyabugogo	priority 1	5,757,092 USD	81,522 USD
	priority 2	4,662,714 USD	64,437 USD
	priority 3	2,557,676 USD	25,920 USD
	TOTAL	**12,977,483 USD**	**171,880 USD**

TOTAL	**45 381 000 USD**
Total for priority 1	18 646 000 USD
Total for priority 2	12 757 000 USD
Total for priority 3	13 978 000 USD

9. CONCLUSION AND WAY FORWARD

This report has allowed to collect primary data to developed rehabilitation scenarios. These data covered botanical surveys, extensive stakeholder engagement activities and flood and flow models.

This report recommends implementing the first variant, as it offers more balanced performances and meets all rehabilitation objectives. Variants 2 and 3 both have important shortcomings. However, stakeholders recommended to develop a lake (a large pond) in Gikondo, therefore this measure will be implemented in this wetland.

Three scenarios were developed for Variant 1, each are presenting a set of restoration treatment prescriptions categorized by order of priorities. These actions are as follow:

- Priority 1 actions: these are short term action to be implemented by 2025. They represent the most urgent actions to allow the wetlands to be partially rehabilitated while maintaining some agriculture.
- Priority 2 actions: these are the medium-term action to be implemented by 2035. They represent the second most urgent actions to allow the wetlands to be partially rehabilitated while maintaining some agriculture.
- Priority 3 actions: these are the long-term actions to be implemented by 2050. They represent the least urgent rehabilitation activities and consider that all agriculture stops in the wetland.

The optimum scenario, which covers all actions, shows very high performance to mitigate floods, to filter pollutants in water, offer interesting recreational activities and enhances landscape of the city while ensuring maximum benefits for biodiversity conservation. This optimum scenario is however expensive since it covers 500 ha of the wetland. Two other scenarios were developed: one alternative scenario that includes the first and second levels of actions and a priority scenario that includes the first level of actions. The alternative scenario maintains good performances for flood mitigation, water filtration, offers interesting recreational activities and enhances landscape of the city while improving biodiversity conservation. However, this alternative scenario is still very expensive as it modifies most of the wetlands and will require important O&M costs. The priority scenario is less expensive and aims at selected areas in the wetlands where priority actions are needed in the short-term. **This report recommends this scenario to be implemented and studied in the Detailed design.**

Although this priority scenario does not cover all surfaces of the wetland, it allows to phase actions in the wetlands in the future as second level actions and third level actions could be latter implemented when funds are available. The priority scenario is therefore a more realistic approach to wetland rehabilitation as it allows actions to be implemented step by step until the optimum scenario is completed in 2050.

Other baseline studies will be undertaken by the consultant to fine-tune the preferred scenario during the Detailed design.

Other baseline activities will be undertaken at selected locations to initiate the Detailed design of the preferred scenario:

- Soil sampling: investigations to know the permeability of soils at the level of each sector where depressions and buffer basins will be created.
- Geotechnical investigations to determine the load-bearing capacity of the soil. Exploratory boreholes and trial pits for soil sampling and testing for engineering properties will be done for interventions requiring foundations. The Consultant has considered, for each wetland, the following investigations to be fine-tuned once interventions are defined:
  - Standard Penetration Test (SPT) at a depth of 25m,
  - Excavation test pits at a depth of 5m,
  - Laboratory testing on disturbed and undisturbed samples
- Identification of soil texture and its hydromorphy at the level of each sector where depressions and buffer basins will be created.
- Implementation of piezometric trackings in each area where drains (agriculture ditches) will be blocked.
- Sediment / soil quality analysis in main area where meanders, depressions and buffer basins will be created (in all areas where soil excavation will take place). Soil contamination will be done in areas where the Study will propose excavation work (as excavation represent a risk of mobilization of contaminants).

- Surface water quality analysis at main discharge of drains where it is intended to create filtering wetlands.

Comprehensive utility services search in conjunction with city officials may be necessary to map all known services crossing or around the perimeter of the wetlands that may be impacted by construction activities or the long-term operation of the wetland. Water pipes were already identified with WASAC, but other utility services may be present (electric lines, boreholes, etc.).

The following maps provide the location of the sampling campaign for physical parameters that will be undertaken during the Detailed design.

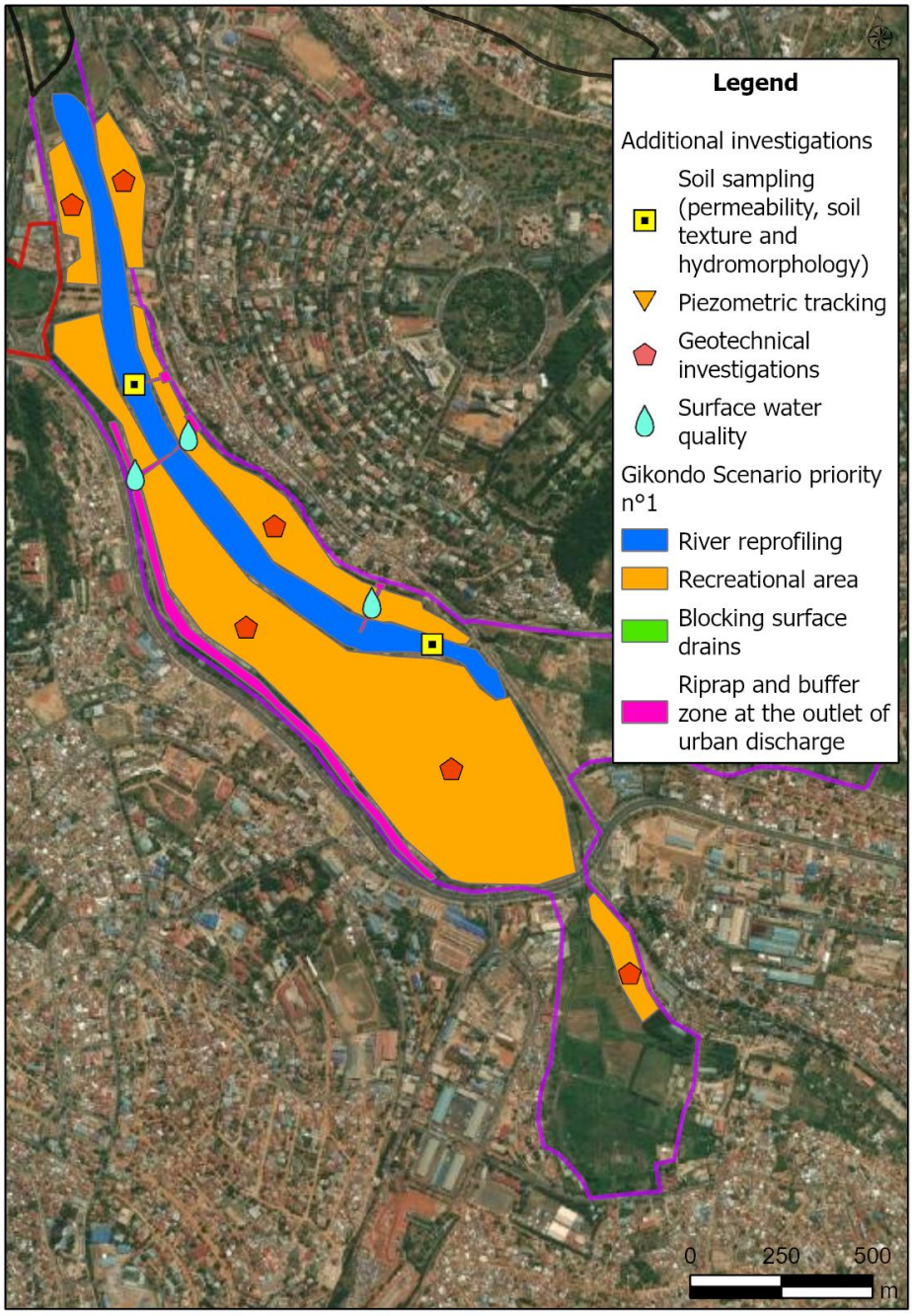


FIGURE 9-1 PROPOSED SAMPLING CAMPAIGN AT GIKONDO

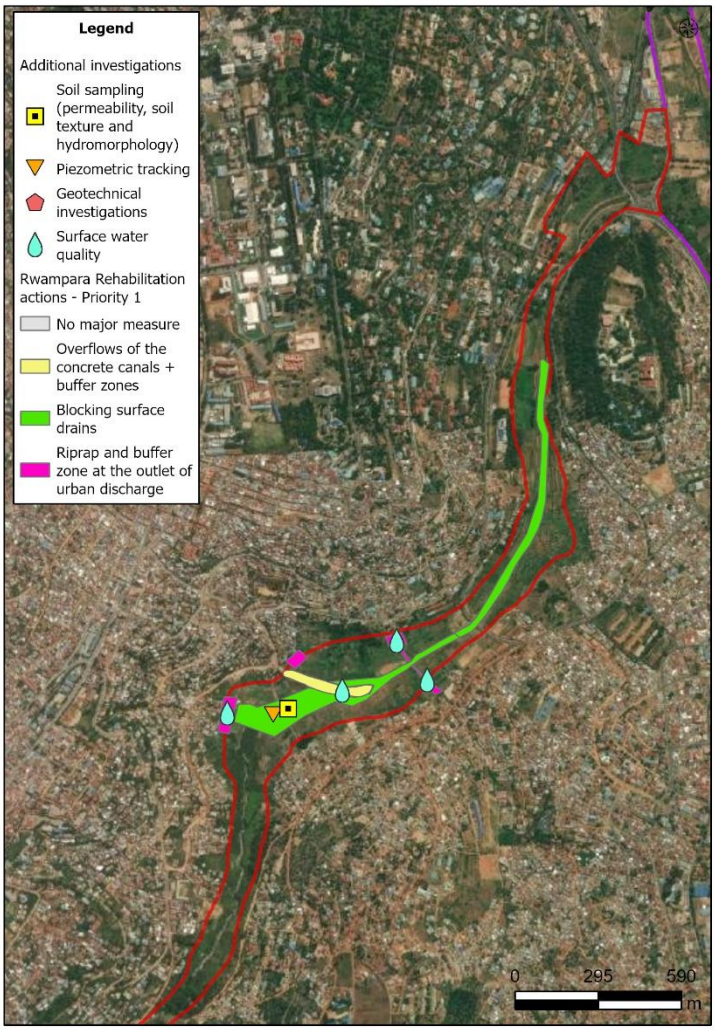


FIGURE 9-2 PROPOSED SAMPLING CAMPAIGN AT RWAMPARA

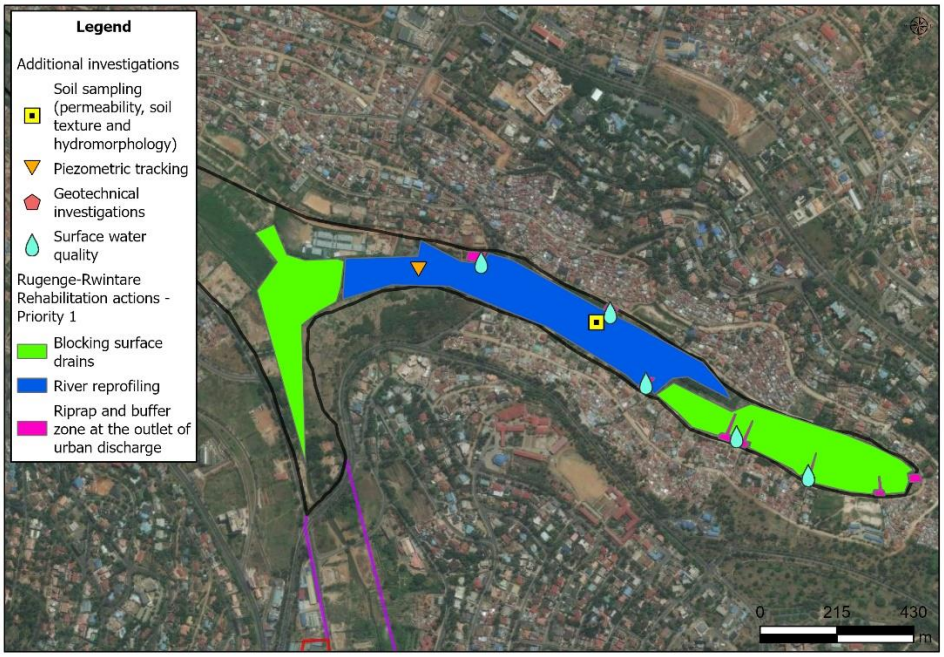


FIGURE 9-3 PROPOSED SAMPLING CAMPAIGN AT RUGENGE-RWINTARE

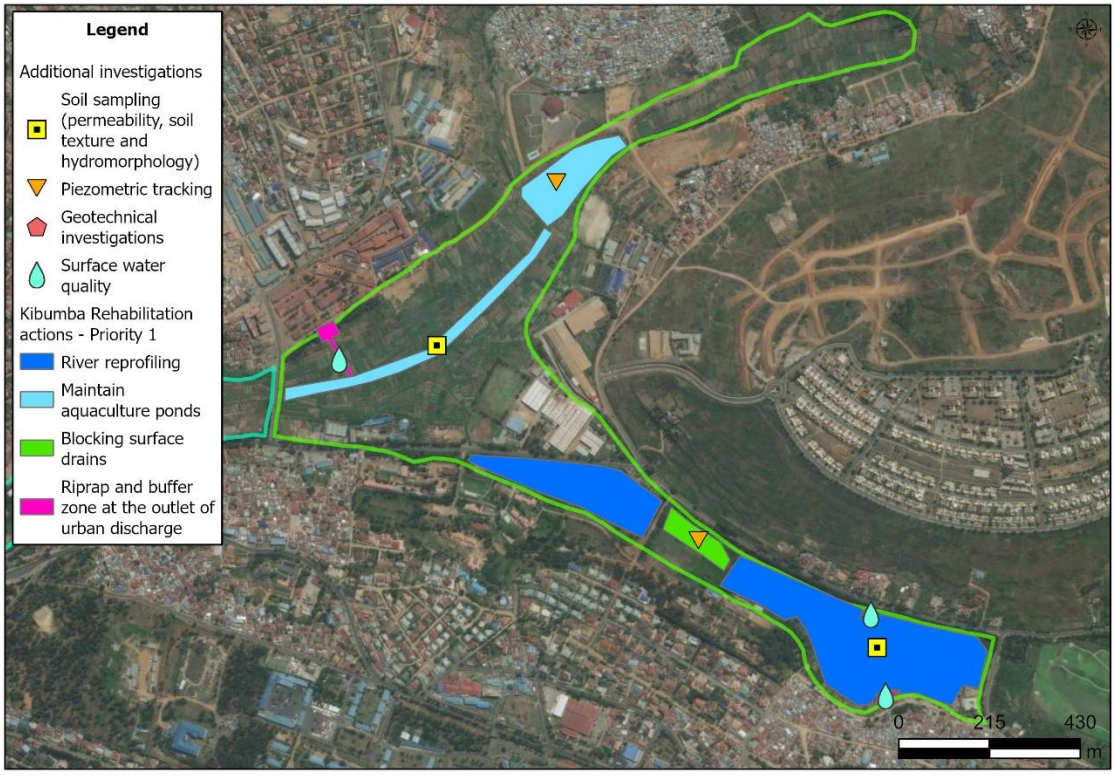


FIGURE 9-4 PROPOSED SAMPLING CAMPAIGN AT KIBUMBA

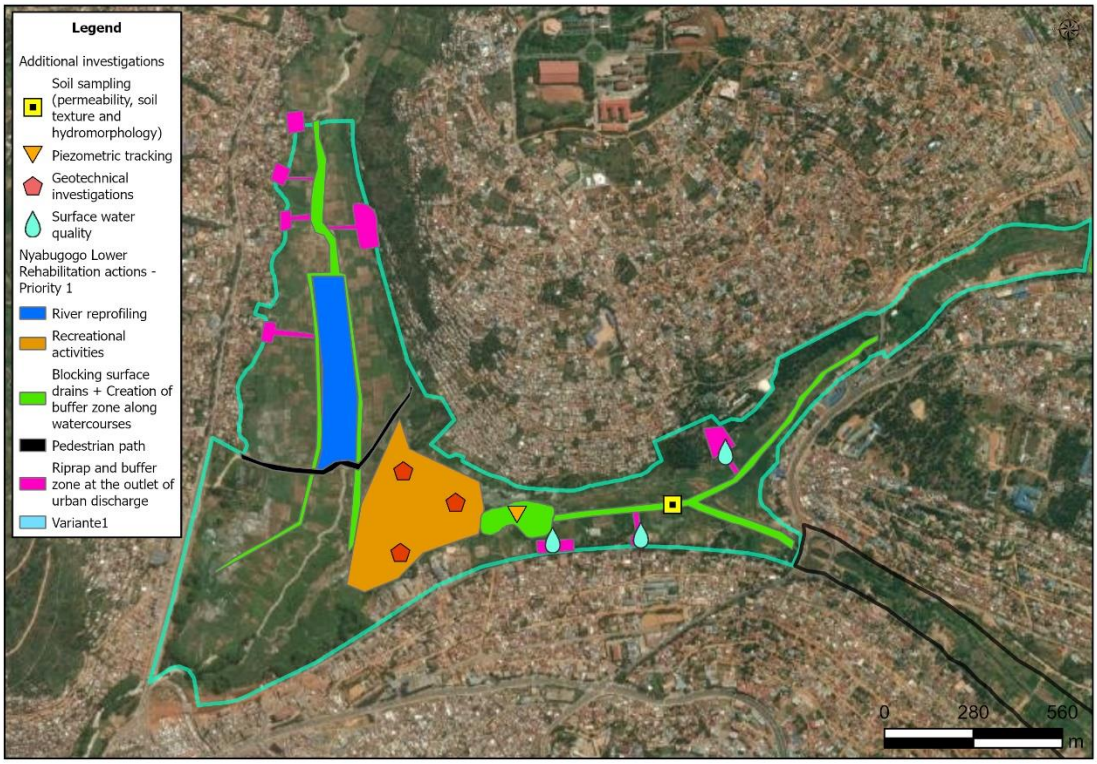


FIGURE 9-5 PROPOSED SAMPLING CAMPAIGN AT NYABUGOGO LOWER

Recommendations for the ESIA study and other E&S instruments

The project will lead to significant positive environmental impacts but also negative impacts and risks, mainly associated with the loss of some agricultural parcels in the wetlands, source of livelihood for local communities. It is therefore recommended that the ESIA be accompanied by a robust stakeholder engagement plan, in line with requirements of World Bank Environmental and Social Framework (ESF) and mainly with the Environmental and Social Standard 1 ESS1: Assessment and Management of Environmental and Social Risks and Impact (ESS1) and ESS10: Stakeholder Engagement and Information Disclosure.

Rehabilitation entails that the detention time of water in the wetland will increase to ensure that the rehabilitation targets are met, this concept has to be well integrated by stakeholders and communities, who view the wetlands and the presence of water as the main reason for floods. It is therefore recommended that stakeholder engagement be accompanied by sensitization to ensure the support of the people. Without the support of communities, the rehabilitation program could fall short of implementation.

It is also required that the Resettlement Action Plan (RAP) or the Livelihood Restoration Plan (LRP) comply with ESS5: Land Acquisition, Restrictions on Land Use and Involuntary Resettlement. Based on site observations, it is inevitable that some economic displacement will be encountered, which will trigger ESS5.

The RUDP II program has developed several framework documents that shall be followed when developing the ESIA, RAP and other E&S instruments:

- The RUDPII Environmental and Social Management Framework (ESMF)
- The RUDP II Resettlement Process Framework
- The RUDP II Stakeholder Engagement Framework

As required by ESS1, the ESIA shall be accompanied by an Environmental and Social Management Plan (ESMP) with a robust monitoring program to study the long-term effect of wetland rehabilitation on ecosystems and ecosystem services.

Depending on the relevance of the ESIA study report and the provided mitigations, recommendations could be integrated in the Detailed Design study. During the production of this feasibility study, the ESIA process had not been initiated. Therefore, involvement of the ESIA at development stages of the scheme options to minimize or mitigate potential negative impacts or to enhance positive impacts was not possible. However, it is expected that the ESIA will provide with site-specific mitigations for the Detailed Design Study and ready to use ESMP to include in the tenders for construction contractors. It is also expected that the ESMP will cover all risks associated with the construction phase and provide operational mitigations, including (but not limited to):

- OHS risks and risks associated with poor labor conditions as required by ESS2: Labor and Working Conditions.
- Risks associated with contaminated soils and waste generation as required by ESS3: Resource Efficiency and Pollution Prevention and Management. It is expected that the ESMP provides with guidance on the fate of contaminated soils (where to store them).
- Environmental and social impacts at off-site facilities such as quarries and borrow pits and landfills for waste as required by ESS1: Assessment and Management of Environmental and Social Risks and Impact.
- Risk associated with the spread of invasive plant species as required by ESS6: Biodiversity Conservation and Sustainable Management of Living Natural Resources. The risk of spread is particularly high during construction with the movement of soil and machinery.

Recommendations or the hotspot study

It is recommended that the hotspot acknowledges all priority 1 actions from the priority scenario and their specifications.

Recommendations for all interventions in the watershed of the wetlands

It is recommended that all interventions in the watershed of the wetland be tailored to ensure that no additional pollutions are brought inside the wetlands. This would require that no additional urban drains be directly connected to the wetlands without pre-treatment to remove sediment and oil (stormwater separators). In addition, to ensure long-life span of the rehabilitated wetlands, it is key that all wastewater and illegal connections of sewage water be progressively diverted from the wetlands.

Rehabilitated wetland management plan and governance of the wetlands

It is recommended that the Kigali Wetland Master Plan be updated to consider the restoration treatment prescriptions developed in this study (priority 1, 2 and 3) and that a dedicated institution be formed for management, maintenance and monitoring of NBS and other infrastructures and management of relationship with investors for recreational activities and communication with stakeholders. Ongoing maintenance is needed to prevent deleterious impacts and carry out post-project completion monitoring to avoid regression into a degraded state of the wetlands.

Governance issues were the underlining cause of the wetland degradation in the past, allowing encroachment and informal occupation to take place. In an urban context, with multiple stakeholders and pressure, it is key that such institution be created. New pressures could arise on newly created wetlands such as the unsustainable use of the wetlands for fishing, bathing and car washing. Strict regulation and enforcement would need to be put in place and would require hiring staff for law enforcement and park operation and maintenance. This institution which would be within REMA or accountable to REMA could chair a committee of multiple stakeholders, a “Conservancy board”, including governmental agencies, district authorities the civil society and environmental NGOs.

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11. APPENDIX 1: WATER QUALITY RESULTS

Rwanda National Water Resources Master Plan (MINIRENA-RNRA, 2015), has developed a classification system for a limited number of parameters (Chemical Oxygen Demand (COD); Biochemical Oxygen Demand (BOD), nitrate; phosphate; faecal coliforms and e. coli bacteria). The categories are as follow: very good, good, satisfactory, modified, strongly modified

Some results are compared to the thresholds established in the Rwanda National Water Resources Master Plan.

Very good	
Good	
Satisfactory	
Modified	
Strongly modified	

TABLE 11-1 NEMUS SAMPLING STATIONS

Type of parameter	Parameter	Station 1 (Nyabugogo upstream)		Station 2 (Nyabugogo downstream)		Station 3 (Kibumba)		Station 4 (downstream Gikondo)		Station 5 (downstream Rwampara)	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Physical	pH	7.56	7.37	7.27	6.94	7.22	7.01	7.57	7.10	7.68	6.99
	Turbidity (NTU)	630	2727	371	2646	50.3	44.1	91.4	381	241	10.4
	Conductivity (µs/cm)	332	169.7	354	227	544	573	667	689	551	576
Chemical	Calcium (mg/l Ca2+)	2	1.3	1.7	1.5	3.9	3.9	3.3	4.3	4.4	3.8
	Magnesium (mg/l Mg2+)	1.5	0.56	2.8	0.62	1.6	1.30	2.1	1.40	1.3	1.40

Type of parameter	Parameter	Station 1 (Nyabugogo upstream)		Station 2 (Nyabugogo downstream)		Station 3 (Kibumba)		Station 4 (downstream Gikondo)		Station 5 (downstream Rwampara)	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
	Copper (mg/l)	0.10	0.015	0.60	0.017	0.13	<0.002	0.16	0.0096	0.05	<0.002
	Manganese (mg/l)	0.208	0.910	0.091	0.800	0.029	0.610	0.032	0.420	0.063	0.150
	Zinc (mg/l)	0.04	0.027	0.04	0.027	0.03	<0.01	0.04	0.10	0.04	0.023
	Chromium (mg/l)		0.0051		0.0036		<0.001		0.0039		<0.001
	Mercury (µg/l)	0.960	<0.05	0.550	<0.05	0.870	<0.05	0.790	<0.05	0.730	<0.05
	Lead (mg/l)	nd	0.0170	nd	0.0130	nd	0.0036	nd	0.0240	nd	<0.002
	Cadmium (µg/l)	nd	<0.2	nd	<0.2	nd	<0.2	nd	<0.2	nd	<0.2
	Ammonia Nitrogen (mg/l)	1.01	<0.15	0.52	0.40	0.50	1.50	0.45	0.70	0.47	0.20
	Nitrites Nitrogen (mg/l)	0.001	0.030	0.001	0.030	0.003	0.270	0.002	0.280	0.003	0.150
	Nitrates Nitrogen (mg/l)	0.3	1.4	2.8	1.2	0.6	2.0	0.2	4.6	1.5	4.3
	Fluoride (mg/l)	nd	<0.2	nd	0.22	nd	0.38	nd	0.50	nd	0.44
	Phosphates (mg/l)	0.08	0.46	0.14	0.44	0.26	<0.15	0.22	0.38	0.51	0.27
	Chlorides (mg/l)	81.2	24.6	82.3	28.2	91.1	64.3	122.4	96.2	80.7	81.0

Type of parameter	Parameter	Station 1 (Nyabugogo upstream)		Station 2 (Nyabugogo downstream)		Station 3 (Kibumba)		Station 4 (downstream Gikondo)		Station 5 (downstream Rwampara)	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
	Chemical Oxygen Demand (COD) (mg/l)	17	22	39.5	22	377	28	47	21	22	25
	Biochemical Oxygen Demand (BOD) (mg/l)	4.9	< 3	5.3	< 3	5.2	< 3	5.0	< 3	5.2	< 3
	Polycyclic Aromatic Hydrocarbons PAH (µg/l)	nd	< 0.6	nd	< 0.6	nd	< 0.6	nd	< 0.6	nd	< 0.6
	Hexachlorobenzene HCB (µg/l)	nd	< 0.005	nd	< 0.005	nd	< 0.005	nd	< 0.005	nd	< 0.005
	Polychlorinated biphenyls PCB (µg/l)	nd	< 0.07	nd	< 0.07	nd	< 0.07	nd	< 0.07	nd	< 0.07
Biological	Total Coliforms (Cfu/100 ml)	400	> 100	800	> 100	200	> 100	200	> 100	500	> 100
	Fecal Coliforms (Cfu/100 ml)	200	> 80	200	> 80	70	> 80	90	> 80	200	< 10

nd: non determined

MINIRENA, NIRAS: Water Pollution Study Final Report, July 2017 also sampled two stations inside the study area at the end of the wet season. One station in Nyabugogo and one station at the junction between Nyabugogo and Rugenge-Rwintare wetland. The following table shows the parameters and results.

TABLE 11-2 MINIRENA, NIRAS SAMPLING STATIONS

	Dissolved Oxygen [DO] (%)	Electrical Conductivity (µS cm^{-1})	Dissolved Inorganic Nitrogen [DIN] (mg L-1)	Dissolved Inorganic Phosphorus [DIP] (mg L-1)	pH	Total Suspended Solids [TSS] (mg L-1)	Turbidity (NTU)	Total Dissolved Solids [TDS] (mg L-1)	E. coli (CFU/100ml)	Temperature (°C)
Point 9 inside Nyabugogo wetland	87.10	179	2.60	0.10	7.30	632.70	1,541.70	90.60	34.00	22
Point 10 junction between Nyabugogo and Rugenge-Rwintare wetland	19.10	432.70	4.50	0.90	7.30	67.30	242.70	224.70	3,133.00	21.40

Macfarlane has determined an adapted set of standards based on several sources. The following table shows the results for the months of May, June and July 2020.

more than 10 time the prescribed standards
less than 10 times the prescribed standards
less than 5 times the prescribed standards
less than 2 times the prescribed standards
According to the prescribed standards

May

Parameter	Standard (Upper)	Standard (Lower)	Units	GK-01	GK-02	GK-03	GK-04	NYA-02	NYA-03	NYA-04	NYA-05	NYA-07
Total suspended solids	50		mg/L	49	75	105	220	192	136	587	316	293
Total dissolved solids	40		mg/L	330	400	400	467	400	267	133	267	200
pH	9	5	pH	7,67	7,58	7,48	7,8	7,89	7,69	7,68	7,46	7,68
Temperature	28	8	°C	27,7	28,1	25,3	25,6	26,9	25	22,9	23,3	23,9
Dissolved Oxygen	6		mg/L	5,98	1,72	4,87	5,29	5,63	3,89	6,43	6,16	6,35
Biochemical Oxygen Demand	50		mg/L	6,6	28,35	19,05	19,05	32,85	87,75	28,95	11,85	27,3
Electrical conductivity	500		µS/cm	371	392	271	296	323	240	68,9	160,9	148
Turbidity	50		NTU	75	132	143	347	208	323	991	498	482
Nitrate-Nitrogen	0,5		mg/l	3,36	5,6	7,56	7,56	4,48	5,04	6,16	18,21	18,77
Nitrite-Nitrogen	0,06		mg/l	12,11	6,09	6,82	7,51	8,66	9,08	1,83	6,47	1,1
Ammonium-Nitrogen	0,05		mg/l	1,96	0,56	2,52	5,6	2,24	3,64	3,92	2,24	2,52
Total hardness				139,16	161,16	173,86	176,96	189,92	140,42	88,46	104,3	85,66
Calcium	1000		ppm	5305,02	5873,27	5766,41	5552,8	5642,29	4843,99	3052,02	4386,88	3175,78
Sodium	70		mg/L	59,72	58,32	65,31	66,01	50,63	54,82	32,45	50,63	40,84
Potassium	0		mg/L	31,14	30,39	31,74	27,69	24,23	11,62	8,17	28,29	9,22
Chloride	1		mg/L	20,78	21,87	24,59	23,81	25,68	20,78	17,66	25,91	31,98
Fluoride	0,75		mg/L	2,13	2,53	2,9	2,6	2,52	2,24	1,89	2,01	2,01
Sulphate	500		mg/	344,03	250,16	280,02	336,92	344,03	399,5	112,19	169,08	86,59
Escherichia Coli	130		cfu/100 ml	210	400	750	850	250	270	920	700	800
Total coliforms	0		cfu/100 mL	13000	8300	20000	44000	8800	5100	64000	32000	9100

Parameter	Standard (Upper)	Standard (Lower)	Units	GK-01	GK-02	GK-03	GK-04	NYA-02	NYA-03	NYA-04	NYA-05	NYA-07
Fecal coliforms	130		cfu/100 mL	8200	3500	6600	21000	3600	5100	12000	7400	3300
Orthophosphate	0,03		mg/L	1,6	3,99	2,14	2,6	1,83	2,83	3,91	2,07	4,6
Copper	0,2		ppm	69,3	46,6	37,7	47,5	45	67,7	18,2	26,1	11,1
Lead	0,2		ppm	28,76	63,3	126,59	0,001	72,42	38,525	19,4	56,56	71,315
Mercury	0,04		ppb	333,85	0,001	0,001	30,26	0,001	0,001	0,001	0,001	512,12
Arsenic	0,001		ppm	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Cadmium	0,00015		ppm	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Chromium	0,007		ppm	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Zinc	0,002		ppm	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

June

Parameter	Standard (Upper)	Standard (Lower)	Units	GK-01	GK-02	GK-03	GK-04	NYA-02	NYA-03	NYA-04	NYA-05	NYA-07
Total suspended solids	50		mg/L	49	75	105	220	192	136	587	316	293
Total dissolved solids	40		mg/L	330	400	400	467	400	267	133	267	200
pH	9	5	pH	6,74	6,92	6,88	7,15	7,21	7,17	7,38	7,27	7,29
Dissolved Oxygen	6		mg/L	5,1	3,59	5,7	7,08	6,58	5,71	6,47	4,18	6,72
Biochemical Oxygen Demand	50		mg/L	18,45	10,65	24,75	27,45	15,45	9,45	30	10,65	6,15
Electrical conductivity	500		µS/cm	316	290	315	322	290	310	342	201	202
Nitrate-Nitrogen	0,5		mg/l	6,92	16,25	13,14	12,36	21,31	14,31	29,47	15,09	15,86
Nitrite-Nitrogen	0,06		mg/l	32,63	11,29	29,47	18,42	10,75	15,32	55,16	1,77	1,33

Parameter	Standard (Upper)	Standard (Lower)	Units	GK-01	GK-02	GK-03	GK-04	NYA-02	NYA-03	NYA-04	NYA-05	NYA-07
Ammonium-Nitrogen	0,05		mg/l	2,8	2	2,4	2,4	3,6	2,4	2,4	2	6,4
Sulphate	500		mg/	308,77	188,28	180,32	206,47	262,17	178,05	189,42	167,82	96,21
Escherichia Coli	130		cfu/100 ml	70	32	33	70	20	41	150	83	98
Fecal coliforms	130		cfu/100 mL	20	100	87	240	150	120	370	250	310
Orthophosphate	0,03		mg/L	2,69	2,46	1,53	1,84	1,14	2,22	3,15	0,99	3,38

July

Parameter	Standard (Upper)	Units	GK-01	GK-02	GK-03	GK-04	NYA-02	NYA-03	NYA-04	NYA-05	NYA-07
Total suspended solids	50	mg/L	18	16	29	31	9	22	57	187	169
Total dissolved solids	40	mg/L	67,7	84,9	98,2	82,1	76,9	89,2	105,6	45,4	39,2
pH	9	pH	6,8	6,88	7,13	7,37	7,51	7,39	7,46	7,35	7,46
Dissolved Oxygen	6	mg/L	5,67	4,22	7,06	8,97	8,65	6,71	6,44	3,66	6,56
BOD	50	mg/L	6,13	5,95	6,19	5,46	6,08	5,97	4,52	3,66	3,96
Electrical conductivity	500	µS/cm	255	269	319	321	271	309	334	180,6	148,6
Nitrate-Nitrogen	0,5	mg/l	225,57	114,74	119,87	125	262,52	353,86	197,86	309,73	14,16
Nitrite-Nitrogen	0,06	mg/l	26,33	5,67	35,1	16,91	13,81	10,7	78,55	2,99	2,78
Ammonium-Nitrogen	0,05	mg/l	1,34	3,6	3,14	5,29	3,89	3,84	4,82	2,21	3,08
Sulphate	500	mg/	326,13	257,84	243,46	238,07	345,9	327,93	293,78	27,8	15,22
Escherichia Coli	130	cfu/100ml	24	27	74	14	19	57	200	200	440
Fecal coliforms	130	cfu/100mL	84	84	340	94	120	3400	250	61	1800
Orthophosphate	0,03	mg/L	4,64	5,08	12,53	2,02	3,77	7,71	5,52	2,45	11,65

12. APPENDIX 2: BOTANICAL SURVEY REPORT

:

Botanical Surveys - Kigali Wetlands

Kigali City

Field report

Prepared by

Samuel Nshutiyayesu



For

SGI-IBC SERVICES

April 2022

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1. INTRODUCTION

1.1. Key Concepts

The Ramsar Convention defines wetlands as areas where water is the primary factor controlling the environment and the associated plant and animal life. Wetlands occur where the water table is at or near the surface of the land, or where the land is covered by shallow water1. The Convention uses this broad definition of wetlands to include: all lakes and rivers, underground aquifers, swamps and marshes, wet grasslands, peatlands, and all human-made sites such as fishponds, rice paddies, reservoirs, salt pans, etc. To distinguish between major types of wetlands2 (Swamps, Marshes, Bogs and Fens), Kigali Wetlands can be classified as "Marshes" (defined as wetlands frequently or continually inundated with water, characterized by emergent soft-stemmed vegetation adapted to saturated soil conditions). According to Rwanda agroclimatic zones, these wetlands can also be classified as mid-altitude central plateau wetlands, ranging from an altitude of 1400-1800 m a.s.l.[3]

The types of vegetation growing in a wetland can be categorized based on their ecological adaptation4:

1. **Obligate Wetland Plants** almost always occur in wetlands.
   With few exceptions, these plants (herbaceous or woody) are found in standing water or seasonally saturated soils (14 or more consecutive days) near the surface.

2. **Facultative Wetland Plants** usually occur in wetlands but may occur in non-wetlands.

These plants predominately occur with hydric soils, often in geomorphic settings where water saturates the soils or floods the soil surface at least seasonally.

3. **Facultative Plants** occur in wetlands and non-wetlands.

These plants can grow in hydric habitats. The occurrence of these plants in different habitats represents responses to a variety of environmental variables other than just hydrology, such as shade tolerance, soil pH, and elevation, and they have a wide tolerance of soil moisture conditions.

[1] Ramsar Convention Secretariat, 2013. The Ramsar Convention Manual: a guide to the Convention on Wetlands (Ramsar, Iran, 1971), 6th ed. Ramsar Convention Secretariat, Gland, Switzerland.

[2] https://www.epa.gov/wetlands/classification-and-types-wetlands#undefined retrieved on April 26, 2022

[3] REMA (2009): Rwanda State of Environment and Outlook Report. Rwanda Environment Management Authority P.O. Box 7436 Kigali, Rwanda.

[4] Robert, W.L., Norman, C.M., Mary, L.B., William, N.K., 2012. National Wetland Plant List Indicator Rating Definitions. US Army Corps of Engineers. Engineer Research and Development Center. Wetland Regulatory Assistance Program. ERDC/CRREL TN-12-1. Washington, DC.

4. **Facultative Upland Plants** usually occur in non-wetlands but may occur in wetlands.

These plants predominately occur on drier settings where water rarely saturates the soils or floods the soil surface seasonally.

5. **Upland Plant** almost never occur in wetlands.

These plants almost never occur in standing water or saturated soils. Typical growth forms include herbaceous, shrubs, woody vines, and trees.

Based on ecological adaptations of the plants and our knowledge on plants as well as the definitions given above, the plants identified from Kigali Wetlands were categorized as:

1. **Deep water plants**: Obligate wetland plants which are anchored in water and grow with their bases submerged. They prefer permanent flooding and permanent soil saturation and occur under a wide hydrological gradient from firmly rooted in the substratum to loosely anchored and easily detached floating mats (e.g., Papyrus). This category also comprises plants which most often grow their leaves and parts floating on the surface of water (e.g., Nymphaea, Water Hyacinth…)
2. **Emergent plants:** Obligate or facultative wetland plants that grow their bases submerged and rooted in seasonally saturated soils and their upper portions, including most of the vegetative and reproductive organs, growing above the water level (e.g., Catail, *C. latifolius, Ludwigia abyssinica,* willow weed, etc.)
3. **Upland plants**: Upland or facultative upland plants whose usual occurrence in wetlands under normal conditions (undegraded wetland) is less than 1%.

1.2. Objective and Scope

The objective of the study was to undertake botanical surveys in selected plots of Kigali wetlands. Botanical field surveys were organized at six (6) selected survey plots from March-April 2022.

The survey plots were the following wetlands:

1. **Nyabugogo Wetland**: *2 survey plots*
2. **Rugenge Wetland**: *1 survey plot*
3. **Gikondo Wetland:** *1 survey plot*
4. **Kibumba Wetland**: *2 survey plots*

In addition to these pre-selected survey plots, three (3) more were selected based on local conditions:

1. Two sites in degraded wetlands, one in Kimicanga another in Rwandex:
2. One site in a good ecological state wetland, in Nyandungu

A visit was also done to a plant nursery at Mulindi to collect information related to the presence of native wetland plant species and their capacity to grow needed plants based on demand.

2. METHODOLOGY

The survey of plant species was carried out using systematic sampling approach. Regularly positioned line transects throughout each survey plot were used to determine sampling areas, and their numbers could vary based on the size of each survey plot and the homo/heterogeneity of the site. Effort was made to identify all plants along each transect, and within the distance between every two parallel transects. However, some areas were not possible to access due to water levels, and species could be observed and identified from distance.



Figure 1: Illustration of transect locations in sampling plots (case of Nyabugogo survey plot 1).

For vegetation description, emphasis was placed on their types based on wetland's permanent or seasonal saturation which determines the growth of specifically adapted wetland plants. Each vascular plant species was assigned a Braun-Blanquet cover-abundance scale estimate (Table 1)[5] :

[5] Braun-Blanquet, J. (1932). Plant sociology. The study of plant communities. *Plant sociology. The study of plant communities. First ed.*

Table 1: Braun-Blanquet cover-abundance scale.

Braun-Blanquet scale	Range of cover	Midpoint of cover range (%)
+	< 1%	0.1
1	1-5%	2.5
2	5-25%	15
3	25-50%	37.5
4	50-75%	62.5
5	75-100%	87.5

Plant species identification was done immediately in the field, and if uncertain, or for nomenclature accuracy purpose, reference was made to monographs such as Troupin (1971, 1982, 1983 and 1985), and the Plant List Database (www.theplantlist.org).

For each plant, the following information was recorded:

- Species names: scientific, common names (Kinyarwanda and English)
- Family
- Wetness condition
- Commonness and conservation status
- Species origin (native or introduced)

In addition, pictures and geographic coordinates were also added for habitats and species of particular interest (e.g., invasive species, etc.).

Any **observation of wildlife** was also recorded during the sampling. The list of identified wildlife is given by scientific and common English names.

A survey of existing **nurseries** in Kigali with potential and capacity to grow wetland plants (native plants) was done based on previous experience with known establishments in Kigali.

3. FINDINGS

A. FLORA

3.1. Nyabugogo Wetland

3.1.1. Nyabugogo 1

A. General description

Nyabugogo survey plot 1 displays high invasion by water hyacinth. These might have been introduced to the wetland due to the close proximity with adjacent plant nurseries, where most of the plants are of exotic origin. This site is also bordered with grown trees of *Acacia kirkii*, at the south-eastern side of the site. The biggest part of the plot is flooded, and access is only possible at the edges of the southern side. This area faces threats of pollution from the dumping of waste, mainly from nurseries. Fertilizers from the nursery are also suspected of leaching and polluting the wetland.



Figure 2: Overview of Nyabugogo Wetland survey plot 1

Historical imagery shows that the trees of *Acacia kirkii* were planted after 2014 (Figure 3), and that some buildings close to the wetland were removed since then. The level of water also seems to have increased, probably because the Nyabugogo River has been better managed over past few years.



Figure 3: Comparison of Nyabugogo 1(left: imagery of July 2014; right: imagery of April 2022).

B. List of identified plant species

A total of 19 species were identified from this site (Table 2) and many other ornamental plants from nearby nursery which were not taken into consideration for identification.

Table 2: List of plants from Nyabugogo 1

No	Species	Common name: Kiny/Eng	Family	Wetness preference	Commonness* /Conservation status**	Origin
1	*Acacia kirkii*	Umunyaryera/Flood-plain Acacia	Fabaceae	Upland	C/LC	Indigenous
2	*Achyranthes aspera*	Umuhurura/Devil's horsewhip	Amaranthaceae	Upland	C/NA	Indigenous
3	*Bidens pilosa*	Inyabarasanya/Black jack	Asteraceae	Upland	C/NA	Indigenous
4	*Brillantaisia cicatricosa*	Ikirogora	Acanthaceae	Upland	C/NA	Indigenous
5	*Centella asiatica*	Indian pennywort	Apiaceae	Emergent	C/LC	Indigenous
6	*Colocasia esculenta*	Amateke/Taro	Araceae	Upland	C/LC	Exotic
7	*Commelina benghalensis*	Uruteja/Blue commelina	Commelinaceae	Upland	C/NA	Indigenous
8	*Cyperus latifolius*	Urukanganga/Epiphytic flatsedge	Cyperaceae	Emergent	C/LC	Indigenous
9	*Cyperus papyrus*	Urufunzo/Papyrus	Cyperaceae	Deep water	C/LC	Indigenous
10	*Eichhornia crassipes****	Amarebe/Water hyacinth	Pontederiaceae	Deep water	C/NA	Exotic
11	*Galinsoga parviflora*	Kimali/Gallant soldier	Asteraceae	Upland	C/NA	Indigenous
12	*Ipomoea cairica*	Umuzenga/Mile a minute vine	Convolvulaceae	Upland	C/LC	Indigenous
13	*Leersia hexandra*	Urukembagufa/Cut grass	Poaceae	Emergent	C/NA	Indigenous
14	*Ludwigia abyssinica*	Umuzigangore	Onagraceae	Emergent	C/NA	Indigenous

15	*Persicaria decipiens*	Igorogonzo/Watersmart weed	Polygonaceae	Emergent	C/LC	Indigenous
16	*Plantago palmata*	Imbatabata	Plantaginaceae	Upland	C/NA	Indigenous
17	*Saccharum officinalum*	Igisheke/Sugarcane	Poaceae	Upland	C/NA	Exotic
18	*Setaria homonyma*	Setariya	Poaceae	Upland	C/NA	Indigenous
19	*Typha domingensis*	Umuberanya/Southern Cat-tail	Typhaceae	Emergent	C/LC	Indigenous
	Unidentified ornamentals from nurseries					

***C:** Common; **O:** Occasional; **R:** Rare

** **LC:** Least Concern; **NA:** Not Assessed

*** Invasive species

The most occurring species were *Eicchornia crassipes* and *Persicaria decipiens* (Table 3).

Table 3: Species occurrence in Nyabugogo 1 transects.

No	Species	Cover-Abundance (in transects)							
		T1 DoW*: 0-2m	**T2 DoW: 0-2m**	**T3 DoW: 0-2m**	**T4 DoW: 0-2m**	**T5 DoW: 0-2m**	**T6 DoW: 0-2m**	**T7 DoW: 0-2m**	**T8 DoW: 0-2m**
1	*Acacia kirkii*	1	0	0	0	0	3	2	0
2	*Achyranthes aspera*	0	0	0	0	0	1	1	0
3	*Bidens pilosa*	0	0	0	0	0	0	2	0
4	*Brillantaisia cicatricosa*	0	0	0	0	0	0	+	0
5	*Centella asiatica*	0	0	0	2	1	1	2	0
6	*Colocasia esculenta*	0	0	0	0	0	0	3	3
7	*Commelina benghalensis*	0	0	0	0	0	3	3	2
8	*Cyperus latifolius*	0	0	0	0	1	0	0	0
9	*Cyperus papyrus*	0	0	0	0	1	0	0	0
10	*Eichhornia crassipes*	2	3	2	2	2	4	2	2
11	*Galinsoga parviflora*	0	0	0	0	0	0	0	3
12	*Ipomoea cairica*	0	0	0	0	0	3	2	1
13	*Leersia hexandra*	0	0	3	3	3	1	2	5
14	*Ludwigia abyssinica*	0	2	1	1	1	2	0	0
15	*Persicaria decipiens*	0	4	5	5	5	4	3	2
16	*Plantago palmata*	0	0	1	0	0	0	0	1
17	*Saccharum officinale*	0	2	0	0	0	0	0	0
18	*Setaria homonyma*	0	0	0	0	0	0	3	3
19	*Typha domingensis*	0	2	0	0	0	0	0	0
	Unidentified ornamentals from nurseries	5	0	0	0	0	3	2	1

*** DoW: Depth of Water**

3.1.2. Nyabugogo 2

A. General description

Nyabugogo survey plot 2 is characterized by some zones of relatively good ecological condition and covered with *Cyperus papyrus* on permanently flooded areas. In less degraded areas and seasonally flooded *Typha domingensis* is most common Some other patches, mainly the southern side, have been degraded due to agriculture encroachment, and the boundaries between the crop fields and the wetland natural vegetation is absent. In some other abandoned crop fields, secondary wetland vegetation can be observed, mainly dominated with *Cyperus latifolius*, *Persicaria salicifolia* and *Ludwigia abyssinica* species. In addition to agriculture, other main threats to this wetland include the invasion of water hyacinth (*Eichhornia crassipes*), mostly observed at the eastern and northern sides of the survey plot, and pollution due to dumping of wastes, including plastic bottles. The waters of Nyabugogo wetlands take source from the Nyabugogo River.



Figure 4: East side view of Nyabugogo 2

As it is the case with Nyabugogo 1, available historical imagery indicates that the removal of some buildings near the site and some crop fields as well as the management at the level Nyabugogo River made changes in the state of the site (Figure 5).



Figure 5: Comparison of Nyabugogo 2 (left: imagery of Dec 2017; right: imagery of April 2022).

B. List of identified plant species

A total of 15 species were identified from this site (Table 4).

Table 4: List of plants from Nyabugogo 2

No	Species	Common name: Kiny/Eng	Family	Wetness preference	Commonness* /Conservation status**	Origin
1	*Aspilia pluriseta*	Icyumya	Asteraceae	Upland	C/NA	Indigenous
2	*Centella asiatica*	Indian pennywort	Apiaceae	Emergent	C/LC	Indigenous
3	*Commelina benghalensis*	Uruteja/Blue commelina	Commelinaceae	Upland	C/NA	Indigenous
4	*Crassocephalum montuosum*	Igifuraninda	Asteraceae	Upland	C/NA	Indigenous
5	*Cyperus latifolius*	Urukanganga/Epiphytic flatsedge	Cyperaceae	Emergent	C/LC	Indigenous
6	*Cyperus papyrus*	Urufunzo/Papyrus	Cyperaceae	Deep water	C/LC	Indigenous
7	*Drymaria cordata*	Ubwungo/Heartleaf drymary	Caryophyllaceae	Emergent	C/NA	Indigenous
8	*Eichhornia crassipes****	Amarebe/Water hyacinth	Pontederiaceae	Deep water	C/NA	Exotic
9	*Laggera alata*	Winged-stem laggera/Igitabitabi	Asteraceae	Upland	C/NA	Indigenous
10	*Leersia hexandra*	Urukembagufa/Cut grass	Poaceae	Emergent	C/NA	Indigenous
11	*Ludwigia abyssinica*	Umuzigangore	Onagraceae	Emergent	C/NA	Indigenous
12	*Panicum maximum*	Guinea grass	Poaceae	Upland	C/NA	Indigenous
13	*Persicaria decipiens*	Igorogonzo/Willow weed	Polygonaceae	Emergent	C/NA	Indigenous
14	*Persicaria pulchra*	Igorogonzo/Watersmart weed	Polygonaceae	Emergent	C/LC	Indigenous
15	*Typha domingensis*	Umuberanya/Southern Cat-tail	Typhaceae	Emergent	C/LC	Indigenous

***C:** Common; **O:** Occasional; **R:** Rare

** **LC:** Least Concern; **NA:** Not Assessed

*** Invasive species

The most frequent and abundant species was Leersia hexandra (Table 5).

Table 5: Species occurrence in Nyabugogo 2 transects.

No	*Species*	*Cover-Abundance (in transects)*					
		T1 DoW*: 0-2m	**T2 DoW: 0-2m**	**T3 DoW: 0-2m**	**T4 DoW: 0-2m**	**T5 DoW: 0-2m**	**T6 DoW: 0-2m**
1	*Aspilia pluriseta*	1	0	0	3	0	1
2	*Centella asiatica*	0	0	0	1	1	2
3	*Commelina benghalensis*	1	2	3	0	2	0
4	*Crassocephalum montuosum*	0	0	0	0	+	0
5	*Cyperus latifolius*	1	1	4	2	3	2
6	*Cyperus papyrus*	1	2	3	3	2	2
7	*Drymaria cordata*	0	1	0	0	1	0
8	*Eichhornia crassipes*	0	1	0	1	0	3
9	*Laggera alata*	0	0	0	0	1	0
10	*Leersia hexandra*	5	4	5	5	5	5
11	*Ludwigia abyssinica*	2	3	2	2	2	3
12	*Panicum maximum*	0	0	0	0	0	1
13	*Persicaria decipiens*	1	3	1	3	3	4
14	*Persicaria pulchra*	0	1	0	1	0	2
15	*Typha domingensis*	4	0	0	1	2	1

*** DoW: Depth of Water**

3.2. Rugenge Wetland

A. General description

Rugenge survey plot comprises large areas cultivated with elephant grass as cattle folder (Figure 6). Some other parts of the wetland are also covered with different crops such as sweet potatoes, taro, etc. The major threat to this wetland is agriculture.



Figure 6: Overview of Rugenge Wetland

Apart from agriculture, there seem to be no other great source of degradation to this wetland. However, it appears that some constructions used to be not far from the survey plot (Figure7).



Figure 7: Comparison of Rugenge Wetland (left: imagery of Dec 2019; right: imagery of April 2022).

B. List of identified species

A total of 31 species were identified from this site (Table 6). Many of the observed species are characteristic of ruderal vegetation, as a result of wetland disturbance due to agriculture.

Table 6: List of plants from Rugenge

No	Species	Common name: Kiny/Eng	Family	Wetness preference	Commonness*/Conservation status**	Origin
1	*Ageratum conyzoides*	Akaziraruguma/Goatweed	Asteraceae	Upland	C/NA	Indigenous
2	*Amaranthus sp*	Imboga/Amaranth	Amaranthaceae	Upland	C/NA	Exotic
3	*Aspilia pluriseta*	Icyumya	Asteraceae	Upland	C/NA	Indigenous
4	*Bidens pilosa*	Inyabarasanya/Blackjack	Asteraceae	Upland	C/NA	Indigenous
5	*Centella asiatica*	Indian pennywort	Apiaceae	Emergent	C/LC	Indigenous
6	*Cleome gynandra*	Isogi/Spiderplant	Cleomaceae	Upland	O/NA	Indigenous
7	*Colocasia esculenta*	Amateke/Taro	Araceae	Upland	C/LC	Exotic
8	*Commelina benghalensis*	Uruteja/Blue commelina	Commelinaceae	Upland	C/NA	Indigenous
9	*Conyza sumatrensis*	Bambuwa/Broadleaf leabane	Asteraceae	Upland	C/NA	Indigenous
10	*Cucurbita pepo*	Igihaza/Pumpkin	Cucurbitaceae	Upland	C/LC	Indigenous
11	*Cynodon dactylon*	Umucaca/Bermuda grass	Poaceae	Upland	C/NA	Indigenous
12	*Cyperus papyrus*	Urufunzo/Papyrus	Cyperaceae	Deep water	C/LC	Indigenous
13	*Desmodium sp*	Ituza	Fabaceae	Upland	C/NA	Indigenous
14	*Eragrostis sp*	-	Poaceae	Upland	C/NA	Indigenous
15	*Galinsoga parviflora*	Kimali/Gallant soldier	Asteraceae	Upland	C/NA	Indigenous
16	*Indigofera sp*	-	Fabaceae	Upland	C/NA	Indigenous
17	*Ipomoea batatas*	Ibijumba/Sweet potatoes	Convolvulaceae	Upland	C/DD	Exotic
18	*Ipomoea cairica*	Umuzenga/Mile a minute vine	Convolvulaceae	Upland	C/LC	Indigenous
19	*Lactuca attenuata*	Uruvunanka	Asteraceae	Upland	C/NA	Indigenous
20	*Leersia hexandra*	Urukembagufa/Cut grass	Poaceae	Emergent	C/NA	Indigenous
21	*Lepidium didymum*	Lesser swine-cress	Brassicaceae	Upland	O/NA	Indigenous
22	*Musa sp*	Igitoki/Banana	Musaceae	Upland	C/NA	Exotic
23	*Pennisetum purpureum*	Urubingo/Elephant grass	Poaceae	Emergent	C/NA	Exotic
24	*Persicaria decipiens*	Igorogonzo/Willow weed	Polygonaceae	Emergent	C/NA	Indigenous
25	*Persicaria pulchra*	Igorogonzo/Watersmart weed	Polygonaceae	Emergent	C/LC	Indigenous
26	*Plantago palmata*	Imbatabata	Plantaginaceae	Upland	C/NA	Indigenous
27	*Portulacca oleracea*	Purslane	Portulacaceae	Upland	O/LC	Indigenous
28	*Psidium guajava*	Ipera/Guava	Myrtaceae	Upland	C/NA	Exotic
29	*Ricinus communis*	Ikibonobono/Castor	Euphorbiaceae	Upland	C/NA	Indigenous
30	*Setaria homonyma*	Setariya	Poaceae	Upland	C/NA	Indigenous
31	*Tithonia diversifolia*	Icyicamahirwe/Mexican sunflower	Asteraceae	Upland	C/NA	Exotic

***C:** Common; **O:** Occasional; **R:** Rare

** **LC:** Least Concern; **NA:** Not Assessed; **DD:** Data Deficient

The elephant grass (Napier grass) planted for cattle feeding is the most abundant species at the site.

Table 7: Species occurrence in Rugenge transects.

No	Species	Cover-Abundance (in transects)						
		T1 DoW*: 0-0.5m	T2 DoW: 0-0.5m	T3 DoW: 0-0.5m	T4 DoW: 0-0.5m	T5 DoW: 0-0.5m	T6 DoW: 0-0.5m	T7 DoW: 0-0.5m
1	*Ageratum conyzoides*	1	0	1	0	2	0	1
2	*Amaranthus sp*	1	2	0	0	1	0	1
3	*Aspilia pluriseta*	0	0	3	1	0	0	0
4	*Bidens pilosa*	1	2	0	0	0	2	1
5	*Centella asiatica*	0	0	2	0	0	0	0
6	*Colocasia esculenta*	2	0	0	0	0	1	2
7	*Commelina benghalensis*	0	2	0	0	0	1	0
8	*Conyza sumatrensis*	1	0	1	0	0	0	1
9	*Cucurbita pepo*	0	1	0	0	0	0	0
10	*Cynodon dactylon*	0	1	2	0	0	0	0
11	*Cyperus papyrus*	0	2	0	0	0	0	0
12	*Desmodium sp*	0	0	2	0	0	0	0
13	*Eragrostis sp*	0	1	0	0	0	0	0
14	*Galinsoga parviflora*	0	2	0	0	0	2	0
15	*Gynandropsis gynandra*	0	+	0	0	0	0	0
16	*Indigofera sp*	0	+	0	0	0	0	0
17	*Ipomoea batatas*	3	0	0	0	4	2	3
18	*Ipomoea cairica*	0	0	0	3	0	0	0
19	*Lactuca attenuata*	0	1	1	0	0	0	0
20	*Leersia hexandra*	0	3	3	0	0	0	0
21	*Lepidium didymum*	0	0	1	0	0	0	0
22	*Musa sp*	0	0	0	0	0	+	0
23	*Pennisetum purpureum*	2	3	5	5	5	2	2
24	*Persicaria decipiens*	0	4	3	3	0	0	0
25	*Persicaria pulchra*	0	2	0	0	0	0	0
26	*Plantago palmata*	0	1	1	0	0	0	0
27	*Portulacca oleracea*	0	+	0	0	0	0	0
28	*Psidium guava*	+	0	0	0	0	0	+
29	*Ricinus communis*	0	0	0	0	0	0	0
30	*Setaria homonyma*	0	0	1	0	0	0	0
31	*Tithonia diversifolia*	1	1	0	0	0	1	1

*** DoW: Depth of Water**

3.3. KibumbaWetland

3.3.1. Kibumba 1

A. General description

Kibumba 1 survey plot sits on a flat land quasi-covered with *Cyperus latifolius* in the western and central zones of the wetland (Figure 8).



Figure 8: Overview of Kibumba 1

To the central and south-easter sides of the wetland, vestiges of former crop fields can be observed (Figure 9). The major source of threat to this wetland is agriculture.



Figure 9: Comparison of Kibumba 1 (left: imagery of Dec 2019; right: imagery of April 2022).

B. List of identified species

A total of 30 species were identified from this site (Table 8).

Table 8: List of plants from Kibumba 1

No	Species	Common name: Kiny/Eng	Family	Wetness preference	Commonness*/Conservation status**	Origin
1	*Acacia sp*	-	Fabaceae	Upland	C/NA	Indigenous
2	*Ageratum conyzoides*	Akaziraruguma/Goatweed	Asteraceae	Upland	C/NA	Indigenous
3	*Aspilia pluriseta*	Icyumya	Asteraceae	Upland	C/NA	Indigenous
4	*Bidens pilosa*	Inyabarasanya/Blackjack	Asteraceae	Upland	C/NA	Indigenous
5	*Canna indica*	Indian shot	Cannaceae	Upland	C/NA	Exotic
6	*Centella asiatica*	Indian pennywort	Apiaceae	Emergent	C/LC	Indigenous
7	*Colocasia esculenta*	Amateke/Taro	Araceae	Upland	C/LC	Exotic
8	*Commelina benghalensis*	Uruteja/Blue commelina	Commelinaceae	Upland	C/NA	Indigenous
9	*Crotalaria sp*	Umuyogera	Fabaceae	Upland	C/NA	Indigenous
10	*Cyperus dives*	Urugaga	Cyperaceae	Emergent	C/LC	Indigenous
11	*Cyperus latifolius*	Urukanganga/Epiphytic flatsedge	Cyperaceae	Emergent	C/LC	Indigenous
12	*Desmodium sp*	Ituza	Fabaceae	Upland	C/NA	Indigenous
13	*Dichondra micrantha*	Gutwikumwe/Carolina dichondra	Convolvulaceae	Emergent	C/LC	Indigenous
14	*Digitaria abyssinica*	Urwiri/Couchgrass	Poaceae	Upland	C/NA	Indigenous
15	*Dypsis sp*	Umukindo	Arecaceae	Upland	C/NA	Exotic
16	*Hibiscus sp*	-	Malvaceae	Upland	C/NA	Indigenous
17	*Hygrophila auriculata*	Gangabukari/Hygrophila	Acanthaceae	Emergent	C/LC	Indigenous
18	*Indigofera sp*	-	Fabaceae	Upland	C/NA	Indigenous
19	*Ipomoea cairica*	Umuzenga/Mile a minute vine	Convolvulaceae	Upland	C/LC	Indigenous
20	*Kyllinga sp*	-	Cyperaceae	Upland	C/NA	Indigenous
21	*Leersia hexandra*	Urukembagufa/Cut grass	Poaceae	Emergent	C/NA	Indigenous
22	*Ludwigia abyssinica*	Umuzigangore	Anagraceae	Emergent	C/NA	Indigenous
23	*Ocimum sp*	Umwenya/Ocimum	Lamiaceae	Upland	C/NA	Indigenous
24	*Pennisetum purpureum*	Urubingo/Elephant grass	Poaceae	Emergent	C/NA	Exotic
25	*Persicaria decipiens*	Igorogonzo/Willow weed	Polygonaceae	Emergent	C/NA	Indigenous
26	*Persicaria pulchra*	Igorogonzo/Watersmart weed	Polygonaceae	Emergent	C/LC	Indigenous
27	*Psidium guava*	Ipera/Guava	Myrtaceae	Upland	C/NA	Exotic
28	*Sida cordifolia*	Umucundura/Flannel weed	Malvaceae	Upland	C/NA	Indigenous
29	*Triumfetta cordifolia*	Umunaba/Burweed	Malvaceae	Upland	C/NA	Indigenous
30	*Vernonia amygdalina*	Umubirizi/Bitterleaf	Asteraceae	Upland	C/NA	Indigenous

***C:** Common; **O:** Occasional; **R:** Rare

** **LC:** Least Concern; **NA:** Not Assessed

Cyperus latifolius is the most erect and abundant species, with extensive coverage of *Leersia hexandra* in understory (Table 9).

Table 9: Species occurrence in Kibumba 1 transects.

No	Species	Cover-abundance (in transects)			
		T1 DoW*: 0-0.5m	T2 DoW: 0-0.5m	T3 DoW: 0-0.5m	T4 DoW: 0-0.5m
1	*Acacia sp*	0	0	0	0
2	*Ageratum conyzoides*	1	0	1	0
3	*Aspilia pluriseta*	0	0	1	0
4	*Bidens pilosa*	1	0	2	0
5	*Canna indica*	1	1	0	0
6	*Centella asiatica*	1	0	0	0
7	*Colocasia esculenta*	0	0	2	0
8	*Commelina benghalensis*	0	0	1	0
9	*Crotalaria sp*	0	0	+	0
10	*Cyperus dives*	1	1	0	0
11	*Cyperus latifolius*	5	4	0	0
12	*Desmodium sp*	1	0	0	0
13	*Dichondra micrantha*	0	0	0	0
14	*Digitaria abyssinica*	0	1	0	0
15	*Dypsis sp*	0	0	3	4
16	*Hibiscus sp*	0	1	0	0
17	*Hygrophila auriculata*	2	0	0	0
18	*Indigofera sp*	0	0	+	0
19	*Ipomoea cairica*	1	0	0	0
20	*Kyllinga sp*	0	2	0	2
21	*Leersia hexandra*	5	3	4	1
22	*Ludwigia abyssinica*	0	1	0	0
23	*Ocimum sp*	1	0	0	0
24	*Pennisetum purpureum*	0	0	1	0
25	*Persicaria decipiens*	2	0	0	0
26	*Persicaria pulchra*	1	0	0	0
27	*Psidium guava*	0	+	0	0
28	*Sida cordifolia*	0	0	0	1
29	*Triumfetta cordifolia*	0	0	0	1
30	*Vernonia amygdalina*	0	0	+	0

*** DoW: Depth of Water**

3.3.2. Kibumba 2

A. General description

Similarly to Kibumba 1, this site also comprises large coverage of *Cyperus latifolius,* but the level and amount of water is higher than in Kibumba 1 (Figure 10).



Figure 10: Overview of Kibumba 2

High water levels can be explained by the possibility that this area used to be a water pond in the past, as shown in historic google earth imagery (Figure 11).



Figure 11: Comparison of Kibumba 2 (left: imagery of Dec 2019; right: imagery of April 2022).

B. List of identified species

A total of 17 species were identified from this site (Table 10).

Table 10: List of plants from Kibumba 2

No	Species	Common name: Kiny/Eng	Family	Wetness preference	Commonness*/Conservation status**	Origin
1	*Ageratum conyzoides*	Akaziraruguma/Goatweed	Asteraceae	Upland	C/NA	Indigenous
2	*Aspilia pluriseta*	Icyumya	Asteraceae	Upland	C/NA	Indigenous
3	*Bidens pilosa*	Inyabarasanya/Blackjack	Asteraceae	Upland	C/NA	Indigenous
4	*Centella asiatica*	Indian pennywort	Apiaceae	Emergent	C/LC	Indigenous
5	*Clerodendrum johnstonii*	Ikiziranyenzi	Verbenaceae	Upland	C/NA	Indigenous
6	*Conyza sumatrensis*	Bambuwa/Broadleaf leabane	Asteraceae	Upland	C/NA	Indigenous
7	*Crassocephalum montuosum*	Igifuraninda	Asteraceae	Upland	C/NA	Indigenous
8	*Cyperus dives*	Urugaga	Cyperaceae	Emergent	C/LC	Indigenous
9	*Cyperus latifolius*	Urukanganga/Epiphytic flatsedge	Cyperaceae	Emergent	C/LC	Indigenous
10	*Dichrocephala integrifolia*	Umubuzo	Asteraceae	Emergent	C/NA	Indigenous
11	*Ipomoea cairica*	Umuzenga/Mile a minute vine	Convolvulaceae	Upland	C/LC	Indigenous
12	*Kyllinga sp*	-	Cyperaceae	Upland	C/NA	Indigenous
13	*Leersia hexandra*	Urukembagufa/Cut grass	Poaceae	Emergent	C/NA	Indigenous
14	*Ludwigia abyssinica*	Umuzigangore	Onagraceae	Emergent	C/NA	Indigenous
15	*Nymphaea nouchali*	Amarebe/Blue lotus	Nymphaeacae	Deep water	C/NA	Exotic
16	*Persicaria decipiens*	Igorogonzo/Watersmart weed	Polygonaceae	Emergent	C/LC	Indigenous
17	*Solanum sp*	Intobo	Solanaceae	Upland	C/NA	Indigenous

***C:** Common; **O:** Occasional; **R:** Rare

** **LC:** Least Concern; **NA:** Not Assessed

There are same vegetation characteristics as in Kibumba 1: *Cyperus latifolius* is the most erect and abundant species, with extensive coverage of *Leersia hexandra* in understory (Table 11).

Table 11: Species occurrence in Kibumba 2 transects.

No	Species	Cover-abundance (in transects)		
		T1 DoW*: 0-1m	T2 DoW: 0-1m	T3 DoW: 0-1m
1	*Ageratum conyzoides*	1	0	0
2	*Aspilia pluriseta*	1	0	0
3	*Bidens pilosa*	2	0	1
4	*Centella asiatica*	0	1	1
5	*Clerodendron johnstonii*	1	0	0

6	*Conyza sumatrensis*	1	0	0
7	*Crassocephalum montuosum*	0	1	0
8	*Cyperus dives*	1	0	1
9	*Cyperus latifolius*	4	3	3
10	*Dichrocephala integrifolia*	1	1	0
11	*Ipomoea cairica*	0	0	2
12	*Kyllinga sp*	1	0	1
13	*Leersia hexandra*	4	4	4
14	*Ludwigia abyssinica*	0	1	0
15	*Nymphaea nouchali*	0	2	2
16	*Persicaria decipiens*	2	2	2
17	*Solanum sp*	0	0	1

*** DoW: Depth of Water**

3.4. Gikondo Wetland

A. General description

The vegetation of Gikondo survey plot comprises different species, mostly dominated by *Typha domingensis.* The wetland is adjacent to crop fields which, apparently, increase in size encroaching on the wetland (Figure 12) . Some fields are located between Typha and sedge bushes, indicating penetrating encroachment into the wetland. Recently cut typha can also be found at the edges of the wetland to extend the crop fields into the wetland.



Figure 12: Overview of Gikondo Wetland

However, compared to the last 12 years where historical imagery indicate that agriculture was extensively practiced in this area, in the eastern part particularly, substantial limitations in cultivating the wetland seem to have been taking place since then (Figure 13).



Figure 13: Comparison of Gikondo Weland (left: imagery of July 2010; right: imagery of April 2022).

B. List of identified species

A total of 19 species were identified from this site (Table 12).

Table 12: List of plants from Gikondo

No	Species	Common name: Kiny/Eng	Family	Wetness preference	Commonness*/Conservation status**	Origin
1	*Ageratum conyzoides*	Akaziraruguma/Goatweed	Asteraceae	Upland	C/NA	Indigenous
2	*Aspilia pluriseta*	Icyumya	Asteraceae	Upland	C/NA	Indigenous
3	*Bidens pilosa*	Inyabarasanya/Blackjack	Asteraceae	Upland	C/NA	Indigenous
4	*Centella asiatica*	Indian pennywort	Apiaceae	Emergent	C/LC	Indigenous
5	*Commelina benghalensis*	Uruteja/Blue commelina	Commelinaceae	Upland	C/NA	Indigenous
6	*Crassocephalum vitellinum*	Isununu	Asteraceae	Upland	C/NA	Indigenous
7	*Cyperus latifolius*	Urukanganga/Epiphytic flatsedge	Cyperaceae	Emergent	C/LC	Indigenous
8	*Ethulia conyzoides*	Umuvumo	Asteraceae	Upland	C/NA	Indigenous
9	*Guizotia scabra*	Igishikashike	Asteraceae	Upland	C/NA	Indigenous
10	*Hygrophila auriculata*	Gangabukari/Hygrophila	Acanthaceae	Emergent	C/LC	Indigenous
11	*Ipomoea batatas*	Ibijumba/Sweet potatoes	Convolvulaceae	Upland	C/DD	Exotic
12	*Ipomoea cairica*	Umuzenga/Mile a minute vine	Convolvulaceae	Upland	C/LC	Indigenous
13	*Kyllinga sp*	-	Cyperaceae	Upland	C/NA	Indigenous
14	*Leersia hexandra*	Urukembagufa/Cut grass	Poaceae	Emergent	C/NA	Indigenous
15	*Ludwigia abyssinica*	Umuzigangore	Onagraceae	Emergent	C/NA	Indigenous
16	*Nymphaea nouchali*	Amarebe/Blue lotus	Nymphaeacae	Deep water	C/NA	Exotic
17	*Persicaria decipiens*	Igorogonzo/Watersmart weed	Polygonaceae	Emergent	C/LC	Indigenous
18	*Sida cordifolia*	Umucundura/Flannel weed	Malvaceae	Upland	C/NA	Indigenous
19	*Typha domingensis*	Umuberanya/Southern Cat-tail	Typhaceae	Emergent	C/LC	Indigenous

***C:** Common; **O:** Occasional; **R:** Rare

** **LC:** Least Concern; **NA:** Not Assessed

The most abundant and frequent plant species in Gikondo Wetland are *Typha domingensis and Leersia hexandra* (understory) (Table 13).

Table 13: Species occurrence in Gikondo.

No	Species	Cover-abundance (in transects)				
		T1 DoW*: 0-1m	**T2 DoW: 0-1m**	**T3 DoW: 0-1m**	**T4 DoW: 0-1m**	**T5 DoW: 0-1m**
1	*Ageratum conyzoides*	1	0	0	0	+
2	*Aspilia pluriseta*	0	0	0	1	+
3	*Bidens pilosa*	0	0	0	0	1
4	*Centella asiatica*	0	0	1	0	0
5	*Commelina benghalensis*	0	1	0	0	1
6	*Crassocephalum vitellinum*	1	0	0	0	0
7	*Cyperus latifolius*	2	2	3	2	2
8	*Ethulia conyzoides*	0	0	0	0	+
9	*Guizotia scabra*	0	0	0	0	1
10	*Hygrophila auriculata*	0	0	0	0	1
11	*Ipomoea batatas*	0	0	0	1	1
12	*Ipomoea cairica*	1	2	0	1	0
13	*Kyllinga sp*	0	0	0	0	0
14	*Leersia hexandra*	3	3	2	4	3
15	*Ludwigia abyssinica*	1	1	0	1	0
16	*Nymphaea nouchali*	0	0	1	0	0
17	*Persicaria decipiens*	1	0	1	1	1
18	*Sida cordifolia*	1	0	0	0	1
19	*Typha domingensis*	5	5	4	3	5

***DoW: Depth of Water**

3.5. Kimicanga Wetland

A. General description

This site is located at an abandoned formerly constructed area (Figure 15), and the vegetation is characteristic of a heavily disturbed wetland (Figure 14).



Figure 14: Overview of Kimicanga Wetland



Figure 15: Comparison of Kimicanga Weland (left: imagery of Dec 2019; right: imagery of April 2022).

B. List of identified species

A total of 36 species were identified from this site (Table 14). Very few wetland species can be observed, most others are ruderal species.

Table 14: List of plants from Kimicanga

No	Species	Common name: Kiny/Eng	Family	Wetness preference	Commonness*/Conservation status**	Origin
1	*Abutilon mauritianum*	Umuhatura/Old man's gold	Malvaceae	Upland	C/NA	Indigenous
2	*Ageratum conyzoides*	Akaziraruguma/Goatweed	Asteraceae	Upland	C/NA	Indigenous
3	*Alternanthera ficoidea*	Umutepfu/Calico plant	Amaranthaceae	Upland	C/NA	Indigenous
4	*Amaranthus sp*	Imboga/Amaranth	Amaranthaceae	Upland	C/NA	Exotic
5	*Bidens pilosa*	Inyabarasanya/Blackjack	Asteraceae	Upland	C/NA	Indigenous
6	*Calliandra calothyrsus*	Kaliyandara/Calliandra	Fabaceae	Upland	C/NA	Exotic
7	*Centella asiatica*	Indian pennywort	Apiaceae	Emergent	C/LC	Indigenous
8	*Commelina benghalensis*	Uruteja/Blue commelina	Commelinaceae	Upland	C/NA	Indigenous
9	*Conyza sumatrensis*	Bambuwa/Broadleaf leabane	Asteraceae	Upland	C/NA	Indigenous
10	*Crassocephalum montuosum*	Igifuraninda	Asteraceae	Upland	C/NA	Indigenous
11	*Crotalaria sp*	Umuyogera	Fabaceae	Upland	C/NA	Indigenous
12	*Cyathula uncinulata*	Igifashi	Amaranthaceae	Upland	C/NA	Indigenous
13	*Cynodon dactylon*	Umucaca/Bermuda grass	Poaceae	Upland	C/NA	Indigenous
14	*Cyperus sp*	-	Cyperaceae	Upland	C/NA	Indigenous
15	*Datura stramonium*	Rwiziringa/Thorn apple	Solanaceae	Upland	C/NA	Indigenous
16	*Desmodium sp*	Ituza	Fabaceae	Upland	C/NA	Indigenous
17	*Hibiscus sp*	-	Malvaceae	Upland	C/NA	Indigenous
18	*Indigofera sp*	-	Fabaceae	Upland	C/NA	Indigenous
19	*Ipomoea cairica*	Umuzenga/Mile a minute vine	Convolvulaceae	Upland	C/LC	Indigenous
20	*Kyllinga sp*	-	Cyperaceae	Upland	C/NA	Indigenous
22	*Lagenaria sphaerica*	Umutanga/Wild bottle gourd	Cucurbitaceae	Upland	C/NA	Indigenous
21	*Laggera alata*	Winged-stem laggera/Igitabitabi	Asteraceae	Upland	C/NA	Indigenous
23	*Lantana camara****	Maviyakuku/Lantana	Verbenaceae	Upland	C/NA	Indigenous
24	*Leersia hexandra*	Urukembagufa/Cut grass	Poaceae	Emergent	C/NA	Indigenous
25	*Melinis repens*	Urwarikafundi/Natal grass	Poaceae	Upland	C/NA	Indigenous
26	*Oxalix corniculata*	Ubwunyu bwa nyamanza/Creeping oxalis	Oxalidaceae	Upland	C/NA	Indigenous
27	*Oxygonum sinuatum*	Ubuhandanzovu/Kindri	Polygonaceae	Upland	C/NA	Indigenous
28	*Physalis peruviana*	Umuhuhu/Cape gooseberry	Solanaceae	Upland	C/NA	Indigenous
29	*Ricinus communis*	Ikibonobono/Castor	Euphorbiaceae	Upland	C/NA	Indigenous
30	*Senna occidentalis*					
31	*Sida cordifolia*	Umucundura/Flannel weed	Malvaceae	Upland	C/NA	Indigenous
32	*Solanum torvum*	Intagarasoryo/Pea eggplant	Solanceae	Upland	C/NA	Indigenous
33	*Tagetes minuta*	Nyiramunukanabi/Mexican marigold	Asteraceae	Upland	C/A	Indigenous
34	*Tithonia diversifolia*	Icyicamahirwe/Mexican sunflower	Asteraceae	Upland	C/NA	Exotic
35	*Triumfetta cordifolia*	Umunaba/Burweed	Malvaceae	Upland	C/NA	Indigenous
36	Unid liana	-	-	-	-	-

***C:** Common; **O:** Occasional; **R:** Rare;

** **LC:** Least Concern; **NA:** Not Assessed

*** Invasive species

In this highly disturbed area, the cover-abundance rating does not show any distinctive species (Table 15).

Table 15: Species occurrence in Kimicanga

No	Species	Cover-abundance (in transects)		
		T1 DoW*: 0m	T2 DoW: 0m	T3 DoW: 0m
1	*Abutilon mauritianum*	0	+	0
2	*Alternanthera ficoidea*	0	+	0
3	*Amaranthus sp*	0	0	1
4	*Bidens pilosa*	2	0	1
5	*Calliandra calothyrsus*	2	+	0
6	*Centella asiatica*	1	0	0
7	*Commelina benghalensis*	0	0	1
8	*Conyza sumatrensis*	1	0	1
9	*Crassocephalum montuosum*	0	0	1
10	*Crotalaria sp*	1	0	0
11	*Cyathula uncinulata*	0	0	0
12	*Cynodon dactylon*	0	1	0
13	*Cyperus sp*	1	0	0
14	*Datura stramonium*	1	0	1
15	*Desmodium sp*	0	0	1
16	*Hibiscus sp*	0	+	0
17	*Indigofera sp*	0	0	+
18	*Ipomoea cairica*	0	0	1
19	*Kyllinga sp*	1	0	0
20	*Lagenaria sphaerica*	0	2	2
21	*Laggera alata*	0	0	1
22	*Lantana camara*	0	1	0
23	*Leersia hexandra*	1	0	2
24	*Melinis repens*	2	0	1
25	*Oxalix corniculata*	1	0	1
26	*Oxygonum sinuatum*	0	1	0
27	*Physalis peruviana*	0	0	+
28	*Ricinus communis*	1	0	1
29	*Senna occidentalis*	0	+	0
30	*Sida cordifolia*	0	+	0
31	*Solanum torvum*	+	0	0
32	*Tagetes minuta*	0	0	1
33	*Tithonia diversifolia*	1	0	0
34	*Triumfetta cordifolia*	0	0	+
35	Unid liana	0	0	1

***DoW: Depth of Water**

3.6. Rwandex Wetland

A. General description

This site is also located at a formerly constructed area as shown in historical imagery below (Figure 17). Some remnants of wetland vegetation can still be seen, but degradation is very advanced that mostly ruderal species can be found at the site (Figure 16).



Figure 16: Overview of Rwandex Wetland

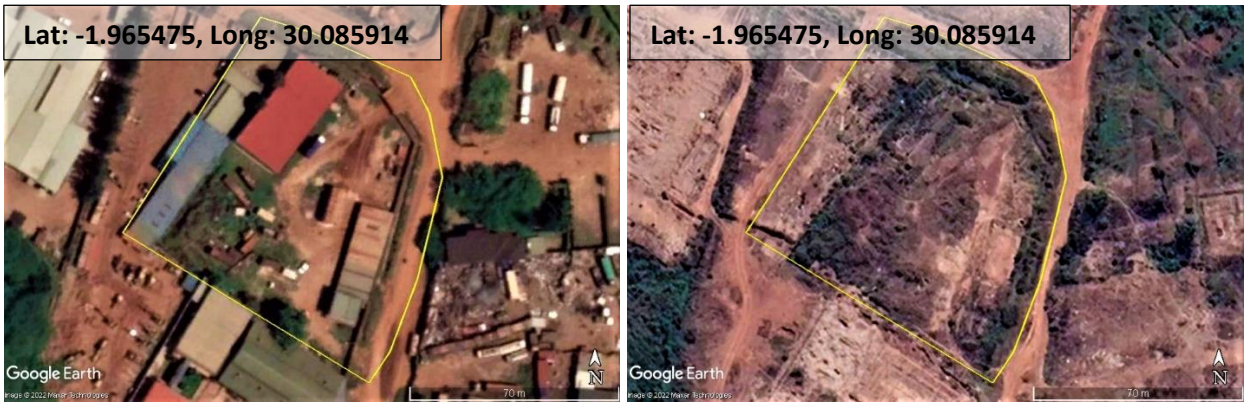


Figure 17: Comparison of Rwandex Weland (left: imagery of Jan 2019; right: imagery of April 2022).

B. List of identified species

A total of 23 species were identified from this site (Table 16). Very few wetland species can be observed, most others are ruderal species.

Table 16: List of plants from Rwandex

No	Species	Common name: Kiny/Eng	Family	Wetness preference	Commonness*/Conservation status**	Origin
1	*Amaranthus sp*	Imboga/Amaranth	Amaranthaceae	Upland	C/NA	Exotic
2	*Bidens pilosa*	Inyabarasanya/Blackjack	Asteraceae	Upland	C/NA	Indigenous
3	*Blumea brevipes*	Winged-stem laggera/Igitabitabi	Asteraceae	Upland	C/NA	Indigenous
4	*Casuarina equisetifolia*	Filaho/Coast she-oak	Casuarinaceae	Upland	C/LC	Exotic
5	*Cedrella serrata*	Isederi	Meliaceae	Upland	C/NA	Exotic
6	*Conyza sumatrensis*	Bambuwa/Broadleaf leabane	Asteraceae	Upland	C/NA	Indigenous
7	*Crotalaria sp*	Umuyogera	Fabaceae	Upland	C/NA	Indigenous
8	*Cynodon dactylon*	Umucaca/Bermuda grass	Poaceae	Upland	C/NA	Indigenous
9	*Datura stramonium*	Rwiziringa/Thorn apple	Solanaceae	Upland	C/NA	Indigenous
10	*Hygrophila auriculata*	Gangabukari/Hygrophila	Acanthaceae	Emergent	C/LC	Indigenous
11	*Indigofera sp*	-	Fabaceae	Upland	C/NA	Indigenous
12	*Ipomoea cairica*	Umuzenga/Mile a minute vine	Convolvulaceae	Upland	C/LC	Indigenous
13	*Lactuca attenuata*	Uruvunanka	Asteraceae	Upland	C/NA	Indigenous
14	*Leersia hexandra*	-	Cyperaceae	Upland	C/NA	Indigenous
15	*Luffa cylindrica*	Icyangwe/Smooth loofah	Cucurbitaceae	Upland	R/NA	Indigenous
16	*Melinis repens*	Urwarikafundi/Natal grass	Poaceae	Upland	C/NA	Indigenous
17	*Ricinus communis*	Ikibonobono/Castor	Euphorbiaceae	Upland	C/NA	Indigenous
18	*Saccharum officinalum*	Igisheke/Sugarcane	Poaceae	Upland	C/NA	Exotic
19	*Sida cordifolia*	Umucundura/Flannel weed	Malvaceae	Upland	C/NA	Indigenous
20	*Tecoma stans*	Yellow trumpetbush	Bignoniaceae	Upland	C/LC	Exotic
22	*Tithonia diversifolia*	Icyicamahirwe/Mexican sunflower	Asteraceae	Upland	C/NA	Exotic
21	*Triumfetta cordifolia*	Umunaba/Burweed	Malvaceae	Upland	C/NA	Indigenous
23	*Typha domingensis*	Umuberanya/Southern Cat-tail	Typhaceae	Emergent	C/LC	Indigenous

*__C:__ Common; __O:__ Occasional; __R:__ Rare

** __LC:__ Least Concern; __NA:__ Not Assessed

In this disturbed area, the cover-abundance rating does not show any distinctive species (Table 17).

Table 17: Species occurrence in Rwandex

No	Species	Cover-abundance (in transects)		
		T1 DoW*: 0m	**T2 DoW: 0m**	**T3 DoW: 0-0.5m**
1	*Amaranthus sp*	1	0	0
2	*Bidens pilosa*	1	0	2
3	*Blumea brevipes*	1	0	0
4	*Casuarina equisetifolia*	0	1	0
5	*Cedrella serrata*	0	2	0
6	*Conyza sumatrensis*	0	1	0
7	*Crotalaria sp*	2	0	0
8	*Cynodon dactylon*	2	0	2
9	*Datura stramonium*	0	2	0
10	*Hygrophila auriculata*	0	0	2
11	*Indigofera sp*	0	1	0
12	*Ipomoea cairica*	0	2	0
13	*Lactuca attenuata*	0	1	0
14	*Leersia hexandra*	0	0	3
15	*Luffa cylindrica*	0	1	0
16	*Melinis repens*	2	0	1
17	*Ricinus communis*	0	2	0
18	*Saccharum officinalum*	1	0	0
19	*Sida cordifolia*	1	0	0
20	*Tecoma stans*	0	+	0
21	*Tithonia diversifolia*	2	0	0
22	*Triumfetta cordifolia*	0	1	0
23	*Typha domingensis*	2	0	1

***DoW: Depth of Water**

3.7. Nyandungu Wetland

A. General description

Nyandungu Wetland represents a well-protected wetland, in a good ecological state. Since its establishment as an eco-tourism park, the wetland has restored from past disturbances, which were mainly caused by agriculture activities (Figures 18 and 19).



Figure 18: Overview of Nyandungu Wetland (Central zone)



Figure 19: Comparison of Nyandungu Weland (left: imagery of Sept 2010; right: imagery of April 2022).

B. Identified species

One dominant species is characteristic of the site today: *Typha domingensis*, which occupies more than 90% of vegetation cover. Other few species include Cyperus papyrus (less than 5%), and the understory is dominated with ferns and *Leersia hexandra* species.

This state is not the climax state. However, it is heading to the climax state as the wetland evolves into a more stable and equilibrium condition, and also depending on changes in water levels.

The reverse stages of ecological succession process for wetlands (and from experiences in Rwanda), is that as degradation removes pioneer species (mostly submersed species) and leaves space for floating-leaved species (such as Nymphaea) and sprouting of papyrus, then typhas, then cyperus latifolius, then juncus, then carex which ultimately lead to complete cover with upland herbaceous and later shrubs and tree species.

Over the years, and as Nyandungu wetland protection is sustained, we can expect to have most of the Typhas replaced with Papyrus (if water levels increase higher than the current situation).

B. FAUNA

Some birds were observed during the field surveys, but a thorough investigation may be required to provide an exhaustive list of present birds and other wildlife at the study sites. 12 bird species were observed in 5 of the initial target 6 survey sites (Table 18). There were some other birds which were heard but not seen at all survey sites (including the 3 selected in Kimicanga, Rwandex and Nyabugogo), but these could not be correctly identified. None of the observed birds has known protection/conservation status., and their importance is limited to their ecological roles as part of an ecosystem through interactions with other organisms (e.g., interactions between egrets and cattle).

Table 18: Identified bird species

No	Species	Site					
		Nyabugogo 1	**Nyabugogo 2**	**Rugenge**	**Kibumba 1**	**Kibumba 2**	**Gikondo**
1	African sacred ibis	x	x	x			
2	Black kite	x	x			x	
3	Black-headed heron	x					x
4	Black-headed weaver	x				x	
5	Cattle egret			x			
6	Great egret					x	
7	Hadada ibis			x			

8	Hamerkop			x			
9	Lapwig		x				
10	Marabou stork			x			
11	Southern red bishop		x				
12	Yellow-billed stork			x			

C. VISIT TO A PLANT NURSERY

A visit was done to a plant nursery at Mulindi (Lat: -1.9737274; Long: 30.181372).



Figure 20: Overview of the plant nursery at Mulindi

1. List of native wetland plant species that are currently grown in the nursery: The nursery does not grow much of the native wetland plant species due to lack of demand for these species. There is therefore no target species in the nursery, currently.

2. Capacity of the nursery to grow plants based on demand, and time needed to start the culture: The owners have experience in growing plants based on demand and have already worked on wetland ecosystems in the past, supplying the plants for Nyandungu Wetland restoration. According to collected information, it can require between 30 and 45 days to start the culture from the time of the demand. For this purpose, the nursery could source the seeds from wetlands around Kigali

3. Description of the capacity of the nursery to grow plants (equipment, irrigation method, etc.): The nursery is located near a stream which contains enough water to irrigate the plants even in dry season. There is also a water pump available to irrigate the plants which are far from the stream (The whole nursery covers about 2 ha). Other equipment and facilities are also available, including constructions and shade nets, equipment for water storage, land preparation and tillage, transport, and storage, etc. In addition, the nursery employs 15 permanent staff responsible of daily nursery activities.

ANNEX

I. Picture data

Site	Picture title	GPS waypoints		Comments
		Lat	Long	
Nyabugogo 1	1-Nyabugogo 1-water hyacinth invasion	-1.93831	30.04806	The pictures indicates high invasion of water hyacinth which has covered large areas in this wetland
	2-Nyabugogo 1-nursery	-1.9383	30.04803	Many plant nurseries can be potential source of threats to the wetland
	3-Nyabugogo 1-Acacia kirkii	-1.93742	30.04963	These trees are well ecologically adapted and more should be planted
	4-Nyabugogo 1-waste pollution	-1.93865	30.0479	Waste from the nurseries is dumped in the wetland
Nyabugogo 2	1-Nyabugogo 2-agriculture encroachment	-1.93498	30.05517	There is huge pressure on wetland by agriculture
	2-Nyabugogo 2-waste pollution(a)	-1.93506	30.05519	Wastes from neighboring communities and commercial activities are dumped in the wetland
	3-Nyabugogo 2-waste pollution(b)	-1.93503	30.05511	
	4-Nyabugogo 2-water hyacinth invasion	-1.93492	30.0552	Water hyacinth should be controlled before it invades the whole wetland
	5-Nyabugogo 2-waste pollution(c)	-1.93504	30.05463	More wastes dumped in the wetland
	6-Nyabugogo 2-waste and water hyacinth	-1.93494	30.05519	Mixture of waste and water hyacinth poses more threats to the ecosystem
	7-Nyabugogo 2-wetland burning	-1.93505	30.05458	Typha and other plants are burned, most probably to expand agriculture fields
Rugenge	1-Rugenge- intensive napier grass	-1.94399	30.0734	Napier grass covers almost the whole wetland, which, according to people found at the site, is used to feed the animals of a private owner.
	2-Rugenge- agriculture encroachment	-1.94155	30.0724	The wetland also faces threats from agriculture around the wetland
	3-Rugenge- stream	-1.94106	30.0726	This is the main source of water for the wetland
	4-Rugenge- construction remnants(a)	-1.94219	30.0729	This is an indication of buildings in this wetland in the past

	5-Rugenge- construction remnants(b)	-1.94234	30.0732	
Kibumba 1	1- Kibumba 1- agriculture fields(a)	-1.92988	30.0796	This indicates recent cultivations in the wetland
	2- Kibumba 1- agriculture fields(b)	-1.93031	30.08014	
Kibumba 2	1- Kibumba 2- water table	-1.93094	30.08106	This site has higher levels of water, and some species such as Nymphaea can be found
	2- Kibumba 2- water table and nymphaea	-1.93103	30.08109	
Gikondo	1- Gikondo- agriculture encroachment	-1.97556	30.09004	Intensive agriculture in this wetland is the main source of degradation
	2- Gikondo- waste dumping	-1.97556	30.08969	Waste is also dumped in this wetland, most probably by people from the neighboring institution
	3- Gikondo- crop fields in the wetland	-1.97594	30.08869	Some fields penetrate inside the wetland, a great threat to this ecosystem
Kimicanga	1- Kimicanga- construction remnants	-1.95111	30.07539	Indication of former buildings in this area
	2- Kimicanga- waste and ruderal vegetation	-1.95106	30.07531	Indication of advanced level of degradation
Rwandex	1- Rwandex- relics of typha	-1.96556	30.08556	Some remnants of vegetation wetland as a sign of restoration potential
	2- Rwandex- construction remnants	-1.96531	30.08606	Indication of former buildings in this area and advanced level of degradation
	3- Rwandex- ruderal vegetation	-1.96519	30.08606	
Mulindi nursery	1- Nursery- stream	-1.97495	30.18127	Main source of irrigation water
	2- Nursery- shade nets	-1.97397	30.18133	Some capacity indications of the facility
	3- Nursery- nursery beds	-1.9736	30.18136	

II. Habitats Description

For wetlands restoration purposes, this section describes some common obligate wetland plant in Rwandan wetland ecosystems and facultative wetland plant species. In addition to observed species, non-observed species but which are common in wetland ecosystems are listed. Emphasis is put on native wetland species and details are provided for their tolerance to flood or drought, and their tolerance to pollution.

Note:

- The list is not exhaustive and all native wetland species of Rwanda which can adapt to study sites could be longer. The list below is only indicative of key species.
- Coverage figures are general and broad estimates.

1) Obligate Wetland Plants

Habitat description: Standing water or seasonally saturated soils (14 or more consecutive days)							
Plant species characteristic of the habitat – Kinyarwanda/English name	Plant species characteristic of the habitat - Latin name	Status in Rwanda (common, rare, listed, endemic, invasive)/ IUCN status	Typical average plant coverage in this habitat type (in %)	Preference for wetness (facultative wetland plant (FWP), obligatory wetland plant (OWP), submerged plant (SP))	Flood tolerance (FT) or Drought tolerance (DT)	Tolerance to water pollution	Invasive Species (Yes/No)
Observed native wetland plants							
Indian pennywort	*Centella asiatica*	C/LC	5%	OWP	FT	Yes	No
Urugaga	*Cyperus dives*	C/LC	5%	OWP	FT		
Urukanganga/Epiphytic flatsedge	*Cyperus latifolius*	C/LC	15%	OWP	FT	No	No
Carolina dichondra	*Dichondra micrantha*	C/LC	5%	OWP	DT	Yes	No
Ubwungo/Heartleaf drymary	*Drymaria cordata*	C/NA	NA	FWP			
Urufunzo/Papyrus	*Cyperus papyrus*	C/LC	40%	OWP	FT	No	No

Umuberanya/Southern Cattail	*Typha domingensis*	C/LC	25%	OWP	FT	Yes	No
Non-observed native wetland plants							
NA	*Carex mildbraediana*	C/LC	5%	OWP	DT	NA	No
Urukirakenja/Jointed flatsedge	*Cyperus articulatus*	C/LC	5%	OWP	FT	Yes	No
Umujangaja/winged sedge	*Cyperus denudatus*	C/LC	5%	OWP	FT	NA	No
Carolina dichondra	*Dichondra micrantha*	C/LC	5%	OWP	DT	Yes	No
Urujenone	*Enhydra fluctuans*	C/NA	2%	OWP	FT	Yes	No
Gutwikumwe/Floating pennywort	*Hydrocotyle ranunculoides*	C/NA	5%	OWP	DT	Yes	No
Ubusuna/Common rush	*Juncus effusus*	C/LC	10%	OWP	DT	Yes	No

2) Facultative Wetland Plants

Habitat description: Hydric soils, often in geomorphic settings where water saturates the soils or floods the soil surface at least seasonally. This habitat is a transition between permanently flooded wet habitats and upland habitats.							
Plant species characteristic of the habitat – Kinyarwanda/English name	Plant species characteristic of the habitat - Latin name	Status in Rwanda (common, rare, listed, endemic, invasive)/ IUCN status	Typical average plant coverage in this habitat type (in %)	Preference for wetness (facultative wetland plant (FWP), obligatory wetland plant (OWP), submerged plant (SP))	Flood tolerance (FT) or Drought tolerance (DT)	Tolerance to water pollution	Invasive Species (Yes/No)
Observed native wetland plants							
Urukembagufa/Cut grass	*Leersia hexandra*	C/NA	5%	FWP	DT	Yes	No

Ikirogora	*Brillantaisia cicatricosa*	C/NA	1%	FWP	DT	Yes	No
Umuzigangore	*Ludwigia abyssinica*	C/NA	5%	FWP	DT	Yes	No
Igorogonzo/Watersmart weed	*Persicaria decipiens*	C/LC	5%	FWP	DT	Yes	No
Igorogonzo/Watersmart weed	*Persicaria pulchra*	C/LC	5%	FWP	DT	Yes	No
Non-observed native wetland plants							
Umuzibaziba	*Fleroya rubrostipulata*	C/NT (Near Threatened)	1%	FWP	FT and DT	Yes	No
Umukindo/Wild date palm	*Phoenix reclinata*	C/LC	1%	FWP	FT and DT	Yes	No
Urutaretare/	*Pycreus macrostachys*	C/LC	5%	FWP	FT and DT	Yes	

13. APPENDIX 3: AGRICULTURE SURVEY REPORT

Kigali Wetlands Rehabilitation Feasibility and Detailed Design

Assessment of Agriculture activities in five wetlands of the City of Kigali

Final Report

May 2022

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Annexes

1 Context

The Agriculture and Social report was produced as part of the feasibility study and detailed designs for the rehabilitation of five wetlands in the City of Kigali, planned under the Rwanda Urban Rehabilitation Project (RUDPII). These wetlands are shared by the three administrative Districts of Gasabo, Nyarugenge and Kicukiro. The wetlands designated for rehabilitation comprise Rwampara (65ha), Gikondo (162ha), Rugenge-Rwintare (65ha), Kibumba (68ha) and Nyabugogo lower (131ha) as displayed in Table 1.

Table 1. Overview of wetlands selected for detailed planning.

Wetland Name	River/Stream	Area (ha)	Administrative Districts
Gikondo	Rugenge	162	Kicukiro/Gasabo
Rugenge-Rwintare	Rugenge-Rwintare	65	Nyarugenge/Gasabo
Kibumba	Kibumba-Rwezangoro	68	Gasabo
Nyabugogo Lower	Nyabugogo	131	Nyarugenge/Gasabo
Rwampara	Rwampara	65	Nyarugenge/ Kicukiro

Source: REMA, Call for Consultancy services to develop a feasibility study and carry out detailed designs for wetland rehabilitation in the City of Kigali.

- **The Rwampara wetland** is located between Kicukiro District and Nyarugenge District, in the City of Kigali. It is a long and narrow wetland surrounded by densely populated urban areas of Gikondo and Nyamirambo. An incised gully has developed during the past decade and now extends through most of the wetland, being most prominent though, in the steep, upper reaches. The Kigali Sport Club, an important recreational site, is located alongside the lower reaches of the wetland.
- **The Gikondo wetland** includes a broad valley bottom between Nyarugenge, Kicukiro and Gasabo District: It was previously used as an industrial park. Its two tributary arms are utilized for subsistence agriculture and are separated from the main wetland by critical road linkages.
- **The Rugenge-Rwintare wetland** includes the main Rugenge valley between Nyarugenge and Gasabo Districts and the Rwintare secondary tributary between Kimihurura and Kacyiru sectors, in Gasabo District. It connects the Nyabugogo (lower) Wetland with the Gikondo wetland in its upstream.
- **The Kibumba wetland** located in the Kinyinya sector, Gasabo District feeds into the lower reaches of the Nyabugogo (Lower) wetland. The South-eastern arm of the Kibumba wetland is located in the immediate downstream of the Kigali golf course.
- **The lower Nyabugogo** site includes the lower reaches of the main Nyabugogo wetland, including the Mpazi confluence, as well as tributaries from the lower Kibumba and Rugenge-Rwintare wetlands. A large artificial drainage channel also runs through most of this wetland and feeds into an artificial lake at the confluence with the Main Nyabugogo Wetland.

2 Methodology

The methodology for conducting the Agriculture and Social study was designed for collecting, analysing information related to the 5 wetlands and presenting them in a report according to guidelines defined in the Terms of Reference of the study. It was conducted as follows:

Review of key document:

The consultants have reviewed key documents on the Rwanda Urban development Project (RUDPII), agriculture and wetland development, as well as rice and horticulture production in Rwanda.

Identification of Key informants

- A first visit of the 5 wetlands was organized to: i) identify their boundaries; ii) get a broad view on agricultural features; iii) identify cooperatives to be interviewed. Information on key informants were later on collected from District/sector offices and from other stakeholders.
- Key informants from Government institutions included: i) Minagri-Rwanda Agriculture and Animal resources Development Board; ii) Local government officials in Gasabo, Nyarugenge and Kicukiro District; iii) extension officers and other technical staff in the three districts.
- Regarding the users of the wetlands, key informants were: i) Farmers' cooperatives/groups operating in the targeted wetlands; ii) cooperatives managing nurseries and selling trees and ornamental plants; iii) private companies/organizations.

Interviews:

The methodology adopted was based on interviews with the key informants described in the above paragraph. We used interview guides that were produced by the Team Leader in English language. These interview guides were adapted in Kinyarwanda language and provided a general framework that was used by the Consultants in order to facilitate a systematic collection of data/information as indicated in the terms of reference (questionnaire are in Annex 1 of this report and list of cooperatives that were met in Annex 3).

Other data collection:

- Interviews were followed by capturing the position of different stakeholders in the wetlands by using a DGPS: That exercise led to developing a map to visualize agricultural activities across the 5 wetlands.
- Pictures were also taken in different places survey by the consultants.
- Additional data on lands, agriculture, inputs, and markets were also collected.

3 Key findings of the engagement on farming activities

3.1 Main features of agriculture in the 5 wetlands

3.1.1 Categories of stakeholders engaged in agriculture

Interviews and direct observations on the field showed that there were four (4) main categories of stakeholders engaged in agriculture, and agriculture-related activities in the studied 5 wetlands, namely: 1) Farmers' cooperatives; 2) Farmers groups; 3) Individual smallholder farmers; 4) Private /businesses. Table 2 provides an overview of the different stakeholders engaged in agriculture in the 5 wetlands.

The methodology used was focused on farmers' cooperatives to collect information from local representatives of farmers, but we have also included farmers' groups as they consider themselves as cooperatives, even if they are not/not yet officially registered by the Rwanda Cooperative Agency (RCA).

The Rwanda Cooperative Agency (RCA) is a public institution in charge of regulating and promoting economic, social and other activities of general interest. The core activities of the Agency are: i) Registration of cooperative; ii) Arbitration and settlements of disputes/conflicts; iii) Legal and

technical assistance to cooperatives; iv) Promotion and capacity building; v) Supervision, control and audit of cooperatives.

The registration process does not depend on where the cooperative is located. It is the same and it starts from district level where people committed themselves to work under cooperatives submit a compiled document of (letter requesting provisional certificate, cooperative status, fundamental principles, and list of members, list of leaders and a business plan). After district approval, application is moved to RCA for approval and a temporarily working permit of 1 year. Permanent permit of working as a cooperative can be given to a cooperative based on performance. There is no fee charged for registering a cooperative.

There are many benefits of being in a cooperative: i) it is a public policy to work under cooperatives to ensure facilitation of citizens and raise up their livelihoods; ii) Collective investments are better than working alone ; iii) 80% of Cooperative incomes is back shared by members; iv) Easy access to market.

Cooperatives have a governance structure including a general assembly, an executive committee and specific commissions. The day-to-day management is delegated to a Manager (when the cooperative has the resources to pay salaries) under the direct supervision by the President of the cooperative.

Table 2: Characterization of stakeholders engaged in agriculture in the 5 wetlands

Category of stakeholders engaged in agriculture	**Type of production system**	**Key activities**
Farmers Cooperatives	- Market-oriented - Medium to Low level of intensification	- Production and selling vegetables - Production and selling staple crops (rice, maize, soja , beans) - Fish farming - Bamboo production
Other cooperatives	- Market oriented - Specialization	- Production of trees and ornamental plants in nurseries
Farmers' groups	- Market-oriented or subsistence farming - Low level of intensification - Low productivity/yields	- Production and selling Vegetables - Production of staple crops mainly for subsistence (maize , soja , beans)
Individual farmers	- Subsistence farming - Low level of intensification - Low productivity/yields	- Growing banana, sugar cane mixed crops (cassava, maize, beans) - Production of seasonal crops in rotation (Maize, beans, soja) - Vegetable production - Fodder crops (*Penisetum* grass)
Private/businesses	- Market oriented - Intensification	- Production of trees and ornamental plants in nurseries - Improved seeds multiplication - Sugar cane - Rotation of vegetable production and seasonal crops (Maize, Irish potato) - Fodder crops

Category of stakeholders engaged in agriculture	Type of production system	Key activities
Other organizations (Red Cross; Gatenga Training Center)	- Leasing land to private/businesses	- Seed production - Vegetable production - Other crops (Soja; maize)

Source: survey and field observations

3.1.2 Farming practices

a) The key crops developed in the 5 wetlands were grouped in the following 3 main categories:

Vegetables:

- They are mainly cultivated in Rwampara and Kibumba wetlands and a bit less in Rwintare wetland.
- The main species cultivated are Cabbages; Eggplants; Spinach; Carrots; Amaranths; French beans.

Cereals and legumes:

- Cereals (Maize, Rice) and legumes (Climbing Beans and Soya) are the typical seasonal crops in the 5 wetlands. Soya is grown on a smaller scale compared to the other crops.
- Rice is only cultivated in the lower Nyabugogo.
- The other crops were observed in all the 5 wetlands, but at different levels of crop intensification (e.g., very poor status of crops in the former Gikondo industrial area compared to Rwampara or Kibumba).

Perennial crops:

- Banana is the traditional perennial crop, and it is predominant in some areas of the Rwampara wetland, and at a lower level in Rugenge-Rwintare wetland.
- Sugar cane is mostly developed in Rugenge and Nyabugogo wetlands. As the risks of floods have been increasing over the last years, farmers have been replacing rice by sugar cane in Nyabugogo wetlands, as sugar cane is more resistant to floods.

b) Small-scale agriculture is predominant in the 5 wetlands.

- Polyculture is the dominant cropping pattern in Rwintare and the Gikondo wetland and in the Rukili-Rugando tributary arm (right bank) where farmers use to mix different crops on the same parcel of land. This is a type of subsistence farming that is characterized by the low use of agro-inputs and low yields.
- Maize is mostly grown as a monoculture in Rwampara, Kibumba as this is promoted across Rwanda as part of the Minagri-Crop Intensification Programme (CIP).
- Farmers growing vegetables are well organised and specialized, especially in Rwampara and Kibumba wetlands. The production of vegetables is market-oriented, and farmers do well-planned crop rotations to continuously supply different types of vegetables to the market.
- Regarding rice crop, there are two cropping seasons per year (Season A and Season B), but many farmers in Nyabugogo wetland are only able to do one harvest per year because of problems of flooding that occur in March-April.

c) Use of agro-inputs

- Most of farmers growing vegetables, rice and maize are regularly using fertilizers, and agro-chemicals (insecticides and fungicides). No use of banned agro-chemicals was reported.
- The use of manure is essential for getting good yields and some farmers manage to produce their own compost or purchase manure from other farmers or middle-men (one truck of 10 Tons of manure cost 150,000 RwF).
- Three particular cases related to manure were observed during interviews and field works: i) In Rugenge wetland, the Dukundisuku Cooperative has been producing compost through managing a landfill, sorting and composting organic matter and sending the other inorganic matters (plastic, metal , bottles) to the main Kigali landfill in Nduba, Gasabo District ; ii) In Rwampara wetland, cattle owners are growing fodder crops or harvesting fodder from the wetland to feed their cows, and are in return selling manure to vegetable producers; iii) In Rwintare wetland, Girubuntu women farmers' cooperative produced compost using the grass cut from public gardens in Kimihurura or produce compost from toilets.

Table 3: Key features of agriculture per wetland

Wetland	Key agricultural crop/activity	Other agricultural crop/activities	Main category of stakeholders
Rwampara	Vegetable production	- Banana - Maize	- Individual farmers - Farmers groups
Gikondo	Mixed crops	- Improved seed production in Gatenga - Nurseries near Rwandex area. - Mixed crops in former industrial zone	- Individual farmers - Gatenga Youth Training Center (Catholic Church) - YEAN/UNILAK University in the right tributary arm.
Rwintare-Rugenge	Mixed crops	- Vegetables - Bamboo - Nurseries near la Colombière and along the Poids-lourds road - Compost production - Fodder production	- ULK University (crop production on the site previously occupied the buildings of the University) - Nurseries (3 coops, individual users) - Bamboo Cooperative - Farmers groups
Kibumba	Vegetable production	- Fish farming - Maize production - Bamboo	- KOABIGA Cooperative (Utexrwa Zone 5) - Gaculiro TVET Center
Nyabugogo	Rice production	- Sugar cane (as an alternative to rice due to flooding) - Vegetables	- Rice growers' cooperative - Individual growers of sugar cane (10)

Source: Survey

3.1.3 Agriculture production and access to market

Interviews with key informants have confirmed that agricultural activities in the 5 wetlands play a key role in the livelihoods of farmers both as a source of food and revenues.

a) Subsistence farming

As presented in table 2 and 3, most of farmers in Gikondo, Rwintare and some farmers in Rwampara wetland are engaged in subsistence farming: Their production of banana, beans, maize, cassava, sweet potato contribute to households food intake, but the level of production and productivity is low.

b) Market-oriented agriculture

On the other hand, interviews and field observations have shown that there are many farmers who are specialised in producing crops for the market.

- Vegetable producers in Kibumba, part of Rwampara and part of Rwintare wetlands are engaged in an intensive production system, where they grow a wide variety of vegetables on a continuous basis across the year and supply them to different market places in the City of Kigali. The production system combines different planting dates and crop rotations to enable a consistent and competitive supply of their produce to the market. In most of cases, farmers have developed relationship with buyers, who come to purchase the produce directly from the field.
- The produce of maize in Kibumba, Rugenge wetlands is sold to the local market. As urban consumers prefer to consume maize as a snack, farmers growing maize from the wetlands harvest maize before full maturity and sell it on cobs while it is still green. The demand for such a product is high, and one maize cob is sold for 50-100 Frw per piece.
- Sugar cane constitute the other product targeting urban consumers from the Kigali low-income neighbourhoods. It is mainly produced in Nyabugogo and Rugenge wetlands, in areas probe to floods. When harvested, fresh sugar cane is consumed (chewed) as a source of calories by residents of urban poor neighbourhoods. Sugar cane is harvested after one year, and the cane stems are sold for 100-200 RwF according their size.

3.1.4 Challenges to agriculture

The main challenge for agriculture in the wetlands is related to excess of water, which either destroys crops or delays planting periods. The other challenge is related to lack of extension support that affect the capacity of farmers to produce more or to carry out farming activities in a more sustainable way.

Regarding the excess of water in the wetlands, the scale of this problem varies according to the wetland and across time.

- The problem of inundation is most acute in the Nyabugogo wetland where it has damaged rice crops and transformed some rice land parcel into ponds. According to farmers, that is the consequence of the following three factors: i) the depth of the Nyabugogo river has decreased over time (now 1m-1.5 m) due to continuous accumulation of sediments, causing inundations when the volume of waters increase during heavy rains; ii) when upgrading the road that links Gatsata and Gisozi through the wetland, the 2 canals that used to collect water to the bridge were destroyed; iii) the low velocity of waters at the confluence with the artificial lake is also causing floods in the adjacent fields (rice and sugar cane).
- In Kibumba wetland, the inundation that occurred in season 2022B destroyed maize crops in the downstream part of the wetland. The wetland is surrounded by residential areas and the main canal is narrow.
- In Rugenge wetland, farmers have created deep trenches across the wetland to increase the velocity of water and address the issue of flooding. But the environmental consequence of such practices for the wetland can also be huge.
- In the upstream part of the Gikondo wetland (Gatenga), 3 canals has been created to evacuate the waters, but the small size of the drainage infrastructure at the confluence with the Rwandex crossroads creates accumulation of waters that flow back to the wetland and destroy crops.
- In Rwampara wetland, the high velocity of waters has created a very large/deep gully that present a risk for people and cattle. Flooding occurs in the median and downstream part of the wetland.

3.2 Overview of other activities done in the wetlands

3.2.1 Nurseries (Trees and ornamental plants)

The management of nurseries for the production of trees, flowers and other ornamental plants is a key characteristic of the Kigali wetlands. This is a flourishing business that has attracted cooperatives and private businesses. The clients are households and institutional buyers such projects and other organizations.

- Nurseries are most developed in the Nyabugogo and Rugenge wetlands, along the Poids-Lourds road. These nurseries are managed by Imbuga-itoshye cooperative and the Ornamental Plants Producers Cooperatives (OPPC) as well a large number of individual businesses. Only the 2 cooperatives were surveyed during this study. According to interviews, the value of these nurseries varies between 6million and 20million RwF.
- The Imbuga-itoshye cooperative reported that they submitted to the Ministry of Environment a project to create a recreational site in the Rugenge wetland. The cooperative chairman said that cost this project is estimated at 2 Billion Rwf and they are ready to collaborate with the RUDPII Project for the implementation of the wetland rehabilitation.
- In Gikondo wetland, there is no producers' cooperative of ornamental plants: However, private nurseries are located on both sides of the Rwandex crossroad, and near the Kanogo roundabout.
- In Rugenge-Rwintare wetland, the Kwigira Family Cooperative (Reserve Forces members) has nurseries with a capacity of 150,000 trees/ornamental plants. They have specialized in producing many species of indigenous trees and are ready to partner with the RUDPII for the promotion of such indigenous trees.

3.2.2 Bamboo production

The production of bamboo is managed by the COPAKIKA Cooperative in Rwintare wetland. That cooperative has started planting bamboo in 2007 and has so far planted an area of 13Ha. There is another private bamboo producer in Kibumba wetland, Kinyinya Sector, but he was not surveyed during this study.

The objective of the KOPAKIKA Cooperative was to produce bamboo as a raw material for producing tooth pics, 'imishito' for brochettes and provide construction materials. The cooperative considers that its bamboo field has an estimated value of 100-150 Million RwF and they are ready to expand bamboo plantation if such a decision is taken by RUDP II Project.

3.2.3 Fish farming

Fish farming is done in Kibumba and Nyabugogo wetlands.

In Kibumba wetland, Fish Farming is one of the activities conducted by the KOABIGA Farmers' Cooperative, in addition to growing vegetables and maize. The cooperative has 18 fish ponds on surface area of 3 Ha. However, the productivity of fish ponds is constrained by lack of adequate feeds and fingerlings.

In the upper part of Nyabugogo wetland, there are 6 fish ponds that are managed by individual farmers. They were not part of the target group to be surveyed during this study.

3.3 Key considerations for wetland rehabilitation

3.3.1 Land tenure system

Rwampara Wetland

Four (4) Cooperatives of farmers identified in Rwampara wetland have no concession agreement and no tax given to the state. They use the wetland by the approval of local authorities, and the City of Kigali.

Other individual users continue to cultivate their land left after resettlement done in 2019 by the City of Kigali project of protecting wetlands and their buffer zones.

Gikondo Wetland

The characteristic of Gikondo wetland did not allow the study to identify its land tenure system as it was covered by industrial parks and then turned into an idle space by the government's project of relocating industries. The wetland is now used by individual farmers with mixed crops, owners of nurseries, Gatenga Youth Center, UNILAK student's nursery; YEAN Hydroponic Training Center.

Rugenge-Rwintare wetland

Rugenge -Rwintare wetland was owned by individual citizens with land titles, and anyone who wanted to use the land mostly for trees and ornamental plants was supposed to pay rental fees to land owners. 2019 after relocation of houses and business placements done by the city of Kigali, people started to group themselves under cooperatives and request the working authorisation from sectors for free of rental fee.

Kibumba Wetland

The land tenure status for the identified cooperative, private and individual wetland users can be defined by the general way of accessing wetlands in Kigali, which is the submission of a well-prepared business plan to the Ministry of Environment and the City of Kigali for approval and authorisation. For example, COABIGA Cooperative has submitted a project to the Ministry of Environment requesting an official permit for 30 years, but they had not yet got the authorization up to date of our interview.

Nyabugogo

Nyabugogo Wetland was covered by papyrus, and people from neighbourhood committed to turn bushes of papyrus into an agricultural land for tomatoes, fruits and vegetables, rice and sugar canes. In 2013, the Rwanda Cooperative Agency sensitized wetland users to work under cooperatives and Abunzubumwe from Nyabugogo submitted documents for a permit and they now have a temporally working permit.

Membership fees for being registered under Rwanda cooperative Agency wetland was around 50,000 RwF per year and, still cooperatives are working for free of land rental fees.

3.3.2 Agriculture and livelihoods

Currently, wetlands in Kigali City are being used for agricultural activities and they support a variety of local livelihoods. The following table summarizes agricultural activities and benefits to wetlands users.

Table 4: Agricultural activities and Benefits to wetlands users

Wetland	Users	Key agricultural activity	Incomes	Benefits
Rwampara	a) Cooperatives -Duhuguke Dukora -AVEGA Cooperative -Abishyizehamwe -Uburumbuke -TECOCOKI b) Individual users	Maize, Beans, Soya and Vegetable production	Rwampara has 65ha and only 10ha is covered by agriculture under cooperatives. Average incomes from 1are per season of vegetables is estimated to 125,000 RwF	Produce and revue from agriculture contribute the food security of cooperative members' homes and their neighbourhood. Easy to make savings and get loans among members of cooperatives though IKIMINA; Seasonal availability of agricultural production to the local markets; Easy access to agricultural needed equipment by cooperative.
Gikondo	-Recreational activities -YEAN Training center -Individual farmers -Gatenga training center (catholic) -UNILAK University	-Mixed crops; Seed production in Gatenga -Nurseries near Rwandex area. -Mixed crops in former industrial zone		Business owners benefited from using wetland, especially for seed multiplication and nurseries. Some parts of the wetland have a nice view due to the mentioned occupations
Rugenge-Rwintare	-ULK University (crop production on the site previously occupied the buildings of the University) -Nurseries (3 coops, individual users) -1 Bamboo Cooperative -2 Farmers groups	-Vegetables -Bamboo; Fodder -Nurseries near la Colombiere and along the Poids-lourds road -Compost production	Incomes from bamboo plantation are assured as the bamboo (10m) is sold between 1,000 francs and 1,500 Francs (Clients: restaurants, nurseries and factories)	Farmer are able to pay school fees and medical insurances. Markets satisfaction with seasonal production of bamboo, and vegetables. Contribution to household food security. Easy to pay house rental fees to those who do not have own residential houses.

Wetland	Users	Key agricultural activity	Incomes	Benefits
Kibumba	-KOABIGA Cooperative (Zone 5) -Gaculiro TVET center	-Vegetables -Fish farming -Maize production -Bamboo	It was estimated that 75% of the fish harvest were sold whereas 25% was used for household food needs.	The part of vegetable production that is brought back home is very important for nutrition, especially for children. The revenues from farming and fishing enabled cooperative members to pay school fees for children, pay for the medical insurance scheme and contribute to other family needs.
Nyabugogo	-Rice growers' cooperative -Individual growers of sugar cane (10) -Abunzubumwe cooperative	-Rice production Sugar cane (as an alternative to rice due to flooding) -Tomatoes, fruits and vegetables	Around 2.5M can be raised from 600 Sqm of parcel per season of tomatoes. Sugar canes are sold on a daily basis, incomes to people are assured every time of harvest.	Most of wetland users are native of the area and agriculture is the key source of incomes to their homes. No food insecurity in their homes. They are now able to pay school fees to their children's, able to own medical insurances. Easy to pay house rental fees to those who do not have own residential houses

4 Rwampara wetland

4.1 Historical background of farming in the wetland

According to interviews, the Rwampara wetland started to be exploited for agriculture production in 1998. It was then covered by fields of Penisetum grass and the sector agronomist and other local administration authorities mobilised local residents to start cultivating the wetland. First, the wetland was used for traditional crops (banana, sweet potato, beans) and the production system has then evolved to include vegetable production in order to respond to the increasing demand for vegetables from the urban population.

4.2 Identification of users of the wetland

The study has identified the following four categories of users of the Rwampara wetland:

a) Farmers' cooperatives/groups: As presented in Table 5, four cooperatives were identified during the study. They are engaged in market-oriented production schemes.
b) Individual farmers: They are main group of users of the wetland, and they are engaged in traditional, subsistence agriculture. The key crops grown are banana, maize, beans and sweet potato.
c) Livestock owners: Several urban residents own cows or goats and use Rwampara marshland to produce fodder and as a source of water for cattle. Some cows and goats were observed grazing in the wetland during the study. Farmers who cannot produce enough fodder can also buy fodder that is harvested from the wetland.
d) Other users (recreational facilities)

Only the cooperatives/farmers groups were interviewed.

Table 5: Farmers' cooperatives in Rwampara wetland

Name of the cooperative	District	Date of creation	Number of members	Surface area exploited (Ha)	Main activity
Abishyizehamwe-Rwampara	Nyarugenge	2007	32	5 Ha	Vegetable production
Avega_Nyarugenge	Nyarugenge	2010	12	1Ha	Maize
Duhuguke Dukora	Kicukiro	2009	18	2Ha	Maize; Soja Vegetables
Tecocoki	Kicukiro	2007	12	2.8 Ha	Maize; Soja, Beans, Vegetables

Source: Survey

4.3 Activities done or planned by public/private entities in the wetland

The City of Kigali has recently (2020-2021) upgraded the road network in Nyamirambo, Rwampara neighbourhoods in Nyarugenge District, and the road near the Rwampara wetland was tarmacked. As part of the drainage system of the roads, canals were built in masonry to evacuate waters from the road across the wetland to the Rwampara mainstream. These works have significantly reduced the risk of flooding in the central area of the Rwampara wetland.

4.4 Overview of farming activities in Rwampara wetland

Rwampara wetland is characterized by small scale agriculture, with the following key features:

- The upstream zone of the wetland is a narrow space surrounded by the steep hillsides from Nyamirambo-Mumena: It is covered by traditional, non-intensive banana plantation schemes, and fields of *pennisetum grass* to supply fodder for cows. There are also fields for traditional crops such as maize and sweet potato. The zone is also characterized by a large gully that continuously erode agricultural land and pose a threat to people and downstream areas.
- The central zone is a relatively larger area of the wetland located between hillsides of Rwampara (Nyarugenge) and Kimisange (Kicukiro): It is predominantly used for vegetable production in rotation with maize. The farmers' cooperative are mainly operating in that area. To avoid risks of flooding, farmers have put in place simple drainage systems by growing crops on large "billons". The wetland is also a source of grass for cows.
- The downstream zone of the marshland that is crossed by the tarmac road linking Rwampara and Gikondo and is occupied by fields of *pennisetum* grass and some traditional crops (sweet potato, maize).



Cows in the Rwampara wetland wetland



Maize grown near the big gully-Rwampara



Harvesting fodder for cows_ Rwampara



Maize filed_ Rwampara downstream

4.5 Vegetables as a source of income and livelihoods

In Rwampara wetland, the production of vegetables is mainly done by 3 farmers' cooperatives: i) Abishyizehamwe farmers' cooperative (5Ha; Nyarugenge District); Duhuguke-Dukora Farmers' Cooperative (2 ha; Kicukiro District); Tecocoki Cooperative (2.8 ha; Kicukiro District). Their production schemes are market-oriented, although farmers keep a small part of their produce for the consumption needs of their families.

- The cooperatives have their internal organisation where each farmer was allocated a parcel of land for farming, with a typical parcel size of: i) 9 Ares for Abishyizehamwe farmers' cooperative; ii) 15 Ares for Duhuguke-Dukora Farmers' Cooperative; iii) 4 Ares for Tecocoki Cooperative.
- The production of vegetables is done according to a plan agreed upon at the beginning of each season. The main types of vegetables produced are cabbages, amaranths, tomato, pepper, beetroots, and spinach. Some farmers have started growing high income generating species such as Choux de Chine and Gombo.
- The production system is quite intensive as farmers can do three (3) harvests per year. However, Duhuguke-Dukora cooperative have to reduce the surface cultivated in season C (from May to September) by half, because they do not have enough capacity to irrigate their vegetables during the dry season.
- Seeds are purchased from agro-dealers as well as fertilizers (NPK, Urea, DAP, foliar fertilizers). The use of pesticides is a current practice, and farmers have been trained on how to use them (Rocket: insecticide; Dithane: fungicide). No herbicides were used by the cooperatives.
- Regarding the market, the vegetables produce is primarily sold to the Nyarugenge and Gikondo market, but some clients prefer to come and collect the produce directly from the field. Almost

90% of the crops are sold to the market and the rest is consumed at family level or shared with neighbors.

- The vegetables produce is very important for the farmers' households both for food security and income. The respondent from Abishyizehamwe cooperative said that she gets an income of 600,000 Francs per year from producing and selling vegetables (150,000 Frw per Are), and that contributed to pay school fees for children. For Duhuguke-Dukora Cooperative, a farmer who produce spinach on 1 Ares can sell them for 100,000 Frw. The revenue can be doubled when growing Gombo and Choux de Chine.
- As members of the cooperatives do not have other agricultural land outside of the wetland, they are in fear of being evacuated from the wetland that plays a key role in their livelihoods.

4.6 Challenges and opportunities

The key challenge for agriculture in the Rwampara wetland is the permanent risk of floods, especially in its median zone and downstream zone, but also the intense erosion that has created a large and deep gully in the upstream part of the wetland. The other challenge is that farmers do not have access to small irrigation equipment and training/technical support to improve their farming practices.

Despite these challenges, there is an opportunity to increase the area covered by vegetables that have a high market demand and are a source of revenues and foods to these poor urban households.

5 Gikondo wetland

5.1 Historical background of farming in the wetland

The main Gikondo wetland has been developed into an industrial park in the mid-seventies and was not previously subject to any economic activity. The industrial park was relocated to Masoro, Gasabo District and the wetland is slowly recovering its primary functions, despite few scattered agricultural activities.

The wetland has two tributary arms:

- Most of the land in the Gatenga tributary arm is within the property of the Gatenga Youth Center (Catholic Church) and that land is leased to private businesses for agriculture production;
- The Rukili-Rugando tributary arm has mainly been used by individual farmers for subsistence agriculture. It spreads from the UNILAK University on the upstream to the Rwandex crossroad at the junction with the main Gikondo wetland.

5.2 Identification of the users of the wetland

The main Gikondo wetland is not an area dedicated for agricultural activities. Therefore, one of its characteristics is that there is no organized cooperative or group of farmers operating in that part of the wetland. However, since the recent relocation of the industrial park, many individual farmers coming from neighbouring sectors started growing some traditional crops such as beans and maize in the wetland.

As indicated in Table 6, the users of the Gikondo wetland can be summarized as follows:

- Main Gikondo wetland: i) Individual farmers who came to plant crops after the relocation of the industrial park; ii) owners of nurseries.
- Gatenga tributary arm: i) Individual farmers; ii) Gatenga Youth Center.
- Rukili-Rugando tributary arm: i) Individual farmers; ii) UNILAK students nursery; iii) YEAN Hydroponic Training Center.

5.3 Activities done or planned by public/private entities in the wetland

The key activity done by the Government was the relocation of the industrial park from the Gikondo wetland. The other intervention was from the Gatenga tributary arm where a drainage system was put in place to evacuate storm waters through the Rwandex crossroads. However, the dimensions of the drainage infrastructure do not allow a quick evacuation of water, causing inundation in the downstream part of the Gatenga Youth Center property.

5.4 Overview of Farming activities in Gikondo wetland

Table 6: Overview of Farming activities in Gikondo wetland

Zone of the Gikondo wetland	Categories of users	Key activities
Main Gikondo wetland	Individuals	Scattered subsistence agriculture done by farmers after the relocation of the industrial park. The vegetative aspect of the crops was very poor as the current status of the soil is not suitable to agriculture.
	Individual/small businesses	Private nurseries for production of trees and ornamental plants are located near the junction of the main wetland and its tributary arm (Rukili-Rugando). The other group of nurseries is located between the Kanogo roundabout and the downstream of the Gikondo wetland.
Gatenga tributary arm	Individuals	Scattered subsistence agriculture in the upstream part of the wetland
	Individual/small businesses	Private nurseries for production of trees and ornamental plants are located between the Rwandex crossroad and the Zion Temple Church in Gatenga.
	Gatenga Youth Center	Gatenga Training Center is managed by a congregation affiliated to the Catholic Church: They are Leasing land to a private seed company, whereas the remaining land is used for fodder production.
Rukili-Rugando tributary arm	Individuals	Subsistence agriculture, mainly maize, beans and sweet potato.
	Individuals	Fish farming (2 fish ponds not well maintained)
	YEAN Training Center	Hydroponics Training Center: YEAN is a social enterprise that provides agriculture extension focusing on young in agribusiness. They have installed a demonstration green-house where strawberries are grown under hydroponics.
	UNILAK University	UNILAK University has a partnership with the YEAN Training Center to provide opportunity for practices to students (rural development and environment): A tree nursery (capacity 50,000 seedlings) was put in place by UNILAK students.

Source: Survey

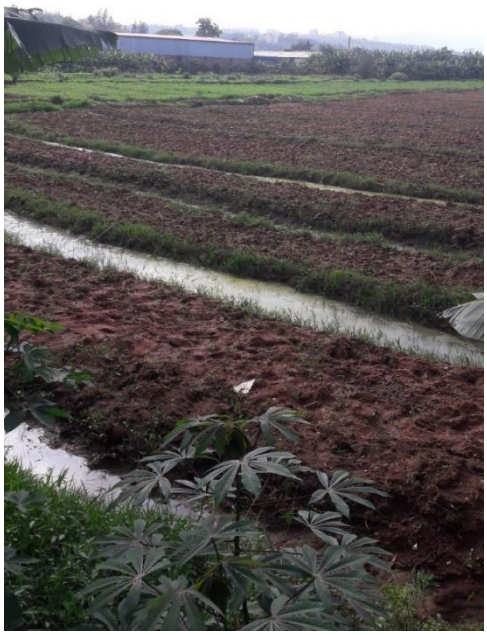


YEAN training ad demonstration Center



Subsistence agriculture near UNILAK University





Improved seeds multiplication site at Gatenga_ Gikondo wetland

5.5 Improved seeds multiplication in Gikondo wetland

The multiplication of improved seeds is the most important agricultural activity in the Gikondo wetland. This is done by Kilimo General Business on 3Ha of land that they lease from the Gatenga Youth Training Center: The remaining part of the compound (5Ha) is covered by buildings of the Gatenga Training center as well as some idle land that is either regularly inundated or covered by fodder crops (*Penisetum purpureum*)

The core activity of Kilimo General Business in the Gikondo wetland is production/multiplication of improved seeds: The Company is specialized in early-stage multiplication of seeds (Basic seeds): The objective is to produce seeds that are re-used for further stages of the seed multiplication process in other sites, in the Northern Province. The production of hybrid maize seeds is a commercial business that is highly encouraged by MINAGRI, as part of the national strategy to make Rwanda self-sufficient in seeds. They work with RAB (Rwanda Agriculture and Animal Resources Development Board) for getting the planting material as well as with another Government Agency for inspection (RICA-Rwanda Inspectorate, Competition and Consumer Protection Authority).

During the interview they were planting single-crossed Hybrid maize, variety 1520. The previous season (2022A), the company has multiplied: i) single-crossed Hybrid maize, variety 1520; ii) single-crossed Hybrid maize, variety 1501; iii) MAC 44 Beans variety. Basic seeds can be re-multiplied twice for producing commercial seeds that are used by farmers.

The company has 2 agronomists who are in charge if all technical activities related to seed production. They use casual workers who are trained/advised on how to manage activities related to seed production.

The main challenge to the seed multiplication is the risk of inundation, and any action to be taken to address the inundation will be valuable.

6 Rugenge-Rwintare wetland

6.1 Historical background of farming in the wetland

Over the last 25 years, the physiognomy of the Rugenge-Rwintare wetland has drastically changed with the development of economic activities (housing, business facilities, learning institutions, agriculture). The recent relocation of houses and business facilities from the wetland was a game changer milestone. It has created a new dynamic for wetland management, and the current users of the wetland are mainly engaged in agriculture or-agriculture-related activities.

6.2 Identification of users of the Rugenge-Rwintare wetland

As presented in Table 6, the main users of the wetland are classified in the following categories:

- Farmers' cooperatives: Despite the small size of the wetland (65Ha), there are 8 farmers' cooperatives, mainly operating in the Rwintare subsidiary, indicating the pressure on land in that particular area.
- Individual farmers
- Tree and Ornamental plants producers Cooperatives:3
- Individual tree nurseries
- Private businesses/organizations.

Table 7: Farmers' cooperatives in Rugenge_Rwintare wetland

Name of the cooperative/Farmer group	District	Number of members	Surface area exploited	Main activity
Imbuga-Itoshye cooperative	Nyarugenge	20	5-20 Ares per member	Nursery
OPPC (Ornamental Plants Producers Cooperative)	Nyarugenge	15	5-15 Ares per member	Nursery
Koperative y'Abahinzi ba Kimihurira na Kacyiru (KOPAKIKA)	Gasabo	37	17Ha	Bamboo (13Ha) Vegetables and maize (3Ha)
Kwigira Family Cooperative (Reserve Force members)	Gasabo	12	1.5 Ha	Nursery with specialisation on indigenous trees
Dufatanye farmers Group	Gasabo	22	2 ha	Banana, Vegetables on the site of former APABENA Association
Girubumuntu Farmers' cooperative	Gasabo	17	0.7Ha	Vegetable production; other subsistence crops
Dukundisuku Cooperative	Gasabo	16	1 ha	Production of compost from landfill; nursery
KOKAWI Cooperative	Gasabo	30	3.5Ha	Mixed crops. Not well organised.

Source: Survey

6.3 Activities done or planned by public/private entities in the wetland

The main intervention done by the Government was to relocate from the Rugenge-Rwintare wetland human settlements as well as commercial buildings and the facilities of the ULK University. Two road drainage infrastructures were also put in place, enabling to channel runoff waters from Kimihurura and Kacyiru main roads directly into the Rwintare canal, and by doing so, partly reducing the risks of inundation in the wetland.

6.4 Farming activities in Rugenge-Rwintare wetland

Agricultural activities across the Rugenge-Rwintare wetland can be subdivided into (5) categories:

a) **Nurseries:** This is the most visible intervention in the wetland, and its importance is justified by the number of stakeholders engaged in nursery management (3 cooperatives and many individual small businesses) as well as its contribution to the beautification of the City of Kigali and environmental conservation.

b) Bamboo production: This is a unique intervention done by a farmers' cooperative (KOPAKIKA) in Rwintare wetland, Gasabo District.

c) Market-oriented crop production: This is done by farmers' cooperatives (e.g. KOPAKIKA and Girubuntu Cooperatives) that produce vegetables for the Kigali market. We have also observed the production of vegetables, Irish potato on a consolidated area estimated at (5Ha) on the site where were removed the facilities of the ULK University.

d) Fodder production: Field of *Penisetum* grass and *Umutete grass* were observed on the site where were removed the facilities of the ULK University.

e) Subsistence agriculture: This is one of the characteristics of Rwintare wetland where farmers continue to grow banana, beans and cassava for subsistence.

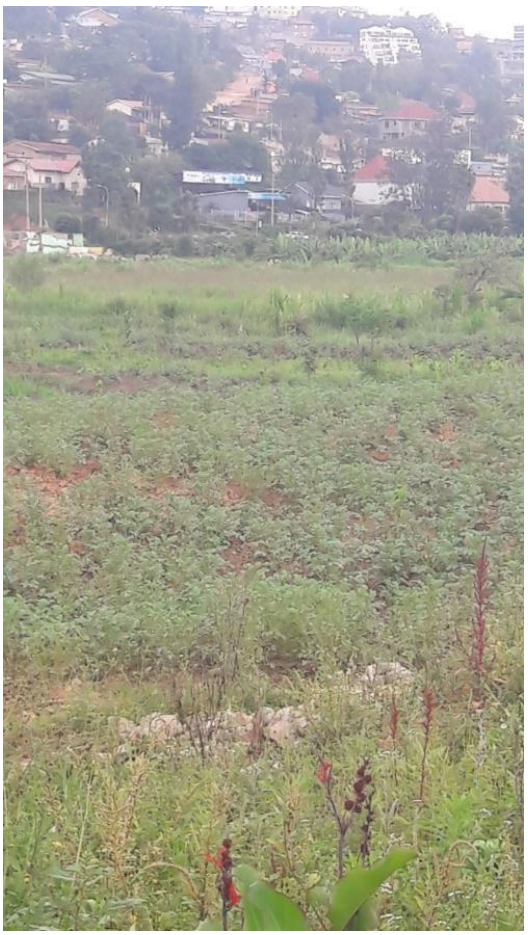
Table 8: Overview of Farming activities in Rugenge-Rwintare wetland

Zone of the wetland	Categories of users	Key activities
Rugenge	Cooperatives of producers of trees and ornamental plants	There are 2 two cooperatives of producers of Trees and Ornamental plants who operate along the Poids-Lourds road, namely Imbuga-Itoshye Cooperative and OPPC(Ornamental Plant Producers Cooperative)
	Individual/small businesses	Private nurseries for production of trees and ornamental plants are located along the Poids-Lourds road. Their number is not known by local authorities/agronomists.
Rwintare	Farmers' Cooperatives	- Bamboo production - Maize and vegetable production - Production of compost
	Individuals	Scattered subsistence agriculture in the upstream part of the wetland
	Cooperatives of producers of trees and ornamental plants	The Kwigira Family Cooperative composed of members of the Reserve Force manage a nursery of 150,000 seedlings. They are specialised in producing indigenous trees.
	Individual/small businesses	Private nurseries for production of trees and ornamental plants are located near Kimicanga and la Colombière School
	ULK University	- Fodder production - Production of Vegetables and Irish potato.

Source: Survey and field observations



Nursey, Kwigira Family Cooperative



Potato and fodder crops at former site of ULK University site



Bambou plantation: Rwintare wetland



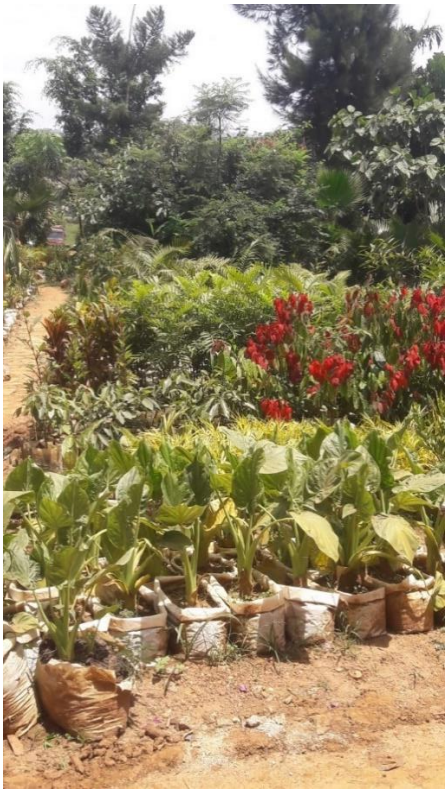
Production of compost_Rugenge wetland



Production of fodder _Rugenge wetland



Nursery and Banana production-Rugenge



Imbuga Itoshye Cooperative_Rugenge

6.5 Bamboo production in Rwintare wetland

The production of bamboo is managed by the COPAKIKA cooperative in Rwintare wetland. The name of the cooperative indicates that it is composed by farmers from Kimihurura and Kacyiru Sectors in Gasabo District. The cooperative has 37 members, with the majority of female members (33).

That cooperative has started planting bamboo in 2007 and has reached a planted area of 13Ha. The bamboo forest is easily accessible, as it is bordered by a tarmac road and 2 lateral feeder roads. Before planting bamboo, the cooperative was involved in the promotion of mulberry trees, in partnership with the National Sericulture Programme. They had to replace mulberry trees by bamboo because of the sericulture business was not successful. When the Kimicanga neighbourhood residents were relocated to other places, the Cooperative was contracted by the Government for planting trees that have developed into a nice forest now.

The objective of the cooperative was to produce bamboo as a raw material for producing tooth pics, 'imishito' for brochettes and provide construction materials. One pole of bamboo (10m) is sold between 1,000 francs and 1,500 Francs. The bamboo produce is also used to get cuttings that are used by owners of nurseries. In that case, specialized technicians come to the site to select most suitable bamboo stems and prepare the cuttings. However, there is a problem of low demand of the bamboo produce, and when bamboo trees are not harvested on time (after 7 years), their quality deteriorate.

The cooperative considers that its bamboo field has an estimated value of 100-150 Million RwF. When they sell bamboo, the revenues are redistributed to members and the cooperative has a saving scheme that enable to give loans up to 100,000 RwF to members with an interest rate of 5%.

They are confident that planting bamboo in the wetland is in line with the development/rehabilitation of wetland and they are ready to plant more bamboo if they were requested to do so. This is a cooperative mostly composed by widows, and what they need is support to address their vulnerability: (e.g. Accessing finance to venture into bamboo processing/adding value).

They think that it would be good to upgrade their bamboo forest into a recreational area, by creating paved walkways to enable people to enjoy these places.

7 Kibumba wetland

Kibumba wetland is located in the Kinyinya sector, Gasabo District. It feeds into the lower reaches of the Nyabugogo (Lower) wetland that is shared by the Nyarugenge and Gasabo districts in the City of Kigali. The South-eastern arm of the Kibumba wetland is located in the immediate downstream of the Kigali golf course.

7.1 Historical background of farming in the wetland

The Kibumba wetland was exploited by smallholder farmers, who gradually organised themselves into farmers' groups until they joined the KOABIGA Cooperative in 2017. Since its creation, KOABIGA had the ambition to consolidate in one cooperative entity all farmers 'groups operating in different sectors/wetlands of the Gasabo District. KOABIGA Cooperative is organised into 5 zones, with each zone corresponding to a particular sector/wetland. Therefore, farmers from Kibumba wetland joined the KOABIGA Cooperative as Zone 5 (or Utexrwa zone) covering the area of the wetland that is located in Kinyinya sector, Kagugu and Gaculiro administrative cells. The Cooperative is made of permanent members but employs more than 800 other residents who work in various agricultural activities.

7.2 Identification of users of the wetland

In Kibumba wetland, KOABIGA cooperative has 200 members who are organized in 9 groups (8 groups for agriculture and 1 group for fish production). Each group is composed by at least 20 farmers, whose houses are located on the hills surrounding the wetland. Each farmer paid a membership fee to the cooperative (10,000 Frw/person) and was allocated a piece of land for farming. The land size per farmer ranges from 2.5 to 65 Ares.

The Cooperative has submitted a project to the Ministry of Environment with a request to get an official lease to use the wetland for 30 years, but they had not yet got the authorization in April 2022 when the interviews were held.

The other users of the wetland are:

- Gaculiro Technical Education and Vocational Center (TVET): They have land and a playing ground within the limits of the wetland. The Center is managed by a congregation affiliated to the Catholic Church.
- Croix-Rouge: This an international Organization with a big property both on hillsides (Kacyiru sector, Gasabo District) and in the Kibumba wetland, starting at the end of the Kigali Golf Club. The land in the wetland is leased to private operators for recreational activities and for agriculture.
- There is another private bamboo producer in Kibumba wetland, Kinyinya Sector, but he was not part of the informants to be surveyed during this study.

7.3 Activities done or planned by public/private entities in the wetland

Kibumba wetland is crossed by a feeder road linking Gisozi and Kinyinya sector, and its downstream part is bordered by a tarmac road heading to the Gisozi commercial park.

From the interviews held at Gasabo district, it was communicated that there was a project idea to build another youth training center near the current Gaculiro TVET.

In 2019, the District of Gasabo in collaboration with other government institutions has relocated houses from the wetland, in Kabuhunde 2 and Kadobogo villages. The people affected by this action are renting houses in the neighbourhood and continue to do agriculture in the wetland.

7.4 Farming activities in Kibumba wetland

In Kibumba wetland, farming activities are done by the 'Utexrwa zone' of KOABIGA Cooperative. That zone is organised into 9 farmers' groups, with 8 groups engaged in agriculture activities, whereas the 9th group is conducting fish farming.

Market-oriented agriculture

The cooperative is engaged in market-oriented agriculture production schemes. The strategic location of the Kibumba wetland near the Gisozi commercial park (Agakiriro) and the densely populated urban area provide an opportunity for market as the demand for vegetables and other fresh produce is high. The produce is purchased directly at farm site by traders who re-sell it to the population in Kinyinya and Gisozi Sectors.

Crops and cropping patterns:

The cooperative is mainly engaged in growing vegetables (tomato, cabbages, amaranths, French beans) as well as seasonal crops such as Maize, Soya and Climbing Beans. They are discussing with a project supported by the African Evangelistic Enterprise (AEE) that plans to introduce a contract-farming approach where farmers will shift to new cash crops (pepper, French beans, garlic, and onions). However, the cooperative is still waiting to understand the profitability of such crops and get the assurance on access to market.

The crop rotation is agreed upon between members of each farmers' group. The detailed planning of activities is done at group level where all members have to follow the same crop calendar.

Despite the key constraint of flooding, especially in the downstream part of the wetland, farmers can do 3 to 4 cropping seasons for vegetables in a year which is quite intensive and shows a good level of internal organisation. They use agro- inputs (seeds, fertilizers, and pesticides), showing that they are following a clear crop intensification path. Farmers have in general the required skills to grow vegetables and maize and they closely work with 2 agricultural advisors who provide extension support and training on agricultural practices.

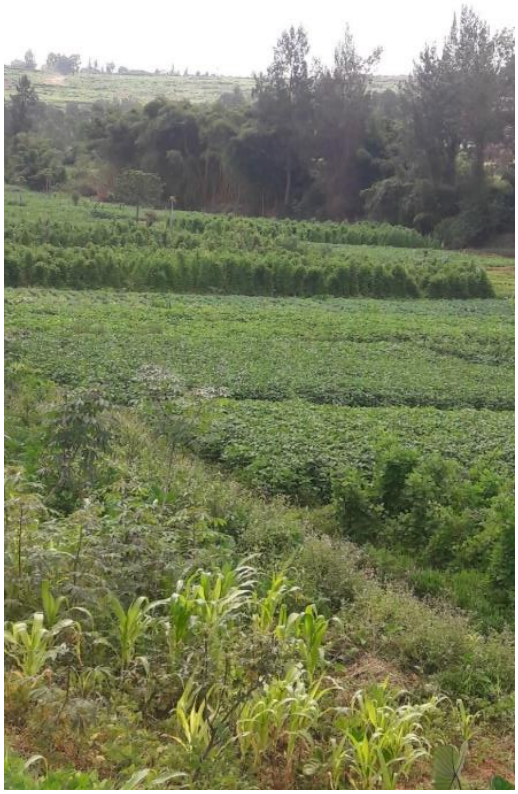
Income and Livelihoods

Interviews have confirmed that farming was the main activity of the members of the KOABIGA cooperative and it is therefore their key source of income. It was estimated that 75% of the crops were sold whereas 25% was used for household food needs. That part of the vegetable production that is brought back home is very important for nutrition, especially for children. The revenues from farming enabled cooperative members to pay school fees for children, pay for the medical insurance scheme and contribute to other family needs.

The cooperative members are also actively engaged in savings and credit operations: Each group has its own saving scheme where a farmer can save between 500 RwF and 30,000 RwF per week according to the capacity, and the amount saved can be withdrawn after one year. In addition to that, each group has a mutual credit scheme *(Ikimina)* where members can contribute 1,000-2,000 RwF per week and each farmer will get back a sum of money to be paid according to an order agreed upon between members. When a farmer wants to access to a bank loan (or from a micro-finance institution), he/she can get a guarantee from the cooperative.

Challenges

The main challenge for farming in the Kibumba wetland is flooding that occurs mainly in April and causes the destruction of crops. During season 2022B, the early rains in February-March have destroyed part of the maize fields.



Beans production _Kibumba wetland



Cabbages, Fish pond, Bamboo_ Kibumba wetland

7.5 Fish farming in Kibumba wetland

In Kibumba wetland, Fish Farming was introduced in 2017 by the KOABIGA Farmers' Cooperative. This was done in addition to growing vegetables and maize, as part of their revenue's diversification strategy. The cooperative has 18 fish ponds on surface area of 3 Ha that were put in place with the support of PAIGELAC, a Government Project funded by the African Development Bank. The cooperative is currently constrained by the lack of quality fingerlings, and had to produce *Clarias* cat fish that are not attractive on the market. They plan to acquire tilapia fingerlings from the Kigembe Pisciculture Center in the Southern Province, but they had not yet the necessary resources.

The other factor that affects the productivity of fish ponds was the lack maintenance and the non-use of fish feeds.



Fish farming _KOAIGA Cooperative _Kibumba wetland

8 Nyabugogo Wetland

In this study, the term Nyabugogo wetland refers to the lower Nyabugogo. The Nyabugogo wetland includes the lower reaches of the main Nyabugogo wetland, including the Mpazi confluence, as well as tributaries from the lower Kibumba and Rugenge-Rwintare wetlands. A large artificial drainage channel also runs through most of this wetland and feeds into an artificial lake at the confluence with the Main Nyabugogo Wetland.

8.1 Historical background of farming in the wetland

As a site of confluence of waters from the main Nyabugogo wetland, Mpazi and the other wetlands subject to this study, the recent history of the lower Nyabugogo wetland was characterized by a continuous increase of flooding in terms of frequency and magnitude. Rice cultivation was introduced in the main Nyabugogo wetland (Kabuye) in 1962, under the responsibility of the Ministry of Agriculture. The scheme was later on transferred to a public entity Soproriz until 2003 and then to cooperatives. CORIKA is the rice producers' cooperative in the main Nyabugogo wetland, whereas farmers in the lower Nyabugogo are organized into the KOPRORIKI Cooperative.

In addition to growing rice, farmers in Nyabugogo wetland are cultivating sugar cane, especially in zones not suitable to rice due to flooding or lack of adequate irrigation system. Some parts of the wetland are also used to growing seasonal crops (maize) and vegetables.

8.2 Identification of users of the wetland

Four main categories of users have been identified in the lower Nyabugogo wetland:

a) **Farmers cooperatives**: Two cooperatives were identified, one for rice production, another one for the production of maize and vegetables.
b) **Ornamental plants producers' cooperatives**: Two cooperatives were identified. They were previously described as they also operate in the Rugenge wetland.
c) **Individual farmers**: These are those who are mainly growing sugar cane in the wetland, whereas others were growing maize or vegetables. Some individual farmers managed to create 6 fish ponds in the upper part of the wetland, near the Kinamba Bridge.
d) **Private/businesses:**
   - These are owners of trees nurseries, who have not yet decided to join the cooperatives or who left those cooperatives. They number is not known as they were not surveyed as part of this study.
   - A private owner has developed a recreational facility near the confluence with Kibumba wetland, and is growing sugar cane in the remaining part, while waiting for the decision of the Ministry of Environment to his request to develop a bigger recreational facility in the zone.

Table 9: Farmers' cooperatives in Nyabugogo wetland

Name of the cooperative/Farmer group	District	Number of members	Surface area exploited	Main activity
Imbuga-Itoshye cooperative	Nyarugenge	20	5-20 Ares per member	Nursery
OPPC (Ornamental Plants Producers Cooperative)	Nyarugenge	15	5-15 Ares per member	Nursery
Coproriki Cooperative	Gasabo	75	30Ha; 12.5 Ares per member	Rice, sugar cane
Abunzubumwe Cooperative	Gasabo	27	3 Ha; 5-30 Ares per member	Vegetables, Maize

Source: Survey

8.3 Activities done or planned by public/private entities in the wetland

The Ministry of Agriculture has executed development works of the irrigation network in the main Nyabugogo wetland (2017), but such works have not been done in the lower part of the wetland. However, some excavation works are regularly done by the City of Kigali near the Kinamba Bridge to enable an adequate flows of waters through the wetland.

Unfortunately, it was reported that some individuals use to burn tires within the wetland, causing pollution to the soil and water.

8.4 Farming activities in Nyabugogo wetland

8.4.1 Rice production constrained by floods

In the lower Nyabugogo wetland, rice production is done by COPRORIKI, a farmers' Cooperative regrouping 50 members. The rice perimeter is subdivided into blocs of 1.25 Ares (25m*25m) and each farmer was allocated between 2 and 4 blocs.

The crop calendar is organized into 2 seasons as follows: i) Season A: June-December; ii) Season B: December– June.

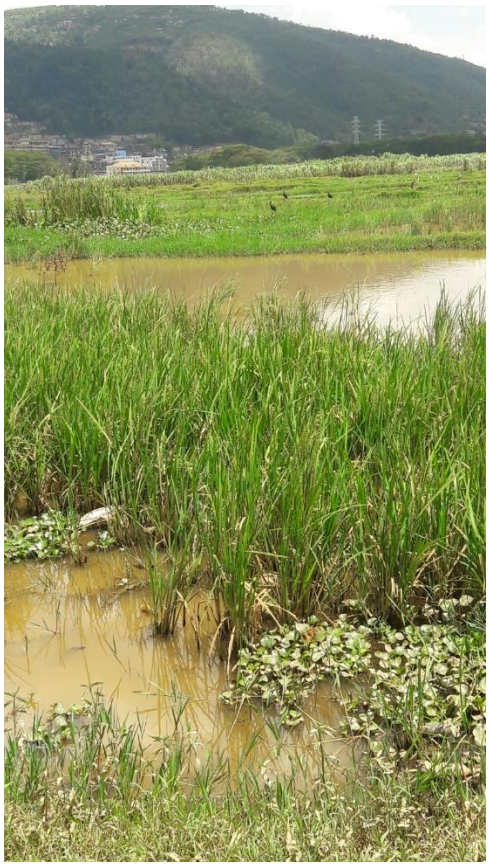
The rice varieties cultivated are *'Fashingabo'* and *'Mbakungahaze',* with a production of 500-600Kg of paddy rice per bloc. With paddy rice sold at 350-380 RwF/Kg, that represents an income ranging between 175,000 RwF and 228,000 RwF per Bloc per season.

However, due to the issues of flooding, planting dates can be delayed and some farmers were obliged to stop cultivating rice in some parcels and replaced rice by sugar cane. The rice that was planted in January 2022 was particularly destroyed by flooding due to heavy rains and the following preexisting factors reported by farmers:

- The depth of the Nyabugogo river has been reducing over time due to accumulation of sediments, leading to inundation during heavy rains;
- The road crossing the wetland and linking Gisozi sector and Gatsata sector was rehabilitated in 2022 in the framework of a water supply project in the City of Kigali. Having that road again operational was a relief for local residents whose only solution was to cross the wetland by boat through the artificial lake. However, two drainage canals were obstructed during the road rehabilitation roads, increasing flooding and transforming rice fields into ponds.

- Farmers reported that the artificial lake created at Nyabugogo had also an impact on increasing inundations and destruction of rice crops.

The rehabilitation of the lower Nyabarongo wetland has the potential to enhance rice production and generate 450 Tons of paddy rice per year, based on two cropping seasons and a yield of 6 MT/Ha.



Nyabugogo wetland : rice crops destroyed by floods crossing the wetland



Destruction of canal alongside the road



Boat transporting people through the artificial lake



Burning tires in Nyabugogo wetland



Nyabugogo wetland: Sugar cane replacing rice in areas prone to flooding



Sugar cane selling point_ Nyabugogo wetland



Maize field near Kinamba



Fish pond and sugar cane in Nyabugogo wetland

ANNEXES

Annex 1:

Qualitative questionnaire to be used with agricultural cooperatives and extension officers

Identification of the respondent

- Names of the respondent:
- Function:
- Location**:**

A. Have you been met in the framework of the RUDPII before?

B. Delineation of the surface of agriculture land managed by the cooperative

C. Description of land tenure system

D. Average (typical) size of parcel

E. Description of activities

F. Number of farmers using the wetlands

G. Description of the use of pesticides, herbicides and fertilizers

- Names of pesticides*:* Herbicides:
- Please describe who provides/authorizes these pesticides:
- Please ask if people are using banned pesticides*:*
- Fertilizers:

H. Description of value chain / use of the crop (subsistence agriculture, commercial agriculture)

I. Role of the parcels in the wetland in the provision of household food and income

J. Have farmers been informed on the city plans to develop/rehabilitate the wetlands?

- If yes, how and when and in what framework (consultants, RUPD II public consultations or the city or the MINAGRI).

K. Discussion on the sustainability of farming practices

L. Have people been physically resettled out of the wetland (recently)?

- Physically resettled means that houses have been relocated outside of the wetlands:

M. Have people been economically resettled out of the wetland (recently)?

- Economically resettled means that agricultural parcels have been moved out of the wetlands.

N. Will people be economically resettled out of the wetland because of RUDPII

- Have farmers already been required to relocate to other parcels?
- Who has asked farmers to relocate?
- People are now allowed to use wetland for agriculture through cooperatives
- When will farmers be relocated and where will they be relocated?
- Have people been compensated accordingly?
- Is there available land nearby for people to relocate their parcels elsewhere?

O. Assessment of farmers' capital

(a) Physical capital (the equipment, tools, infrastructure and physical structures that are accessible and used by farmers to undertake their activities in the wetland)
(b) human capital (knowledge, skills, experiences and capacities that people have to carry out their livelihoods and income-generating activities)
(c) social capital (relationships and connections that people have with each other and that provide them with support in their livelihood activities)
(d) institutional capital (level of support from extension officers)
(e) financial capital (access to credit and loans)

P. Willingness to change agriculture, to adopt new methods (more sustainable agro-ecological methods)

- Are farmers willing to change agriculture, to adopt new methods or management practices?
- Do you think that they have the capacity to change or the willingness?
- Are you aware of any pilot programs where more sustainable approaches to wetland agriculture have implemented?
  (It is key to assess social acceptability of possible changes of agricultural methods for all farmers.)

Q. Willingness to stop agriculture in the wetlands

Do you think that this will lead to severe impacts on their lives and livelihood?

*(Poverty, Lack of medical insurance fees, lack of school fees, Mal nutritional diseases, delay in family financial development**)***

R. Willingness to make compromises

If rehabilitation takes place in some areas, such as along the rivers to re-create natural meanders and this impacts some farmers but not all, will this lead to some issues that we should be aware of?

It is key to assess social acceptability of possible reduction of the number of agricultural parcels in the wetlands.

S. To your knowledge what could be done to improve the state of the wetland or to transform agriculture into more environmentally friendly (sustainable) agriculture?

Please collect opinion and ask about return of experience (what has been done elsewhere).

T. Do you have any manuals or guidelines that you share with farmers on agricultural practices?

Are farmers following some guidelines or a "farmer's manual" detailing authorized practices and agricultural methods?

Can you share this manual or these guidelines?

U. Awareness of the City Wetland Master Plan (with the designation of zones)

Are you aware of the City Wetland Master Plan?

The CoK Master Plan 2020 has developed a zoning of urban wetlands.

The following figure shows the City Master Plan zoning of all wetlands, and this zoning divides the wetlands in 5 categories (according to the Zoning regulations).

W1 - Buffer Zone

W2 - Rehabilitation Zone

W3 - Sustainable Exploitation Zone

W4 - Conservation Zone

W5 - Recreational

Annex 2: Delineation of agricultural activities in the wetland

Name of Wetland	Point Name	Northing	Easting	Elevation
Kibumba	kibumba_ Vegetables-KOABIGA Cooperative	4787639.041	508771.382	1373.749
	kibumba_ Vegetables 1-KOABIGA Cooperative	4787643.018	508787.978	1374.122
	kibumba_ Vegetables 2-KOABIGA Cooperative	4787623.307	508748.711	1373.368
	kibumba_ Fish farming 1-KOABIGA Cooperative	4787543.975	508642.42	1372.968
	kibumba_ Fish farming 2-KOABIGA Cooperative	4787515.156	508590.363	1372.409
	kibumba_ Fish farming 3-KOABIGA Cooperative	4787485.439	508542.94	1372.031
	kibumba_ Fish farming 4-KOABIGA Cooperative	4787451.479	508493.69	1371.897
	kibumba_ Fish farming 5-KOABIGA Cooperative	4787419.76	508460.709	1371.686
	kibumba_ Maize-KOABIGA Cooperative	4787016.141	507867.231	1366.301
	kibumba_ Sugar cane plantation	4786797.683	507284.74	1364.175
	kibumba_ Croix rouge_ Soja production	4786684.41	508702.566	1371.117
	kibumba_ Nursery near Croix rouge	4786757.043	508750.181	1373.061
Nyabugogo				
	nyabugogogo_ Nursery-Imbuga Itoshye Cooperative	4786009.851	506742.244	1362.822
	nyabugogo-Maize field near Kinamba	4786021.396	506798.158	1361.309
	nyabugogogo_ Nursery 2-Imbuga Itoshye Cooperative	4786007.265	506828.282	1362.011
	nyabugogo_ Individual fish farming ponds	4786070.909	506483.701	1359.805
	nyabugogo- Artificial Lake	4785981.892	505707.242	1359.686
	nyabugogo -Rice production- Coproriki cooperative	4786310.898	505301.02	1357.282
	nyabugogo -Sugar cane replacing rice in areas prone to floods	4786251.284	505314.437	1357.93
	nyabugogo -Rice production- Coproriki cooperative	4786309.506	505595.62	1356.641
	nyabugogo -Sugar cane replacing rice in areas prone to floods	4786266.311	505560.492	1355.895

Rugenge-Rwintare	rugenge _Nursery_Kwigira Family Cooperative	4785689.077	507613.915	1365.412
	rugenge_ Dufatanye Farmer group	4785591.836	507665.867	1363.123
	rugenge_ ULK Univesrsity_ Field of fodder crop	4785572.799	507672.051	1363.843
	rugenge_ compost production_Dukundisuku cooperative	4785595.274	507711.072	1364.774
	rugenge_ ULK University _ agricluture (vegetables, irish potato)	4785400.906	508085.426	1367.758
	rugenge _Nursery_Kwigira Family Cooperative	4785191.564	508589.142	1371.796
	rwintare_ Girubumuntu cooperative	4784687.541	509533.91	1388.747
	rwintare_ kowaki cooperative	4784556.739	509778.419	1396.696
	rwintare _bamboo_ Kopakika Cooperative	4785013.063	509084.932	1381.009
	rugenge_ Nursesy_ Imbuga itoshye Cooperative	4785896.73	507113.115	1365.336
	rugenge_ Nuresry_ Imbuga itoshye Cooperative	4785905.592	507097.746	1363.321
RWAMPARA				
	rwampara_Nursey -near Cercle sportif Kigali	4783342.742	507901.323	1381.106
	rwampara_flowers-cercle sportif 1	4783391.575	507908.541	1383.413
	rwampara- individual farmers	4783199.561	507910.584	1381.791
	rwampara AVEGA Nyarugenge- cooperative	4782369.817	507756.564	1389.46
	rwampara- Abishyizehamwe cooperative	4782027.007	507015.975	1398.42
	rwampara _fish ponds Kivu village	4780773.227	506552.446	1431.076
	rwampara_ fish pond 2	4780754.058	506526.135	1432.139
GIKONDO				
	Gikondo_ Individual nursery	4782063.74	509957.808	1395.915
	Gikondo _Gatenga seed multiplication site	4782023.173	509931.064	1398.558
	Gikondo _gatenga seed multiplication site	4781993.034	509904.562	1396.693
	Gikondo_YEAN Hydroponic training center	4782628.571	510395.706	1384.997
	Gikondo_ Nursery_UNILAK University	4782746.188	510519.638	1387.681

Annex 3

List of persons/institutions contacted

N0.	Names	Organisation/Position	Contact
1	Mushimiyimana Bienvenue	District Agronomist/Kicukiro District	0788847377
2	Piyo Nzeyimana	District Agronomist-Gasabo District	0783515669
3	Sylvine Twizeyimana	Agronomist_Kmihurura Sector, Gasabo District	0788403697
4	Nsanganiyimihigo Moise	President Cooperative Abunzubumwe_NYABUGOGO wetland	0783009664
5	Mutabaruka Sylvain	Sugar cane producer_Nyabugogo wetland	0787586343
6	Uzamushaka Donata	Presidente Cooperative KOPAKIKA_RWINTARE wetland	0786742931
7	Nzamurambaho Elysee	President Cooperative KOKAWI_RWAMPARA wetland	0788843431
8	Mukabarega Valerie	Presidente Cooperative CDF_RWAMPARA wetland	0782138298
9	Musaniwabo Eugenie	Presidente Cooperative AVEGA Nyarugenge _RWAMPARA wetland	0788402412
10	Mukamana Mayimuna	V/Presidente Cooperative AVEGA Nyarugenge _RWAMPARA wetland	07833363594
11	Nikuze Marine	Cooperative Abishyizehamwe_RWAMPARA wetland	0788782574
12	Fred Tumwebaze	Croix Rouge Rwandaise	0785376758
13	Ildephonse Munyemazi	President Cooperative OPPC_Rabagirana RUGENGE and NYABUGOGO wetland	0788253812
14	Jean de Dieu Niyoyita	President Cooperative Imbuga Itoshye_RUGENGE and NYABUGOGO wetland	0788804505
15	Rurangirwa	Head of Urugero Village/Kacyiru Sector/Gasabo District	0788681141
16	Rurangirwa Damascene	Owner Sugar cane plantation	0788300055
17	V/President Cooperative KOABIGA_Gasabo District	V/President Cooperative KOABIGA_Gasabo District	0788437872
18	Secretary Cooperative KOABIGA_Gasabo District	Secretary Cooperative KOABIGA_Gasabo District	0789493711
19	Simon Boris Habimana	President/ Fish Farming Group_ KIBUMBA wetland	0788686330
20	Sendege Norbert	Minagri-RAB: Rubirizi Station-Kigali	0788521320
21	Gabriel Sinyigenga	Business development Unit/Gasabo District	0788319997
22	Uwanyiligira Beata	President Zone 5_ Cooperative KOABIGA – Kibumba	0782535684
23	Hanganimana Assinath	Land Officer/ Kinyinya Sector	0788785345
24	Nyiranzabamwita Goretti	Secretary/ Kagugu Cell/Kinyinya sector	
25	Mvano Jean Bosco Hakizumwami	Tecokoki Cooperative_Rwampara wetland	0789316781
26	Minani Frodould	Duhuguke-Dukora Cooperative; President/ Rwampara Wetland	0788355674
27	Nahayo Thacien	Cooperative Officer/ Kigarama Sector-Kicukiro District	0782771688
28	Iyamuremye Eric	Cooperative Officer/ Gikondo Sector-Kicukiro District	0788806825

29	Kajyibwami Clement	Business Investment Promotion Officer/Kicukiro District	0788566019
30	Ingabire Marie Claire	Sector Agronomist/Kigarama Sector-Kicukiro District	0788565414
31	Fidele Bagirebate	AEE-Rwanda	0785130935
32	Arcade Nshimiyimana	YEAN Rwanda	0788845727
33	NGIRIMANA Jean Pierre	President/TECOCOKI Cooperative	0788735633
34	NZAKUNDA Joseph	RCA/Nyarugenge Branch	0788862650
35	Emmanuel NZARORA	President/Abishyizehamwe cooperative	0788750351
36	Clementine UWIMANA	Cell Leader/Ngoma	0785930483
37	Caesar DUSABEYEZU	Land Manager/Nyarugenge District	0788402545

14. APPENDIX 4: DETAILED COMPARISON BETWEEN VARIANTS

This Appendix presents the detailed comparative multicriteria analysis of the 3 Variants.

SCREENING AGAINST CRITERIA: HIGHER LEVEL OBJECTIVES: GIKONDO

Flood mitigation

TABLE 14-1 GIKONDO FLOOD CONTROL ALL VARIANTS

		Baseline	Variant 1	Variant 2	Variant 3
Criterion	**Flood mitigation. Average score**	**6**	**8**	**9**	**10**
Sub criteria	Gikondo Sub-Criteria 1: Water depth over road NR4	6	8	8	10
	Gikondo Sub-Criteria 2: Water depth over KK1 Avenue	4	8	8	10
	Gikondo Sub-Criteria 3: Water depth over KN14 Avenue	2	8	10	9
	Gikondo Sub-Criteria 4: Water depth over Muhazi	10	8	10	9

The hydraulic score at the NR4 road for the baseline situation is 6. The water level at this point depends upon the runoff coming from the upstream part of the wetland but also the Rwandex hotspot which will be sized during the hotspot study. The measures suggested through the Variant 1 (blocking the surface drains which will raise the water level uniformly over the wetland and increase the storage capacity during rainfall event) will greatly improve the hydraulic criteria (reaching a mark of 8) and decrease the flooding risk at the NR4 road. Considering a security factor for the Rwandex hotspot sizing and to account for the urban runoff that doesn't depend on the wetland rehabilitation (runoff coming on the road directly from the urban area), the score for the Variant 1 would not reach 10.

The hydraulic score at the KK1 Ave for the baseline situation is 4. The measures suggested through Variant 1 (blocking the surface drains which will raise the water level uniformly over the wetland and increase the storage capacity during rainfall event) will greatly improve the hydraulic criteria (reaching a mark of 8) and decrease the flooding risk at this road.

The hydraulic score at the KN14 Ave for the baseline situation is 2 with a maximum water level of 2.67 m for a 10-year return period rainfall event. The high level of risk depends upon the Rwampara and Gikondo water contributions. As for the Variant 1 major measures will be taken over both wetlands implying hydrograph peak delay, the score will reach 8.

At the Muhazi road, no flood is expected for a 10 year-return period rainfall event as the cross-section is wide enough to avoid flooding. The hydraulic behaviour will not be degraded.

The proposed notation for the Variant 1 is based on reliable actions for future flooding reduction at identified points. In addition to wetland rehabilitation, this reduction will also be influenced by several factors: development within the wetlands, modification of urbanization within the catchment areas, construction of infrastructures linked to the "flood hotspot" project (see section 4.1.1). Performance of the optimum scenario will have to be confirmed by considering this hotspot project.

In the upstream part of roads NR4 and KK1 Avenue, the measures planed through variant 1 and variant 2 are the same. Therefore, the mark obtained for those two criteria remain the same (8). Under variant 3, upstream of those roads, some flow spreading structures combined with temporary retention ponds are planned. A large volume of water would be stored during extreme rainfall events with the retention ponds creation clearing all flooding risk over the downstream roads (score of 10).

A large lake would be created under variant 2 over the former industrial zone of Gikondo. This lake would act as a retention basin to store large amount of water during extreme rainfall events. Besides, simultaneously, a large lake is also created in Rwampara, delaying and lowering the water flowing into Gikondo lake. Thanks to the creation of these two lakes, flooding over KN14 Avenue and Muhazi roads during extreme events is then avoided (score of 10).

For the variant 3, flow spreading structures combined with temporary retention ponds are planned in both Gikondo former industrial area and Rwampara wetland. Theses would greatly improve flooding over the roads (score of 9) as the water storage capacity would have greatly improved.

Biodiversity enhancement

TABLE 14-2 GIKONDO BIODIVERSITY ENHANCEMENT ALL VARIANTS

		Baseline	Variant 1	Variant 2	Variant 3
Criterion	**Biodiversity enhancement. Average score**	**3**	**7**	**3**	**5**
Sub criteria	Sub-criteria 1: Absence of threats	2	8	2	4
	Sub-criteria 2: Soil hydrologic conditions	5	7	5	6
	Sub-criteria 3: Species composition	1	7	3	6
	Sub-criteria 4: Structural diversity	1	9	5	6
	Sub-criteria 5: Ecosystem function	4	7	3	5
	Sub-criteria 6: External exchanges	3	6	1	5

Variant 1

Sub-criteria 1: Threats

Even if the planned actions will reduce the main existing threats (reduction of artificialization and suppression of intensive agriculture), the urban context of the wetland still suggests an anthropic pressure on a small surface (less than 25% of the total surface). Indeed, anarchic land artificialization at the edge of the wetland and horticulture, facilitating the spontaneous colonization of invasive species, will always be possible.

Sub-criteria 2: Soil hydrologic conditions

The work of plugging the agriculture drains, raising the water level, and meandering the stream will contribute to a better feeding of the wetland. However, a large part of the wetland (downstream sector) will have unremoved fill (former industrial wasteland), which will have an impact on soil waterlogging and flooding during light rainfall.

It is therefore considered that the soil of the wetland will be regularly waterlogged over part of the wetland surface.

Sub-criteria 3: Species composition

The restored areas will be planted mainly with native wetland species and the hydraulic actions carried out will reinforce the wetland character of the area, thus promoting the development of a plant community indicative of wetlands. However, some areas will be used more for landscape purposes, in order to form urban parks and recreational areas, and the plant community will therefore not be systematically indicative of wetlands. The actions implemented will therefore make it possible to achieve a coverage of hygrophilous species between 60 and 80%.

Sub-criteria 4: Structural diversity

The actions aim primarily at developing the herbaceous cover, but also the shrub and tree stratum in order to diversify the habitats. It is indeed planned to plant riparian trees along the watercourses or to plant tree and shrub species on the high points of the basins, reinforcing the landscape and biological aspect. As a result, the wetland will eventually have an overlay of native natural habitats in three vegetative strata (trees, shrubs, and grasses) on more than three-quarters of the wetland's area.

Sub-criteria 5: Ecosystem function

The implementation of the different actions will allow to significantly improve the hydraulic and biological functionalities of the wetland. However, the downstream part of the wetland will still show the stigma of the former industrial zone (polluted fills). It is therefore considered that the hydraulic functionality remains with at a medium level but the biological functionality will be evaluated at high level.

Sub-criteria 6: External exchanges

The actions will create a diversity of ecological connections between the restored natural habitats. Indeed, the plantations along the watercourses, the vegetation of the cultivated areas, the creation of wet depressions... are supports favorable to the reception of the local biodiversity.

However, several linear infrastructures cross the wetland and form cuts between certain parts of the wetland. Thus, the optimal scenario presents a fragmentation of the mosaic of natural habitats even if new ecological connections have been created (watercourses, hedges, woodlands ...).

Ecological connections with the upstream and downstream wetlands will also be limited by the existing infrastructure. Indeed, the study perimeter does not allow for the reworking of structures positioned outside the wetlands.

Variant 2

Under Variant 2, the creation of a water reservoir on the downstream part of the wetland will contribute to a cut in the longitudinal ecological connections. In addition, the construction of such a structure will require significant concrete rights-of-way (civil engineering works) in the wetland. This work will have a direct impact on the biological functioning of the wetland. Even if the edges of the lake can support flora species (colonization of the different plant strata growing spontaneously), the area in water will not allow the development of a biodiversity typical of wetlands on its entire surface.

The downstream part of Gikondo will change from being a wetland (terrestrial environment) to an aquatic environment.

Despite the implementation of measures favorable to wetlands on the upstream part, these ecological actions will be isolated and not very relevant with regard to the urban context (upstream) and water body (downstream).

Variant 3

Under Variant 3, the construction of civil engineering structures to increase the flood expansion area will have a significant wetland footprint. Thus, this physical footprint is likely to impact the biological functions of the wetland. However, areas of water may temporarily form upstream of these mineral structures and allow for the development of interesting biodiversity.

Despite the implementation of ecological actions allowing the improvement of the biological functionalities on the upstream and downstream parts of the wetland, these mineral developments may not bring the benefits expected by these actions. It is favorable to limit the presence of continuous obstacle in the valley will allow the conservation of the remaining ecological connections within the wetland.

Water quality improvement

TABLE 14-3 GIKONDO IMPROVEMENT OF WATER QUALITY ALL VARIANTS

		Baseline	Variant 1	Variant 2	Variant 3
Criterion	**Improvement of water quality. Average score**	**3**	**5**	**6**	**4**
Sub criteria	Sub-criteria 1: Source of pollution inside the wetland	3	6	6	4
	Sub-criteria 2: External sources of pollution flowing in the wetland (point source and nonpoint source)	2	2	2	2
	Sub-criteria 3: Quality of surface water flowing in the wetland	3	6	7	5
	Sub-criteria 4: Natural filtration function of the wetland	3	6	7	5

Sub-criteria 1: Source of pollution inside the wetland

Variant 1:

The restoration actions will limit the sources of pollution within the wetland.

However, given the history of the site on its downstream side (former industrial areas), pollution risks related to existing backfills are possible (discharge to the receiving environment and the water table). This part of the wetland represents a significant surface.

Variant 2 is not changing the value of this sub-criteria as for all variants, the restoration actions aiming at pollution inside the wetland are the same (limitation of agriculture).

Variant 3 could however bring a new source of pollution inside the wetland, caused the lake. This could take place especially during dry months when lack of circulation of water could reduce oxygen level, provide breeding ground for the water hyacinth and create favourable conditions for eutrophication of water due to accumulation of pollutants in stagnant water, thus creating a new source of pollution inside the wetland.

Sub-criteria 2: External sources of pollution flowing in the wetland (point source and nonpoint source)

All variants would have the same score for this sub-criteria.

Even if all water management actions are implemented, the wetland will still receive direct or indirect external pollution (polluted runoff, upstream watershed of the wetland not affected by the actions...). Indeed, the urban context of wetlands cannot ensure the absence of untreated external pollution, and the current threats will remain.

Sub-criteria 3: Quality of surface water flowing in the wetland

Variant 1: in the case of a full implementation of the actions, Variant 1 will allow a strong mitigation of the different types of pollution (organic or inorganic). However, these actions will have to be accompanied by stormwater management measures and development of sewerage within the urban watershed.

The downstream portion of the Gikondo wetland is underlain by polluted fill that will not be treated. The pollution will therefore still exist.

Variant 2 would strongly reduce turbidity of water flowing in the wetland, by slowing down erosive floods.

Variant 3 would allow sediment to settle thanks to lake acting as large retention ponds, thus reducing this source of pollution. The lake would however create eutrophic water, especially during the dry month, impacting water quality for some chemical parameters.

As for all Variants, actions will have to be accompanied by stormwater management measures and development of sewerage within the urban watershed.

Sub-criteria 4: Natural filtration function of the wetland

As for all Variants, Gikondo will focus on the development of recreational activities, while developing a large floodplain to expand. This will will allos the wetland to settle pollutants in comparison with other wetlands.

Variant 1: Restoration actions in the wetland (plugging of drains, establishment of buffer zones at the urban drains, vegetation...) will significantly improve its biogeochemical functionality. Thus, the natural filtering function of the wetland will be effective over a large part of the wetland (downstream part less favourable because of the existing polluted fills).

Variant 2 would be accompanied by the creation of small retention ponds, allowing additional filtration of water by increasing the retention time of water in the wetlands.

The lake proposed under Variant 3 will not have any natural filtering function. The space occupied by the lake would reduce land availability for other more efficient depuration actions.

Development of recreational activities and landscape

TABLE 14-4 GIKONDO DEVELOPMENT OF RECREATIONAL ACTIVITIES AND LANDSCAPE ALL VARIANTS

		Baseline	Variant 1	Variant 2	Variant 3
Criterion	**Landscape and recreational activities. Average score**	**7**	**9**	**7**	**8**
Sub criteria	Sub-Criteria 1: Quality of natural landscape / environment	2	8	8	8

	Sub-Criteria 2: Quality of anthropic landscape / cultural environment	6	9	8	8
	Sub-Criteria 3: Exposures and visual clearances / perceptions	9	9	9	8
	Sub-Criteria 4: Occurrence and level of continuity of green routes	9	9	5	7
	Sub-Criteria 5: Occurrence and/or proximity of recreation facilities (including educational and touristic activities)	7	9	7	7

Variant 1

Sub-Criteria 1: Quality of natural landscape / environment

The rehabilitation of the wetland and the creation of different natural habitats by establishing green urban spaces with the planting of native species (meadows, woodland, etc.), improves considerably the performance of Gikondo in terms of the quality of its natural environment.

Attention point: the contamination of the site, inherited from former industrial activities must be addressed if natural habitats are to thrive.

Sub-Criteria 2: Quality of anthropic landscape / cultural environment

The creation of the proposed eco valley in Gikondo improves considerably the attractiveness of the area and the quality of the cultural environment of the wetland. An entire area is proposed to be dedicated to the celebration of local food and culture (crafts and food valley).

Attention point: the contamination of the site, inherited from former industrial activities must be addressed if food and recreation environments are to be deemed safe and attractive for human uses.

Sub-Criteria 3: Exposures and visual clearances / perceptions

The development of different recreation zones and natural habitats will help to delimitate and ordinate spaces and visual clearances within the wetland. The proposed spatial organisation will improve coherence of the different created spaces, creating new panoramic landscapes and improving the exposure and perception of the area from multiple viewpoints.

Sub-Criteria 4: Occurrence and level of continuity of green routes

The development of the proposed pedestrian and cycling circuits will improve circulation within the wetland and will also improve accessibility of the zone from main urban corridors. It is recommended to develop a circuit that encircles the whole area of the wetland.

Sub-Criteria 5: Occurrence and/or proximity of recreation facilities (including educational and touristic activities)

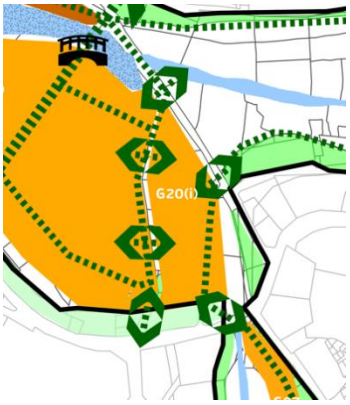
The development of the proposed eco valleys will considerably improve the performance of the wetland in terms of recreative, cultural and tourism activities. In addition, the association of wetland preservation awareness circuits with economic activities (cafes, food stalls, events areas, bike rental kiosks, etc) will contribute to the sustainability and attractiveness of the proposed developments.

Connections could be established with the existing Hydroponics training and demonstration center, located on the eastern ends of the wetland (see image below, for location refer to the plan). This small research lab developed by the University of Lay Adventist of Kigali (UNILAK) in partnership with YEAN and MasterCard could offer opportunities to develop educational activities in relation with the proposed Eco-valley.



Attention point:

The area located at the confluence of important urban axis on the eastern limits of the wetland is considered strategic for the wetland as a whole. It is highly recommended that any development taking place on this specific area considers the improvement of its permeability in relation of the wetland as well as the connection to adjacent urban areas. Construction of enclosed developments on the site is discouraged as to avoid constraining the remainder of the wetland area and isolating it from its context. See zoom below.



Variant 2

Sub-Criteria 1: Quality of natural landscape / environment

Ranking remains unchanged from Variant 1. The creation of different natural habitats by establishing green urban spaces with the planting of native species (meadows, woodland, etc.) can still be developed in the area. Although less dry areas of natural habitat will be developed due to the presence of the large lake (approximately 30ha), the rank remains at a high level as the presence of water features is considered to contribute to the improvement of the user experience and the quality of the landscape.

Sub-Criteria 2: Quality of anthropic landscape / cultural environment

Ranking decreases by one (1) point from Variant 1. Proposed landscaped areas can be developed in the same logic (crafts and food valley) although in smaller scale as available areas will be considerably reduced.

Sub-Criteria 3: Exposures and visual clearances / perceptions

Ranking remains unchanged from Variant 1. The development of the lake can contribute to the quality of visual clearances within the wetland in the same way with the development of the thematic valleys.

Sub-Criteria 4: Occurrence and level of continuity of green routes

Ranking decreases by four (4) points from Variant 1. The proposed lake occupies a considerably large area and creates two fragmented branches on the wetland, restraining the available areas for development of green routes and recreational facilities. These two disconnected areas will impair the spatial continuity of the wetland and impeach the connectivity between the wetland and adjacent urban areas as well as between both “valleys” within the wetland.

Sub-Criteria 5: Occurrence and/or proximity of recreation facilities (including educational and touristic activities)

Ranking decreases by two (2) points from Variant 1. Although the lake can provide the opportunity to develop attractive water activities, the quality of the water needs to be treated in a permanent way (see international example at the section on case study section 4.15). The development of sports facilities such as football grounds will also be impaired due to lack of available large areas.

Attention point: the contamination of the site, inherited from former industrial activities must be addressed if natural habitats are to thrive. In addition, the presence of the lake poses a considerably high risk in terms of maintenance and operation. The development of recreational activities as well as resilient and adaptative landscape on the lake requires previous comprehensive restoration of the local wetland ecosystem. Management and maintenance of water collection and treatment systems at urban discharge points must also be ensured.

These actions can be extremely costly and must be planned on a long term

Variant 3

Sub-Criteria 1: Quality of natural landscape / environment

Ranking remains unchanged from Variant 1. The creation of different natural habitats by establishing green urban spaces with the planting of native species (meadows, woodland, etc.) can still be developed in the area.

Sub-Criteria 2: Quality of anthropic landscape / cultural environment

Ranking decreases by one (1) point in comparison to Variant 1. The development of a series of cascading gabions can have a negative influence on the quality of the landscape if not designed with aesthetic qualities. Some natural landscape areas can be developed around the water ponds and contribute to the attractiveness of the area, but the issue of the quality of the water must be addressed.

Sub-Criteria 3: Exposures and visual clearances / perceptions

Ranking decreases by one (1) point in comparison to Variant 1. The presence of the series cascading gabions will not impair exposure of the wetland from urban areas. The structures can however have a negative impact on the perception of the spaces/visual clearances.

Sub-Criteria 4: Occurrence and level of continuity of green routes

Ranking decreases by two (2) points in comparison to Variant 1. The presence of the series cascading gabions will impair the spatial continuity of the wetland along its longitudinal axis. The structures can however be designed with accessible pedestrian routes that allow the crossing of both branches, creating a series of cross over corridors along the gabions. This actions however can be highly costly and would require considerable level of maintenance, specially to ensure that paths are safe for pedestrian use during the wet season.

Sub-Criteria 5: Occurrence and/or proximity of recreation facilities (including educational and touristic activities)

Ranking decreases by two (2) points in comparison to Variant 1. Although some small educational/research activities could be developed on the created ponds, the quality of the water would have to be treated in a permanent way. The development of sports facilities such as football grounds will also be impaired due to lack of available large areas

SCREENING AGAINST CRITERIA: HIGHER LEVEL OBJECTIVES: RWAMPARA

Flood mitigation

TABLE 14-5 RWAMPARA FLOOD CONTROL ALL VARIANTS

		Baseline	Variant 1	Variant 2	Variant 3
Criterion	**Flood mitigation. Average score**	**4**	**9**	**9**	**9**
Sub criteria	Rwampara Sub-Criteria 1: Water depth over road KN 121	4	6	6	6
	Rwampara Sub-Criteria 2: Water depth over KK 2 Avenue	4	8	10	10
	Rwampara Sub-Criteria 3: Water depth over KK 31 Avenue	4	10	10	10
	Rwampara Sub-Criteria 4: Water depth over Avenue des Poids-Lourds NR4	4	10	10	10

Variant 1:

For the baseline study, the four flooding focus points of this wetland obtain a score of 4. The wetland is characterized by a great and rapid runoff from the urban areas nearby and small river wides upstream of the wetland. Upstream the KN 121 Street bridge, very few measures will be implemented through Variant 1 (score of 6).

At the KK2 Ave the score will be enhance to 8 for the Variant 1 thanks to the buffer zone created.

No measures will be implemented directly nearby the KK 31 Ave and the Avenue des Poids Lourds. However, the measures implemented upstream through the Variant 1 will allow to greatly improve the hydraulic behaviour (score of 10) particularly by blocking the agricultural drains and by creating buffer zones which will increase the storage capacity of the wetland to stop flooding downstream.

Under variant 2, a lake is implemented right upstream of the KK 2 Avenue. The measure would not affect the score over KN 121 road as the lake is located downstream this road, the score remains of 6. The large amount of water coming with a high speed from the narrow part of Rwampara wetland is store and delay through the Rwampara Lake. This measure would therefore clear off any flooding risk over the three downstream roads (score of 10 for the KK2 Avenue, KK31 Avenue and Avenue des Poids Lourds NR4).

Under variant 3, 3 flow spreading structures combined with temporary retention ponds are implemented over the wetland. These measures are implemented downstream KN121 road which means that the first criteria would not be affected (score of 6 remains). However, the flooding situation would be greatly improved over the KK2, KK 31 and NR4 Avenues (score of 10) as a large amount of water could be stored in the retention ponds.

Biodiversity enhancement

TABLE 14-6 RWAMPARA BIODIVERSITY ENHANCEMENT ALL VARIANTS

		Baseline	Variant 1	Variant 2	Variant 3
Criterion	**Biodiversity enhancement. Average score**	**2**	**8**	**2**	**6**
Sub criteria	Sub-criteria 1: Absence of threats	1	8	1	4
	Sub-criteria 2: Soil hydrologic conditions	3	7	3	6
	Sub-criteria 3: Species composition	1	9	3	6
	Sub-criteria 4: Structural diversity	1	9	3	6
	Sub-criteria 5: Ecosystem function	3	8	2	6

	Sub-criteria 6: External exchanges	3	6	2	5

Variant 1

Sub-criteria 1: Threats

Even if the planned actions will reduce the main existing threats (reduction of artificialization and suppression of intensive agriculture), the urban context of the wetland still suggests an anthropic pressure on a small surface (less than 25% of the total surface). Indeed, anarchic land artificialization at the edge of the wetland and horticulture, facilitating the spontaneous colonization of invasive species, will always be possible.

Sub-criteria 2: Soil hydrologic conditions

The work of plugging agricultural drains, raising the water level and meandering the creek will contribute to a better feeding of the wetland and to the waterlogging of the soil. These developments will also promote flooding of the wetland during regular rainfall events. However, the upstream characteristics of the Rwampara wetland (significant incision, narrow valley, significant slope of the natural terrain, etc.) limit the capacity of the soil to be waterlogged during rainfall.

It is therefore considered that the soil of the wetland will be waterlogged on a regular basis over a large part of the wetland.

Sub-criteria 3: Species composition

The restored areas will be planted mainly with native wetland species and the hydraulic actions carried out will reinforce the wetland character of the area, thus promoting the development of a plant community indicative of wetlands. The actions implemented will thus allow to reach a coverage of hygrophilous species higher than 80%.

Sub-criteria 4: Structural diversity

The actions aim primarily at developing the herbaceous cover, but also the shrub and tree stratum in order to diversify the habitats. It is indeed planned to plant riparian trees along the watercourses or to plant tree and shrub species on the high points of the basins, reinforcing the landscape and biological aspect. As a result, the wetland will eventually have an overlay of native natural habitats in three vegetative strata (trees, shrubs, and grasses) on more than three-quarters of the wetland's area.

Sub-criteria 5: Ecosystem function

The implementation of the different actions will allow to significantly improve the hydraulic and biological functionalities of the wetland. However, the upstream part of the wetland will still show signs of past erosion.

It is therefore considered that the hydraulic functionality remains at a medium value but the biological functionality will be evaluated to be of high value.

Sub-criteria 6: External exchanges

The actions will create a diversity of ecological connections between the restored natural habitats. Indeed, the plantations along the watercourses, the vegetation of the cultivated areas, the creation of wet depressions... are supports favorable to the reception of the local biodiversity.

However, several linear infrastructures cross the wetland and form cuts between certain parts of the wetland. Thus, the optimal scenario presents a fragmentation of the mosaic of natural habitats even if new ecological connections have been created (watercourses, hedges, woodlands ...).

Ecological connections with the upstream and downstream wetlands will also be limited by the existing infrastructure. Indeed, the study perimeter does not allow for the reworking of structures positioned outside the wetlands.

Variant 2

Under Variant 2, the creation of a water body in the central portion of the wetland will increase the ecological disruption that currently exists with the upstream features of the wetland. Indeed, the lake will cover an area of wetland that has a strong ecological restoration potential, and the creation of a water body would remove any relevant restoration opportunity. In addition, to create such a structure, significant concrete rights-of-way (civil engineering works) will be required in the wetland. This work will have a direct impact on the biological functioning of the wetland. Even if the edges of the lake will be able to support flora species (colonization of the

different plant strata growing spontaneously), the area in water will not allow the development of a biodiversity typical of wetlands on its entire surface.

The central part of Rwampara will change from being a wetland (terrestrial environment) to an aquatic environment.

The implementation of wetland-friendly measures in the downstream part will improve biological functionality. However, the benefits of these ecological actions will be partially degraded with the creation of an open water body.

Variant 3

Under Variant 3, the construction of civil engineering structures to increase the flood expansion area will have a significant wetland footprint. Thus, this physical footprint is likely to impact the biological functions of the wetland. However, areas of water may temporarily form upstream of these mineral structures and allow for the development of interesting biodiversity. It is favorable to limit the presence of continuous obstacle in the valley will allow the conservation of the remaining ecological connections within the wetland.

Water quality improvement

TABLE 14-7 RWAMPARA IMPROVEMENT OF WATER QUALITY ALL VARIANTS

		Baseline	Variant 1	Variant 2	Variant 3
Criterion	**Improvement of water quality. Average score**	**4**	**6**	**7**	**5**
Sub criteria	Sub-criteria 1: Source of pollution inside the wetland	5	7	7	6
	Sub-criteria 2: External sources of pollution flowing in the wetland (point source and nonpoint source)	5	5	5	5
	Sub-criteria 3: Quality of surface water flowing in the wetland	4	7	8	6
	Sub-criteria 4: Natural filtration function of the wetland	1	5	6	4

Sub-criteria 1: Source of pollution inside the wetland

Variant 1:

Restoration actions will limit the sources of pollution within the wetland. However, due to the size of the area, not all activities can be controlled. Sources of pollution will still be present, but they will be limited to a few areas within the wetland.

Variant 2 is not changing the value of this sub-criteria as for all variants, the restoration actions aiming at pollution inside the wetland are the same (limitation of agriculture).

Variant 3 could however bring a new source of pollution inside the wetland, caused the lake. This could take place especially during dry months when lack of circulation of water could reduce oxygen level, provide breeding ground for the water hyacinth, and create favorable conditions for eutrophication of water due to accumulation of pollutants in stagnant water, thus creating a new source of pollution inside the wetland.

Sub-criteria 2: External sources of pollution flowing in the wetland (point source and nonpoint source)

All variants would have the same score for this sub-criteria.

Even if all water management actions are implemented, the wetland will still receive direct or indirect external pollution (polluted runoff, upstream watershed of the wetland not affected by the actions...). Indeed, the urban context of wetlands cannot ensure the absence of untreated external pollution, and the current threats will remain. Because of the shape the river upstream, it will be impossible to install constructed wetland at the outlet of the two large stormwater drains discharging upstream. Some external sources of pollution are to be expected to be left unmitigated.

Sub-criteria 3: Quality of surface water flowing in the wetland

Variant 1

In the case of a full implementation of the actions, Variant 1 will allow a strong mitigation of the different types of pollution (organic or inorganic). However, these actions will have to be accompanied by stormwater management measures and development of sewerage within the urban watershed.

Variant 2 would strongly reduce turbidity of water flowing in the wetland, by slowing down erosive floods. This would particularly be true in Rwampara where erosion is significant.

Variant 3 would allow sediment to settle thanks to lake acting as large retention ponds, thus reducing this source of pollution. The lake would however create eutrophic water, especially during the dry month, impacting water quality for some chemical parameters.

As for all Variants, actions will have to be accompanied by stormwater management measures and development of sewerage within the urban watershed.

Sub-criteria 4: Natural filtration function of the wetland

Variant 1

Restoration actions in the wetland (plugging of drains, establishment of buffer zones at the urban drains, vegetation...) will significantly improve its biogeochemical functionality. Thus, the natural filtering function of the wetland will be effective over the downstream part of the wetland, but because of its shape and absence of floodplain, the upstream part will never have any role in the filtering of pollutions.

As for all Variants, Rwampara has limited space for allowing large floodplain to expand. This will also limit the capacity of the wetland to settle pollutants in comparison with other wetlands.

Variant 2 would be accompanied by the creation of small retention ponds, allowing additional filtration of water by increasing the retention time of water in the wetlands.

The lake proposed under Variant 3 will not have any natural filtering function (see explanation above). The space occupied by the lake would reduce land availability for other more efficient depuration actions.

Development of recreational activities and landscape

TABLE 14-8 RWAMPARA DEVELOPMENT OF RECREATIONAL ACTIVITIES AND LANDSCAPE ALL VARIANTS

		Baseline	Variant 1	Variant 2	Variant 3
Criterion	**Landscape and recreational activities. Average score**	**3**	**8**	**6**	**7**
Sub criteria	Sub-Criteria 1: Quality of natural landscape / environment	3	8	8	7
	Sub-Criteria 2: Quality of anthropic landscape / cultural environment	3	7	7	7
	Sub-Criteria 3: Exposures and visual clearances / perceptions	3	8	5	6
	Sub-Criteria 4: Occurrence and level of continuity of green routes	3	10	5	8
	Sub-Criteria 5: Occurrence and/or proximity of recreation facilities (including educational and touristic activities)	4	9	6	7

Variant 1

Sub-Criteria 1: Quality of natural landscape / environment

The rehabilitation of the wetland and the creation of different natural habitats by establishing green urban spaces with the planting of native species (meadows, woodland, etc.), will improve considerably the performance of Rwampara in terms of the quality of its natural environment.

Sub-Criteria 2: Quality of anthropic landscape / cultural environment

The creation of small gardens along the walking circuits within the wetland will improve considerably its performance in terms of anthropic landscape. No major manmade structures are proposed in the wetland.

Sub-Criteria 3: Exposures and visual clearances / perceptions

The proposed permeability axis and connection to existing urban corridors (see plan) will improve visual clearances and perceptions of the wetland in some areas.

Sub-Criteria 4: Occurrence and level of continuity of green routes

The development of the proposed pedestrian and cycling circuits will improve circulation within the wetland and will also improve accessibility of the zone from main urban corridors.

Sub-Criteria 5: Occurrence and/or proximity of recreation facilities (incl. educ. and touristic activities)

The creation of a series of outdoor gym circuits, children play areas, picnic areas, bird watching decks, etc. will improve considerably the attractiveness of the wetland in terms of recreational activities. No major recreational parks or structures are proposed in the wetland

Variant 2

Sub-Criteria 1: Quality of natural landscape / environment

Ranking remains unchanged in comparison to Variant 1. The creation of different natural habitats by establishing green urban spaces with the planting of native species along the walking circuits can still be developed in the area although at smaller scale as areas will be reduced with the creation of the lake.

Sub-Criteria 2: Quality of anthropic landscape / cultural environment

Ranking remains unchanged in comparison to Variant 1. No major manmade structures are proposed in the wetland.

Sub-Criteria 3: Exposures and visual clearances / perceptions

Ranking decreases by three (3) points in comparison to Variant 1. The spatial permeability axis and connection to existing urban corridors proposed by the Variant 1 will be considerably impaired by the creation of the lake, affecting visual perceptions of the wetland in surrounding areas.

Sub-Criteria 4: Occurrence and level of continuity of green routes

Ranking decreases by five (5) points in comparison to Variant 1. The spatial continuity of the wetland will be severely impaired as its central branch will be mostly occupied by the new lake, affecting accessibility from main urban corridors, creating fragmented branches, and offering fewer possibilities for the implementation of continuous green corridors.

Sub-Criteria 5: Occurrence and/or proximity of recreation facilities (including educational and touristic activities)

Ranking decreases by three (3) points in comparison to Variant 1. The spatial continuity of the wetland will be severely impaired as its central branch will be mostly occupied by the new lake, creating fragmented branches and offering fewer possibilities for the implementation of recreational activities. The fact that proposed recreational activities are modular and can be installed at any suitable point along the walking circuits mean that similar types of facilities can be kept in this variant although in much lower number.

Variant 3

Sub-Criteria 1: Quality of natural landscape / environment

Ranking decreases by one (1) point in comparison to Variant 1. The development of a series of cascading gabions can have a negative influence on the quality of the landscape if not designed with aesthetic qualities. Some natural landscape areas can be developed around the water ponds and contribute to the attractiveness of the area, but the issue of the quality of the water must be addressed. Special attention must be given to maintenance of dry/wet areas throughout the different seasons as ponds will be seasonal.

Sub-Criteria 2: Quality of anthropic landscape / cultural environment

Ranking remains unchanged in comparison to Variant 1. No major manmade structures are proposed in the wetland.

Sub-Criteria 3: Exposures and visual clearances / perceptions

Ranking decreases by two (2) points in comparison to Variant 1. The visual clearances proposed by the Variant 1 will be impaired by the creation of a series of cascading gabions, affecting perceptions of the wetland in surrounding areas, especially if not designed with good aesthetic qualities.

Sub-Criteria 4: Occurrence and level of continuity of green routes

Ranking decreases by two (2) points in comparison to Variant 1. The presence of the series cascading gabions will impair the spatial continuity of the wetland along its long axis. The structures can however be designed with accessible pedestrian routes that allow the crossing of both branches, creating a series of cross over corridors along the gabions. This actions however can be highly costly and would require considerable level of maintenance, specially to ensure that paths are safe for pedestrian use during the wet season.

Sub-Criteria 5: Occurrence and/or proximity of recreation facilities (including educational and touristic activities)

Ranking decreases by two (2) points in comparison to Variant 1. Although some small educational/research activities could be developed on the created ponds, the quality of the water would have to be treated in a permanent way. Special attention must be given to maintenance of dry/wet areas throughout the different seasons and to ensure safety to the users of the facilities during the wet season. The fact that proposed recreational activities are modular and can be installed at any suitable point along the walking circuits mean that similar types of facilities can be kept in this variant even if in fewer places.

SCREENING AGAINST CRITERIA: HIGHER LEVEL OBJECTIVES: RUGENGE-RWINTARE

Flood mitigation

TABLE 14-9 RUGENGE-RWINTARE FLOOD CONTROL ALL VARIANTS

		Baseline	Variant 1	Variant 2	Variant 3
Criterion	**Flood mitigation. Average score**	**7**	**10**	**10**	**10**
Sub criteria	Rugenge-Rwintare Sub-Criteria 1: Water depth over KG 3 Avenue	10	10	10	10
	Rugenge-Rwintare Sub-Criteria 2: Water depth over Rugenge road	4	10	10	10
	Rugenge-Rwintare Sub-Criteria 3: Water depth over road KN 21	4	10	10	10
	Rugenge-Rwintare Sub-Criteria 4: Water depth over KN 8 Avenue	10	10	10	10

Variant 1:

No flood is expected for a 10 year-return period rainfall event over the KG 3 Ave and the KN8 Ave as the cross-section is wide enough to avoid flooding. The hydraulic behaviour will not be degraded. Therefore, the score for this sub-criterion stays at 10.

Over Rugenge road and KN 21 St, the maximum water depth for a 10 year return period event for the baseline scenario is 1.93 and 0.78 m respectively. The set of suggested actions planned for the Variant 1 will enable to decrease this water depth to 0 for both focus points, preventing from any flood.

Under variant 2, a lake is implemented between the KG 3 Avenue and the Rugenge road. The measure would not affect the score over KG 3 Avenue as the lake is located downstream, the score remains of 10. This lake would act as a retention basin to store large amount of water during extreme rainfall events. The flooding risk have already been completely cleared off with the Variant 1. Adding the Rugenge-Rwintare lake would enable to keep the flooding risk over the three other roads to zero (score of 10).

Under variant 3, 4 flow spreading structures combined with temporary retention ponds are added up to the measured planned through variant 1. Therefore, the flooding risk could only be improved as the storage capacity increase with retention ponds. As with the Variant 1, the criteria have already reached a score of 10, the four criteria for the variant 3 would remain 10.

Biodiversity enhancement

TABLE 14-10 RUGENGE-RWINTARE BIODIVERSITY ENHANCEMENT ALL VARIANTS

		Baseline	Variant 1	Variant 2	Variant 3
Criterion	**Biodiversity enhancement. Average score**	**3**	**8**	**5**	**6**
Sub criteria	Sub-criteria 1: Absence of threats	2	8	2	4
	Sub-criteria 2: Soil hydrologic conditions	6	8	7	7
	Sub-criteria 3: Species composition	1	9	5	6
	Sub-criteria 4: Structural diversity	2	9	6	7
	Sub-criteria 5: Ecosystem function	4	9	5	5
	Sub-criteria 6: External exchanges	4	7	2	5

Variant 1:

Sub-criteria 1: Threats

Even if the planned actions will reduce the main existing threats (reduction of artificialization and suppression of intensive agriculture), the urban context of the wetland still suggests an anthropic pressure on a small surface (less than 25% of the total surface). Indeed, anarchic land artificialization at the edge of the wetland and horticulture, facilitating the spontaneous colonization of invasive species, will always be possible.

Sub-criteria 2: Soil hydrologic conditions

The work of plugging the agricultural drains, raising the water level, and meandering the stream will contribute to a better feeding of the wetland and to the waterlogging of the soil. These improvements will also promote flooding of the wetland during regular rainfall events. It is therefore considered that the wetland soil will be permanently or regularly waterlogged over much of the wetland area.

Sub-criteria 3: Species composition

The restored areas will be planted mainly with native wetland species and the hydraulic actions carried out will reinforce the wetland character of the area, thus promoting the development of a plant community indicative of wetlands. The actions implemented will thus allow to reach a coverage of hygrophilous species higher than 80%.

Sub-criteria 4: Structural diversity

The actions aim primarily at developing the herbaceous cover, but also the shrub and tree stratum in order to diversify the habitats. It is indeed planned to plant riparian trees along the watercourses or to plant tree and shrub species on the high points of the basins, reinforcing the landscape and biological aspect. As a result, the wetland will eventually have an overlay of native natural habitats in three vegetative strata (trees, shrubs, and grasses) on more than three-quarters of the wetland's area.

Sub-criteria 5: Ecosystem function

The implementation of the various actions will significantly improve the hydraulic and biological functions of the wetland.

It is therefore considered that the hydraulic functionality and biological functionality will be evaluated at a high value.

Sub-criteria 6: External exchanges

The actions will create a diversity of ecological connections between the restored natural habitats. Indeed, the plantations along the watercourses, the vegetation of the cultivated areas, the creation of wet depressions... are supports favorable to the reception of the local biodiversity.

However, some linear infrastructures crossing the wetland form cuts between some parts of the wetland. Thus, the optimal scenario presents a partial fragmentation of the mosaic of natural habitats but the ecological connections are multiple (watercourses, hedges, woodlands ...).

Ecological connections with the upstream and downstream wetlands will also be limited by the existing infrastructure. Indeed, the study perimeter does not allow for the reworking of structures positioned outside the wetlands

Variant 2:

Under Variant 2, the creation of a water reservoir in the central part of the wetland will contribute to a cut in the longitudinal ecological connections between the downstream and upstream parts. In addition, in order to build such a structure, significant concrete rights-of-way (civil engineering works) will be required in the wetland. This work will have a direct impact on the biological functioning of the wetland. Even if the edges of the lake can support flora species (colonization of the different plant strata growing spontaneously), the area in water will not allow the development of a biodiversity typical of wetlands on its entire surface.

The central part of Rugenge-Rwintare will change from being a wetland (terrestrial environment) to an aquatic environment.

The implementation of wetland-friendly measures on the downstream and upstream parts will improve biological functionality. However, the benefits of these ecological actions will be partly degraded with the realization of the lake.

Variant 3:

Under Variant 3, the construction of civil engineering structures to increase the flood expansion area will have a significant wetland footprint. Thus, this physical footprint may impact the biological functionality of the wetland

and limit the possibility of implementing other ecological actions to improve the connections between the watercourse and the wetland (downstream and upstream parts). The benefits expected from the implementation of the actions in the central part of the wetland will be limited due to their positioning between the civil engineering structures. However, water areas may temporarily form upstream of these mineral developments and allow for the development of interesting biodiversity. It is favorable to limit the presence of continuous obstacle in the valley will allow the conservation of the remaining ecological connections within the wetland.

Water quality improvement

TABLE 14-11 RUGENGE-RWINTARE IMPROVEMENT OF WATER QUALITY ALL VARIANTS

		Baseline	Variant 1	Variant 2	Variant 3
Criterion	**Improvement of water quality. Average score**	**5**	**8**	**8**	**6**
Sub criteria	Sub-criteria 1: Source of pollution inside the wetland	4	8	8	5
	Sub-criteria 2: External sources of pollution flowing in the wetland (point source and nonpoint source)	6	6	6	6
	Sub-criteria 3: Quality of surface water flowing in the wetland	4	8	9	7
	Sub-criteria 4: Natural filtration function of the wetland	5	8	9	7

Sub-criteria 1: Source of pollution inside the wetland

Variant 1:

Restoration actions will limit the sources of pollution within the wetland. However, due to the size of the area, not all activities can be controlled. Sources of pollution will still be present, but they will be limited to a few areas within the wetland.

Variant 2 is not changing the value of this sub-criteria as for all variants, the restoration actions aiming at pollution inside the wetland are the same (limitation of agriculture).

Variant 3 could however bring a new source of pollution inside the wetland, caused the lake. This could take place especially during dry months when lack of circulation of water could reduce oxygen level, provide breeding ground for the water hyacinth and create favourable conditions for eutrophication of water due to accumulation of pollutants in stagnant water, thus creating a new source of pollution inside the wetland.

Sub-criteria 2: External sources of pollution flowing in the wetland (point source and nonpoint source)

All variants would have the same score for this sub-criteria.

Even if all water management actions are implemented, the wetland will still receive direct or indirect external pollution (polluted runoff, upstream watershed of the wetland not affected by the actions...). Indeed, the urban context of wetlands cannot ensure the absence of untreated external pollution, and the current threats will remain.

Sub-criteria 3: Quality of surface water flowing in the wetland

Variant 1: in the case of a full implementation of the actions, the optimum scenario will allow a strong mitigation of the different types of pollution (organic or inorganic). However, these actions will have to be accompanied by stormwater management measures and development of sewerage within the urban watershed.

Variant 2 would strongly reduce turbidity of water flowing in the wetland, by slowing down erosive floods.

Variant 3 would allow sediment to settle thanks to lake acting as large retention ponds, thus reducing this source of pollution. The lake would however create eutrophic water, especially during the dry month, impacting water quality for some chemical parameters.

As for all Variants, actions will have to be accompanied by stormwater management measures and development of sewerage within the urban watershed.

Sub-criteria 4: Natural filtration function of the wetland

Variant 1:

Restoration actions in the wetland (plugging of drains, establishment of buffer zones at the urban drains, vegetation...) will significantly improve its biogeochemical functionality. Thus, the natural filtering function of the wetland will be effective.

Variant 2 would be accompanied by the creation of small retention ponds, allowing additional filtration of water by increasing the retention time of water in the wetlands.

The lake proposed under Variant 3 will not have any natural filtering function (see explanation above). The space occupied by the lake would reduce land availability for other more efficient depuration actions.

Development of recreational activities and landscape

TABLE 14-12 RUGENGE-RWINTARE DEVELOPMENT OF RECREATIONAL ACTIVITIES AND LANDSCAPE ALL VARIANTS

		Baseline	Variant 1	Variant 2	Variant 3
Criterion	**Landscape and recreational activities. Average score**	**4**	**9**	**6**	**7**
Sub criteria	Sub-Criteria 1: Quality of natural landscape / environment	3	8	8	7
	Sub-Criteria 2: Quality of anthropic landscape / cultural environment	6	9	9	9
	Sub-Criteria 3: Exposures and visual clearances / perceptions	4	8	5	6
	Sub-Criteria 4: Occurrence and level of continuity of green routes	5	10	5	8
	Sub-Criteria 5: Occurrence and/or proximity of recreation facilities (including educational and touristic activities)	3	9	5	7

Variant 1

Sub-Criteria 1: Quality of natural landscape / environment

The rehabilitation of the wetland and the creation of different natural habitats by establishing green urban spaces with the planting of native species (meadows, woodland, etc.), will improve considerably the performance of Rugenge-Rwintare in terms of the quality of its natural environment.

Sub-Criteria 2: Quality of anthropic landscape / cultural environment

In addition to the interventions proposed by the consultant, according to the NYARUGENGE CBD Urban Design & Regulations - Kigali Master Plan 2050 from 2019, the CoK have plans to develop a façade connecting the wetlands and adjacent urban areas. The Wetland front is planned to be developed on a linear area of approximately 5km along the wetland of Rugenge-Rwintare but also adjacent wetland of Nyabugogo. This development will highly benefit from proposed connection to green corridors linking the wetlands to the city centre. Where possible, it is recommended to install kiosks or designated protected areas where small local markets can take place, offering an economic opportunity for plants vendors and horticulture producers currently installed in the downstream area of western branch.

Sub-Criteria 3: Exposures and visual clearances / perceptions

It is recommended to remove bamboo plantations where possible and/or to incorporate it to new designed landscapes in order to create clearances and improve visual perceptions. Coordination with the development

of the “wetland front” by the CoK as per mentioned above will also benefit visual clearances and exposure of the wetland.

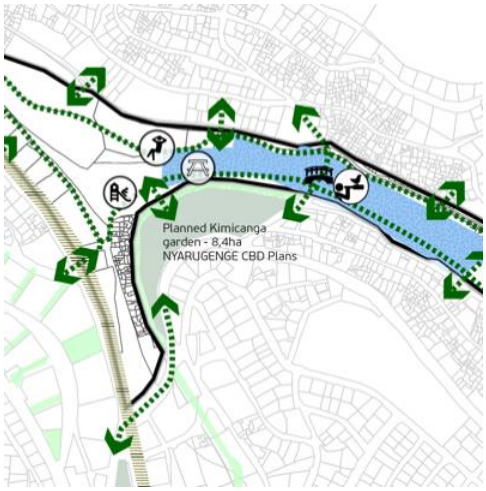
Sub-Criteria 4: Occurrence and level of continuity of green routes

The development of the proposed pedestrian and cycling circuits will improve circulation within the wetland and will also improve accessibility of the zone from main urban corridors. Coordination with the development of the “wetland front” can determine more efficient routes for the pedestrian/cycling paths.

Sub-Criteria 5: Occurrence and/or proximity of recreation facilities (including educational and touristic activities)

The creation of a series of outdoor gym circuits, children play areas, picnic areas, bird watching decks, etc will improve considerably the attractiveness of the wetland in terms of recreational activities. No major recreational parks or structures are proposed by the consultant in the wetland.

According to the NYARUGENGE CBD Urban Design & Regulations - Kigali Master Plan 2050 from 2019, the CoK have plans to develop a public garden area of 8,4ha on the eastern limits of Rugenge-Wintara wetland (see zoom below for location). If developed, the garden will highly benefit the attractiveness of the area, it is recommended to coordinate the routes of the proposed pedestrian paths as well as accessibility to the wetland in the area with the planned garden.



Variant 2

Sub-Criteria 1: Quality of natural landscape / environment

Ranking remains unchanged in comparison to Variant 1. The creation of different natural habitats by establishing green urban spaces with the planting of native species along the walking circuits can still be developed in the area although at smaller scale as areas will be reduced with the creation of the lake.

Sub-Criteria 2: Quality of anthropic landscape / cultural environment

Ranking remains unchanged in comparison to Variant 1. No major manmade structures are proposed in the wetland.

Sub-Criteria 3: Exposures and visual clearances / perceptions

Ranking decreases by three (3) points in comparison to Variant 1. The spatial permeability axis and connection to existing urban corridors proposed by the Variant 1 will be considerably impaired by the creation of the lake, affecting visual perceptions of the wetland in surrounding areas.

Sub-Criteria 4: Occurrence and level of continuity of green routes

Ranking decreases by five (5) points in comparison to Variant 1. The spatial continuity of the wetland will be severely impaired as its central branch will be mostly occupied by the new lake, affecting accessibility from main urban corridors, creating fragmented branches and offering fewer possibilities for the implementation of continuous green corridors.

Sub-Criteria 5: Occurrence and/or proximity of recreation facilities (including educational and touristic activities)

Ranking decreases by four (4) points in comparison to Variant 1. The spatial continuity of the wetland will be severely impaired as its central branch will be mostly occupied by the new lake, creating fragmented branches and offering fewer possibilities for the implementation of recreational activities.

Variant 3

Sub-Criteria 1: Quality of natural landscape / environment

Ranking decreases by one (1) point in comparison to Variant 1. The development of a series of cascading gabions can have a negative influence on the quality of the landscape if not designed with good aesthetic qualities. Some natural landscape areas can be developed around the water ponds and contribute to the attractiveness of the area, but the issue of the quality of the water must be addressed. Special attention must be given to maintenance of dry/wet areas throughout the different seasons.

Sub-Criteria 2: Quality of anthropic landscape / cultural environment

Ranking remains unchanged in comparison to Variant 1. No major manmade structures are proposed in the wetland.

Sub-Criteria 3: Exposures and visual clearances / perceptions

Ranking decreases by two (2) points in comparison to Variant 1. The visual clearances proposed by the Variant 1 will be somehow impaired by the creation of a series of cascading gabions, affecting perceptions of the wetland in surrounding areas, especially if not designed with good aesthetic qualities.

Sub-Criteria 4: Occurrence and level of continuity of green routes

Ranking decreases by two (2) points in comparison to Variant 1. The presence of the series cascading gabions will impair the spatial continuity of the wetland along its long axis. The structures can however be designed with accessible pedestrian routes that allow the crossing of both branches, creating a series of cross over corridors along the gabions. This actions however can be highly costly and would require considerable level of maintenance, specially to ensure that paths are safe for pedestrian use during the wet season.

Sub-Criteria 5: Occurrence and/or proximity of recreation facilities (including educational and touristic activities)

Ranking decreases by two (2) points in comparison to Variant 1. Although some small educational/research activities could be developed on the created ponds, the quality of the water would have to be treated in a permanent way. Special attention must be given to maintenance of dry/wet areas throughout the different seasons and to ensure safety to the users of the facilities during the wet season. The fact that proposed recreational activities are modular and can be installed at any suitable point along the walking circuits mean that similar types of facilities can be kept in this variant even if in fewer places.

SCREENING AGAINST CRITERIA: HIGHER LEVEL OBJECTIVES: KIBUMBA

Flood mitigation

TABLE 14-13 KIBUMBA FLOOD CONTROL ALL VARIANTS

		Baseline	Variant 1	Variant 2	Variant 3
Criterion	**Flood mitigation. Average score**	4	**9**	**9**	**9**
Sub criteria	Kibumba Sub-Criteria 1: Water depth over road KG 550	4	4	4	4
	Kibumba Sub-Criteria 2: Water depth over KG 15 Avenue	4	10	10	10
	Kibumba Sub-Criteria 3: Water depth over road KG 449	4	10	10	10
	Kibumba Sub-Criteria 4: Water depth over KG 33 Avenue	4	10	10	10

Variant 1:

For the baseline study, the four flooding focus points of this wetland obtain a score of 4. The upstream part of KG 550 St is not part of the wetland rehabilitation project zone. However, a hydraulic infrastructure is being implemented (see figure below) upstream of the golf to increase water retention at this point. As it is not part of the study, the score over the KG 550 St is maintained to 4. However, once the hydraulic infrastructure will be operating, the situation downstream will most certainly improve.

Upstream of the KG 15 Ave, river reprofiling and meander creation will allow for a great water retention. Therefore, for the three scenarios the score at this bridge will be of 10.

The cross section under the KG 33 Ave is clearly under-sized as it was already more than half full during the field visit (which was not during the rainy season). As it has be noted, the section is full with sediments and would need to be cleared. Blocking the agricultural drains over the K03 location would allow to create a huge storage capacity and to delay the peak discharge. Therefore, for the Variant 1, the score is of 10.

KG 449 St bridge as a clearly too small cross section (see figure below) to accommodate for the entire upstream runoff. The measures suggested upstream as a secondary priority will allow to create small retention zones in the wetland preventing from flooding over the bridge (score of 10).



HYDRAULIC INFRASTRUCTURE CURRENTLY BEING IMPLEMENTED UPSTREAM OF THE GOLF (ON THE LEFT), KG 33 AVE CROSS SECTION (IN THE MIDDLE) AND KG 449 ST CROSS SECTION (TO THE RIGHT)

A large lake would be created under variant 2 instead of the current agricultural zone. The first three criteria concern roads upstream of this lake. Therefore, the score will not be affected compared to the Variant 1 (score of 4, 10 and 10). This lake would act as a retention basin to store large amount of water during extreme rainfall

events. The flooding risk have already been completely cleared off with the Variant 1. Adding the Kibumba lake would enable to keep the flooding risk over the KG 33 Avenue to zero (score of 10).

Under variant 3, no additional measures are planned upstream of the KG 550 road, the score of the concerned criteria would remain 4. With this variant, 4 flow spreading structures combined with temporary retention ponds are added up to the measured planned through variant 1. Therefore, the flooding risk could only be improved as the storage capacity increase with retention ponds. As with the Variant 1, the criteria have already reached a score of 10, the three last criteria for the variant 3 would remain 10.

Biodiversity enhancement

TABLE 14-14 KIBUMBA BIODIVERSITY ENHANCEMENT ALL VARIANTS

		Baseline	Variant 1	Variant 2	Variant 3
Criterion	**Biodiversity enhancement. Average score**	**3**	**8**	**5**	**6**
Sub criteria	Sub-criteria 1: Absence of threats	2	8	2	4
	Sub-criteria 2: Soil hydrologic conditions	6	8	7	7
	Sub-criteria 3: Species composition	2	9	5	6
	Sub-criteria 4: Structural diversity	1	9	6	7
	Sub-criteria 5: Ecosystem function	5	9	5	6
	Sub-criteria 6: External exchanges	4	7	2	5

Variant 1

Even if the planned actions will reduce the main existing threats (reduction of artificialization and suppression of intensive agriculture), the urban context of the wetland still suggests an anthropic pressure on a small surface (less than 25% of the total surface). Indeed, anarchic land artificialization at the edge of the wetland and horticulture, facilitating the spontaneous colonization of invasive species, will always be possible.

Sub-criteria 2: Soil hydrologic conditions

The work of plugging the drains, raising the water level, and meandering the stream will contribute to a better feeding of the wetland and to the waterlogging of the soil. These improvements will also promote flooding of the wetland during regular rainfall events. It is therefore considered that the wetland soil will be permanently or regularly waterlogged over much of the wetland area.

Sub-criteria 3: Species composition

The restored areas will be planted mainly with native wetland species and the hydraulic actions carried out will reinforce the wetland character of the area, thus promoting the development of a plant community indicative of wetlands. The actions implemented will thus allow to reach a coverage of hygrophilous species higher than 80%.

Sub-criteria 4: Structural diversity

The actions aim primarily at developing the herbaceous cover, but also the shrub and tree stratum in order to diversify the habitats. It is indeed planned to plant riparian trees along the watercourses or to plant tree and shrub species on the high points of the basins, reinforcing the landscape and biological aspect. As a result, the wetland will eventually have an overlay of native natural habitats in three vegetative strata (trees, shrubs, and grasses) on more than three-quarters of the wetland's area.

Sub-criteria 5: Ecosystem function

The implementation of the various actions will significantly improve the hydraulic and biological functions of the wetland.

It is therefore considered that the hydraulic functionality and biological functionality will be evaluated at a high value.

Sub-criteria 6: External exchanges

The actions will create a diversity of ecological connections between the restored natural habitats. Indeed, the plantations along the watercourses, the vegetation of the cultivated areas, the creation of wet depressions... are supports favorable to the reception of the local biodiversity.

However, some linear infrastructures crossing the wetland form cuts between some parts of the wetland. Thus, the optimal scenario presents a partial fragmentation of the mosaic of natural habitats but the ecological connections are multiple (watercourses, hedges, woodlands ...).

Ecological connections with the upstream and downstream wetlands will also be limited by the existing infrastructure. Indeed, the study perimeter does not allow for the reworking of structures positioned outside the wetlands.

Variant 2

Under Variant 2, the creation of a water reservoir in the central part of the wetland will contribute to a cut in the longitudinal ecological connections between the downstream and upstream parts. In addition, in order to build such a structure, significant concrete rights-of-way (civil engineering works) will be required in the wetland. This work will have a direct impact on the biological functioning of the wetland. Even if the edges of the lake can support flora species (colonization of the different plant strata growing spontaneously), the area in water will not allow the development of a biodiversity typical of wetlands on its entire surface.

The central part of Kibumba will change from being a wetland (terrestrial environment) to an aquatic environment.

The implementation of wetland-friendly measures on the downstream and upstream parts will improve biological functionality. However, the benefits of these ecological actions will be partly degraded with the realization of the lake.

Variant 3

Under Variant 3, the construction of civil engineering structures to increase the flood expansion area will have a significant wetland footprint. Thus, this physical footprint is likely to impact the biological functions of the wetland. However, areas of water may temporarily form upstream of these mineral structures and allow for the development of interesting biodiversity. Despite the implementation of ecological actions allowing the improvement of the biological functionalities on the upstream and downstream parts of the wetland, these mineral developments may have a negative impact on the benefits expected by these actions. It is favorable to limit the presence of continuous obstacle in the valley will allow the conservation of the remaining ecological connections within the wetland.

Water quality improvement

TABLE 14-15 KIBUMBA IMPROVEMENT OF WATER QUALITY ALL VARIANTS

		Baseline	Variant 1	Variant 2	Variant 3
Criterion	**Improvement of water quality. Average score**	**4**	**7**	**7**	**6**
Sub criteria	Sub-criteria 1: Source of pollution inside the wetland	5	8	8	6
	Sub-criteria 2: External sources of pollution flowing in the wetland (point source and nonpoint source)	3	3	3	3
	Sub-criteria 3: Quality of surface water flowing in the wetland	4	8	9	7
	Sub-criteria 4: Natural filtration function of the wetland	4	8	9	7

Sub-criteria 1: Source of pollution inside the wetland

Variant 1:

Restoration actions will limit the sources of pollution within the wetland. However, due to the size of the area, not all activities can be controlled. Sources of pollution will still be present, but they will be limited to a few areas within the wetland.

Variant 2 is not changing the value of this sub-criteria as for all variants, the restoration actions aiming at pollution inside the wetland are the same (limitation of agriculture).

Variant 3 could however bring a new source of pollution inside the wetland, caused the lake. This could take place especially during dry months when lack of circulation of water could reduce oxygen level, provide breeding ground for the water hyacinth and create favourable conditions for eutrophication of water due to accumulation of pollutants in stagnant water (especially nutrients and herbicides from the nearby golf course), thus creating a new source of pollution inside the wetland.

Sub-criteria 2: External sources of pollution flowing in the wetland (point source and nonpoint source)

All variants would have the same score for this sub-criteria.

Even if all water management actions are implemented, the wetland will still receive direct or indirect external pollution (polluted runoff, upstream watershed of the wetland not affected by the actions...). Indeed, the urban context of wetlands cannot ensure the absence of untreated external pollution, and the current threats will remain. One important source of pollution is the golf course located upstream; its drainage is hydro connected to Kibumba.

Sub-criteria 3: Quality of surface water flowing in the wetland

Variant 1:

In the case of a full implementation of the actions, Variant 1 will allow a strong mitigation of the different types of pollution (organic or inorganic). However, these actions will have to be accompanied by stormwater management measures and development of sewerage within the urban watershed.

Variant 2 would strongly reduce turbidity of water flowing in the wetland, by slowing down erosive floods.

Variant 3 would allow sediment to settle thanks to lake acting as large retention ponds, thus reducing this source of pollution. The lake would however create eutrophic water, especially during the dry month, impacting water quality for some chemical parameters.

As for all Variants, actions will have to be accompanied by stormwater management measures and development of sewerage within the urban watershed.

Sub-criteria 4: Natural filtration function of the wetland

Variant 1:

Restoration actions in the wetland (plugging of drains, establishment of buffer zones at the urban drains, vegetation...) will significantly improve its biogeochemical functionality. Thus, the natural filtering function of the wetland will be effective.

Variant 2 would be accompanied by the creation of small retention ponds, allowing additional filtration of water by increasing the retention time of water in the wetlands.

The lake proposed under Variant 3 will not have any natural filtering function (see explanation above). The space occupied by the lake would reduce land availability for other more efficient depuration actions.

Development of recreational activities and landscape

TABLE 14-16 NYABUGOGO LOWER DEVELOPMENT OF RECREATIONAL ACTIVITIES AND LANDSCAPE ALL VARIANTS

		Baseline	Variant 1	Variant 2	Variant 3
Criterion	**Landscape and recreational activities. Average score**	**4**	**8**	**7**	**7**
Sub criteria	Sub-Criteria 1: Quality of natural landscape / environment	2	8	8	7

	Sub-Criteria 2: Quality of anthropic landscape / cultural environment	3	7	7	7
	Sub-Criteria 3: Exposures and visual clearances / perceptions	3	8	8	6
	Sub-Criteria 4: Occurrence and level of continuity of green routes	3	10	6	8
	Sub-Criteria 5: Occurrence and/or proximity of recreation facilities (including educational and touristic activities)	9	9	8	7

Variant 1

Sub-Criteria 1: Quality of natural landscape / environment

The rehabilitation of the wetland and the creation of different natural habitats by establishing green urban spaces with the planting of native species (meadows, woodland, etc.), will improve considerably the performance of Kibumba in terms of the quality of its natural environment.

Sub-Criteria 2: Quality of anthropic landscape / cultural environment

The creation of small gardens along the walking circuits within the wetland will improve considerably its performance in terms of anthropic landscape. No major manmade structures are proposed in the wetland.

Sub-Criteria 3: Exposures and visual clearances / perceptions

The proposed permeability axis and connection to existing urban corridors (see plan) will improve visual clearances and perceptions of the wetland in some areas.

Sub-Criteria 4: Occurrence and level of continuity of green routes

The development of the proposed pedestrian and cycling circuits will improve circulation within the wetland and will also improve accessibility of the zone from main urban corridors.

Sub-Criteria 5: Occurrence and/or proximity of recreation facilities (including educational and touristic activities)

The wetland is already deserved by different recreational attractions. Although no major recreation parks are proposed by the consultant, the creation of a series of outdoor gym circuits, children play areas, picnic areas, bird watching decks, etc will contribute to the attractiveness of the wetland in terms of recreational activities and attract additional economic activities. It is recommended to concentrate economic related activities near existing recreational attractions.

Variant 2

Sub-Criteria 1: Quality of natural landscape / environment

Ranking remains unchanged in comparison with Variant 1. The creation of different natural habitats by establishing green urban spaces with the planting of native species (meadows, woodland, etc.) can still be developed in the area. Although less dry areas of natural habitat will be developed due to the presence of the lake, the rank remains at a high level as the presence of open water features is considered to contribute to the improvement of the user experience and the quality of the landscape.

Sub-Criteria 2: Quality of anthropic landscape / cultural environment

Ranking remains unchanged in comparison with Variant 1. Proposed landscaped areas can be developed in the same logic, along the walking/cycling circuits, although in smaller scale as available areas will be considerably reduced.

Sub-Criteria 3: Exposures and visual clearances / perceptions

Ranking remains unchanged in comparison with Variant 1. The development of the lake can contribute to the quality of visual clearances within the wetland in the same way with the development of natural habitat gardens along the walking circuits.

Sub-Criteria 4: Occurrence and level of continuity of green routes

Ranking decreases by four (4) points in comparison with Variant 1. The proposed lake occupies a considerably large area and creates two fragmented branches on the wetland, restraining the available areas for development of green routes and recreational facilities. These two disconnected areas will impair the spatial continuity of the wetland and impeach the connectivity between the wetland and adjacent urban areas as well as within the wetland.

Sub-Criteria 5: Occurrence and/or proximity of recreation facilities (including educational and touristic activities)

Ranking decreases by one (1) point in comparison with Variant 1. The lake can provide opportunities for development of water activities; however, the quality of the water needs to be treated in a permanent way. The creation of a series of outdoor gym circuits, children play areas, picnic areas, bird watching decks, etc will be impaired as fewer surface areas will be available for these activities with the development of the lake

Variant 3

Sub-Criteria 1: Quality of natural landscape / environment

Ranking decreases by one (1) point in comparison to Variant 1. The development of a series of cascading gabions can have a negative influence on the quality of the landscape if not designed with good aesthetic qualities. Some natural landscape areas can be developed around the water ponds and contribute to the attractiveness of the area, but the issue of the quality of the water must be addressed. Special attention must be given to maintenance of dry/wet areas throughout the different seasons.

Sub-Criteria 2: Quality of anthropic landscape / cultural environment

Ranking remains unchanged in comparison to Variant 1. No major manmade structures are proposed in the wetland.

Sub-Criteria 3: Exposures and visual clearances / perceptions

Ranking decreases by two (2) points in comparison to Variant 1. The visual clearances proposed by the Variant 1 will be somehow impaired by the creation of a series of cascading gabions, affecting perceptions of the wetland in surrounding areas, especially if not designed with good aesthetic qualities.

Sub-Criteria 4: Occurrence and level of continuity of green routes

Ranking decreases by two (2) points in comparison to Variant 1. The presence of the series cascading gabions will impair the spatial continuity of the wetland along its long axis. The structures can however be designed with accessible pedestrian routes that allow the crossing of both branches, creating a series of cross over corridors along the gabions. This actions however can be highly costly and would require considerable level of maintenance, specially to ensure that paths are safe for pedestrian use during the wet season.

Sub-Criteria 5: Occurrence and/or proximity of recreation facilities (including educational and touristic activities)

Ranking decreases by two (2) points in comparison to Variant 1. Although some small educational/research activities could be developed on the created ponds, the quality of the water would have to be treated in a permanent way. Special attention must be given to maintenance of dry/wet areas throughout the different seasons and to ensure safety to the users of the facilities during the wet season. The fact that proposed recreational activities are modular and can be installed at any suitable point along the walking circuits mean that similar types of facilities can be kept in this variant even if in fewer places.

SCREENING AGAINST CRITERIA: HIGHER LEVEL OBJECTIVES: NYABUGOGO LOWER

Flood mitigation

TABLE 14-17 NYABUGOGO LOWER FLOOD CONTROL ALL VARIANTS

		Baseline	Variant 1	Variant 2	Variant 3
Criterion	**Flood mitigation. Average score**	**4**	**10**	**10**	**10**
Sub criteria	Nyabugogo Lower Sub-Criteria 1: Water depth over KG 14 Avenue	4	10	10	10
	Nyabugogo Lower Sub-Criteria 2: Water depth over Nyabugogo	4	10	10	10

For the baseline study, both flooding focus points of this wetland obtain a score of 4. Important measures taken through the Variant 1 (reprofiling, meanders and planting species) allow for water to slow down and to be stored to achieve a score of 10 at the two focus points.

A large lake would be created under variant 2, but the score of both criteria would not be affected as the roads concerned are located upstream (remain 10).

In variant 3, several flow spreading structures combined with temporary retention ponds are added up to the measured planned through variant 1. One of these structures is located just upstream of KG14 Avenue which will be able to stop any flooding over the road. The score would then be of 10. Two of these structures are located upstream of the Nyabugogo pedestrian road which would also clear off any flooding risk (score of 10) as the water storage capacity is greatly enhanced.

Biodiversity enhancement

TABLE 14-18 NYABUGOGO LOWER BIODIVERSITY ENHANCEMENT ALL VARIANTS

		Baseline	Variant 1	Variant 2	Variant 3
Criterion	**Biodiversity enhancement. Average score**	**4**	**9**	**4**	**6**
Sub criteria	Sub-criteria 1: Absence of threats	2	8	2	4
	Sub-criteria 2: Soil hydrologic conditions	6	8	7	7
	Sub-criteria 3: Species composition	4	9	5	6
	Sub-criteria 4: Structural diversity	1	9	6	7
	Sub-criteria 5: Ecosystem function	6	9	5	7
	Sub-criteria 6: External exchanges	6	8	1	6

Variant 1

Sub-criteria 1: Threats

Even if the planned actions will reduce the main existing threats (reduction of artificialization and suppression of intensive agriculture), the urban context of the wetland still suggests an anthropic pressure on a small surface (less than 25% of the total surface). Indeed, anarchic land artificialization at the edge of the wetland and horticulture, facilitating the spontaneous colonization of invasive species, will always be possible.

Sub-criteria 2: Soil hydrologic conditions

The work of plugging the agriculture drains, raising the water level, and meandering the stream will contribute to a better feeding of the wetland and to the waterlogging of the soil. These improvements will also promote flooding of the wetland during regular rainfall events. It is therefore considered that the wetland soil will be permanently or regularly waterlogged over much of the wetland area.

Sub-criteria 3: Species composition

The restored areas will be planted mainly with native wetland species and the hydraulic actions carried out will reinforce the wetland character of the area, thus promoting the development of a plant community indicative of wetlands. The actions implemented will thus allow to reach a coverage of hygrophilous species higher than 80%.

Sub-criteria 4: Structural diversity

The actions aim primarily at developing the herbaceous cover, but also the shrub and tree stratum in order to diversify the habitats. It is indeed planned to plant riparian trees along the watercourses or to plant tree and shrub species on the high points of the basins, reinforcing the landscape and biological aspect. As a result, the wetland will eventually have an overlay of native natural habitats in three vegetative strata (trees, shrubs, and grasses) on more than three-quarters of the wetland's area.

Sub-criteria 5: Ecosystem function

The implementation of the various actions will significantly improve the hydraulic and biological functions of the wetland.

It is therefore considered that the hydraulic functionality and biological functionality is evaluated as high.

Sub-criteria 6: External exchanges

The actions will create a diversity of ecological connections between the restored natural habitats. Indeed, the plantations along the watercourses, the vegetation of cultivated areas, the creation of wetland depressions... are supports favorable to the reception of the local biodiversity.

The Nyabugogo wetland has less linear infrastructure crossing the wetland, so the cuts are less detrimental to the migration of animal species. The optimal scenario presents a low fragmentation of the mosaic of natural habitats and the ecological connections are multiple (watercourses, hedges, woodlands ...).

Ecological connections with the upstream and downstream wetlands will also be limited by the existing infrastructure. Indeed, the study perimeter does not allow for the reworking of structures positioned outside the wetlands.

Variant 2

Under Variant 2, the enlargement of the water body on the downstream part of the wetland will contribute to a cut in the longitudinal ecological connections. In addition, in order to build such a structure, significant concrete rights-of-way (civil engineering works) will be required in the wetland. This work will have a direct impact on the biological functioning of the wetland. Even if the edges of the lake will be able to support flora species (colonization of the different plant strata growing spontaneously), the area in water will not allow the development of a biodiversity typical of wetlands on its entire surface. The current water area is heavily colonized by invasive species and its extension will allow invasive plant species to develop easily. This extension could result in significant management costs to control the spread of invasive species.

The downstream portion of Nyabugogo will change from a wetland (terrestrial) to an aquatic environment.

The implementation of wetland-friendly measures on the upstream parts will improve biological functionality. However, the benefits of these ecological actions will be partially degraded with the expansion of the water body.

Variant 3:

The construction of civil engineering structures to increase the flood expansion area will have a significant wetland footprint. Thus, this physical footprint is likely to impact the biological functions of the wetland and limits the possibility of implementing other ecological actions to improve the connections between the watercourse and the wetland (upstream part to the north). However, water areas may temporarily form upstream of these mineral developments and allow for the development of interesting biodiversity.

The benefits expected from the implementation of ecological actions on the other parts of the wetland may be lower due to the implementation of these mineral developments. It is favorable to limit the presence of continuous obstacle in the valley will allow the conservation of the remaining ecological connections within the wetland.

Water quality improvement

TABLE 14-19 NYABUGOGO LOWER IMPROVEMENT OF WATER QUALITY ALL VARIANTS

		Baseline	Variant 1	Variant 2	Variant 3
Criterion	**Improvement of water quality. Average score**	**4**	**7**	**7**	**6**
Sub criteria	Sub-criteria 1: Source of pollution inside the wetland	4	8	8	5
	Sub-criteria 2: External sources of pollution flowing in the wetland (point source and nonpoint source)	5	5	5	5
	Sub-criteria 3: Quality of surface water flowing in the wetland	3	7	8	6
	Sub-criteria 4: Natural filtration function of the wetland	5	9	9	6

Sub-criteria 1: Source of pollution inside the wetland

Variant 1:

Restoration actions will limit the sources of pollution within the wetland. However, due to the size of the area, not all activities can be controlled. Sources of pollution will still be present, but they will be limited to a few areas within the wetland.

Variant 2 is not changing the value of this sub-criteria as for all variants, the restoration actions aiming at pollution inside the wetland are the same (limitation of agriculture).

Variant 3 could however bring a new source of pollution inside the wetland, caused the lake. This could take place especially during dry months when lack of circulation of water could reduce oxygen level, provide breeding ground for the water hyacinth and create favourable conditions for eutrophication of water due to accumulation of pollutants in stagnant water (especially that the lake would be located downstream, of all other wetlands), thus creating a new source of pollution inside the wetland.

Sub-criteria 2: External sources of pollution flowing in the wetland (point source and nonpoint source)

All variants would have the same score for this sub-criteria.

Even if all water management actions are implemented, the wetland will still receive direct or indirect external pollution (polluted runoff, upstream watershed of the wetland not affected by the actions...). Indeed, the urban context of wetlands cannot ensure the absence of untreated external pollution, and the current threats will remain.

Sub-criteria 3: Quality of surface water flowing in the wetland

Variant 1:

In the case of a full implementation of the actions, the optimum scenario will allow a strong mitigation of the different types of pollution (organic or inorganic). However, these actions will have to be accompanied by stormwater management measures and development of sewerage within the urban watershed. Nyabugogo Lower is located downstream and will collect pollutants from all other wetlands, it will most likely always be more polluted that the 4 other wetlands

Variant 2 would strongly reduce turbidity of water flowing in the wetland, by slowing down erosive floods.

Variant 3 would allow sediment to settle thanks to lake acting as large retention ponds, thus reducing this source of pollution. The lake would however create eutrophic water, especially during the dry month, impacting water quality for some chemical parameters.

As for all Variants, actions will have to be accompanied by stormwater management measures and development of sewerage within the urban watershed.

Sub-criteria 4: Natural filtration function of the wetland

Variant 1:

Restoration actions in the wetland (plugging of agricultural drains, establishment of buffer zones at the urban drains, vegetation...) will significantly improve its biogeochemical functionality. Thus, the natural filtering function of the wetland will be effective. The creation of a small delta at the month of the river will be highly effective at settling sediments and pollutants.

Variant 2 would be accompanied by the creation of small retention ponds, allowing additional filtration of water by increasing the retention time of water in the wetlands. However, without the inland delta under Variant 2, this advantage would globally be lost.

The lake proposed under Variant 3 will not have any natural filtering function (see explanation above). The space occupied by the lake would strongly reduce land availability for other more efficient depuration actions especially given the lack of space for the inland delta.

Development of recreational activities and landscape

		Baseline	Variant 1	Variant 2	Variant 3
Criterion	**Landscape and recreational activities. Average score**	**6**	**9**	**9**	**8**
Sub criteria	Sub-Criteria 1: Quality of natural landscape / environment	7	9	9	8
	Sub-Criteria 2: Quality of anthropic landscape / cultural environment	6	9	9	9
	Sub-Criteria 3: Exposures and visual clearances / perceptions	4	10	10	8
	Sub-Criteria 4: Occurrence and level of continuity of green routes	6	10	10	8
	Sub-Criteria 5: Occurrence and/or proximity of recreation facilities (including educational and touristic activities)	5	9	9	7

Variant 1

Sub-Criteria 1: Quality of natural landscape / environment

The rehabilitation of the wetland and the creation of different natural habitats by establishing green urban spaces with the planting of native species (meadows, woodland, etc.), will contribute to the quality of the natural landscape of Nyabugogo. Existing natural areas of green cover and of native habitats should be enhanced and awareness of their preservation should be promoted. Particular attention should be given to areas where the presence of Papyrus was identified as this incidence can enhance the quality of the natural environment.

Sub-Criteria 2: Quality of anthropic landscape / cultural environment

The creation of a series of qualitative spaces (gardens, birdwatching decks, picnic area, etc) as part of the program of the proposed Wetland Centre will highly improve the quality of the anthropic landscape, especially in the areas around the artificial lake. In addition to the interventions proposed by the consultant, according to the NYARUGENGE CBD Urban Design & Regulations - Kigali Master Plan 2050 from 2019, the CoK have plans to develop a façade connecting the wetlands and adjacent urban areas, which will contribute to improvement of the cultural environment.

Sub-Criteria 3: Exposures and visual clearances / perceptions

The proposed improvements to the permeability and accessibility of the wetland (see plan) as well as the spatial organization of different habitats created will improve perception of the wetland from several viewpoints. If the “wetland front”, planned by the CoK as per mentioned above, is developed, coordination with proposed interventions will further enhance visual clearances and exposure of the wetland.

Attention point: areas on the western ends of the wetland which present a challenging topography will impose constrains to the spatial continuity of the "wetland front" into the west (towards Rugenge-Rwintare). An alternative façade for the "wetland front" could be incorporated to the proposed pedestrian/cycling paths focusing on activities that do not necessarily have to be directly connected to the street.

Sub-Criteria 4: Occurrence and level of continuity of green routes

The development of the proposed pedestrian and cycling circuits will improve circulation within the wetland and will also improve accessibility of the zone from main urban corridors as well as to the existing Memorial area. Connectivity should be enhanced into the green corridors that connect the wetland to the transport hub and city centre (see plan). An important pedestrian route with a bridge crossing the Nyabugogo river will connect both sides of the wetland on the main branch will improve connectivity of urban areas on both ends of the wetland.

Sub-Criteria 5: Occurrence and/or proximity of recreation facilities (incl educational and touristic activities)

Development of ecologic awareness and recreational activities proposed by the development of the Nyabugogo wetland centre in the identified area around the artificial lake (see plan) will have a positive impact on the improvement of the attractiveness of the wetland and the promotion of preservation awareness. Association with the development of economic activities (restaurants, gift shops, events spaces for rent, exhibition areas, etc.) will increase the sustainability of the investments.

Variant 2

The raking of the variant 2 for Nyabugogo remains unchanged in relation to Variant 1. The same area is kept for the development for recreational and landscape activities and a lake is already in place.

Variant 3

Sub-Criteria 1: Quality of natural landscape / environment

Ranking decreases by one (1) point in comparison to Variant 1. The development of a series of cascading gabions can have a negative influence on the quality of the landscape if not designed with good aesthetic qualities. Some natural landscape areas can be developed around the water ponds and contribute to the attractiveness of the area, but the issue of the quality of the water must be addressed. Special attention must be given to maintenance of dry/wet areas throughout the different seasons.

Sub-Criteria 2: Quality of anthropic landscape / cultural environment

Ranking remains unchanged in comparison to Variant 1. No major manmade structures are proposed in the wetland.

Sub-Criteria 3: Exposures and visual clearances / perceptions

Ranking decreases by two (2) points in comparison to Variant 1. The visual clearances proposed by the optimum scenario will be somehow impaired by the creation of a series of cascading gabions, affecting perceptions of the wetland in surrounding areas, especially if not designed with good aesthetic qualities.

Sub-Criteria 4: Occurrence and level of continuity of green routes

Ranking decreases by two (2) points in comparison to Variant 1. The presence of the series cascading gabions will impair the spatial continuity of the wetland along its long axis. The structures can however be designed with accessible pedestrian routes that allow the crossing of both branches, creating a series of cross over corridors along the gabions. This actions however can be highly costly and would require considerable level of maintenance, specially to ensure that paths are safe for pedestrian use during the wet season.

Sub-Criteria 5: Occurrence and/or proximity of recreation facilities (including educational and touristic activities)

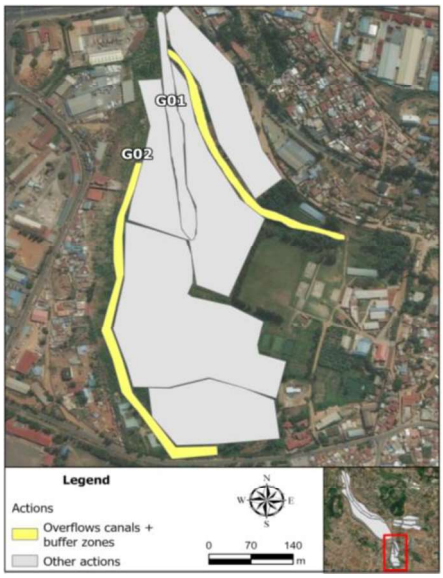
Ranking decreases by two (2) points in comparison to Variant 1. Although some small educational/research activities could be developed on the created ponds, the quality of the water would have to be treated in a permanent way. Special attention must be given to maintenance of dry/wet areas throughout the different seasons and to ensure safety to the users of the facilities during the wet season. The fact that proposed recreational activities are modular and can be installed at any suitable point along the walking circuits mean that similar types of facilities can be kept in this variant even if in fewer places

15. APPENDIX 5: PRELIMINARY DESIGNS / ACTION SHEETS

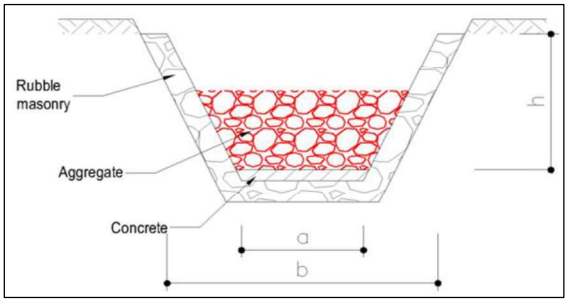
Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet		
Action 1.G	Name	Raising the water level in the outfalls
	Action target	Water filtration, Biodiversity, Flood mitigation
	Wetland	Gikondo

Location (map) G01 - G02



Photos / examples





Characteristics	Rough cost estimate	Priority	Objectives
G01 : recharge the end of the channel over 200 m with different diamter aggregates	4,600 USD	1 - Short-term 2025	- Limit the drainage of the wetland - Favor overflow over the concrete channel and the river beds - Reduce the water quantity and velocity downstream - Favor aquatic environment in the wetland
G02 : recharge the end of the channel over 200 m with different diamter aggregates	14,700 USD	1 - Short-term 2025	
G06 : recharge the end of the channel over 200 m with different diamter aggregates	18,387 USD	1 - Short-term 2025	
G09 : recharge the end of the channel over 200 m with different diamter aggregates	18,387 USD	2 - Medium-term 2035	
G15 : recharge the end of the channel over 200 m with different diamter aggregates	18,387 USD	1 - Short-term 2025	

Comments	

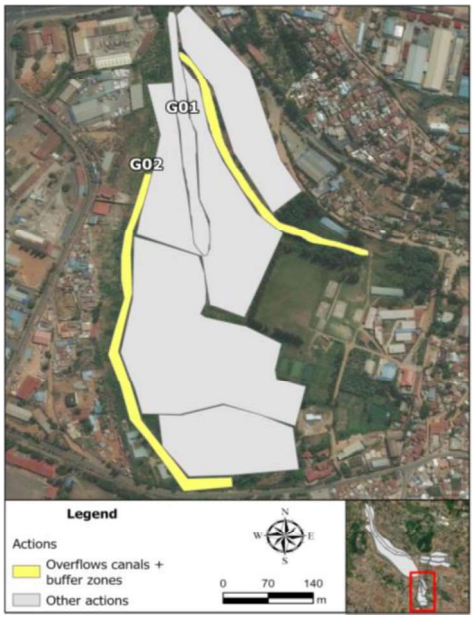
Maintenance need	Needs to be defined according to the monitoring management report
Management monitoring	The work will be the subject of a technical file of the works carried out with the plans of the built installations. A follow-up of the profile of the restored banks and the minor bed will be carried out 6 months after the end of the work and then the year that follows. The frequency will be adapted according to the possible disorders observed and the results of this follow-up. On the basis of the technical file, the following will be identified - Possible movements, departures or contributions of blocks; - All possible traces of erosion, scouring on the resumed zones as well as on the transition zones and the zones peripheral to the development not impacted by the works. All the elements of this follow-up will be recorded in a report. In conclusion, recommendations will be made on possible rework, the frequency of monitoring, and on future developments.

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

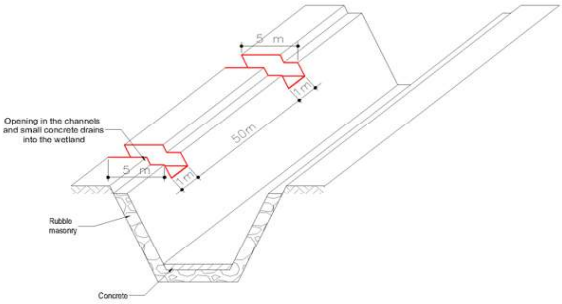
Action sheet

Action 2.G	Name	Creation of overflows on the two concrete canals to ensure overflow of water into the wetland during rainfall
	Action target	Water filtration, Biodiversity
	Wetland	Gikondo

Location (map) G01 - G02



Photos / examples





Characteristics	Rough cost estimate	Priority	Objectives
G01: make 10 openings (each 50 m) in the existing channel and build small concrete drains	22,005 USD	1 - Short-term 2025	- Limit the drainage of the wetland - Favor overflow the concrete channel and the river beds - Reduce the water quantity and velocity downstream - Improve water quality - Favor aquatic environment in the wetland
G02: make 13 openings (each 50 m) in the existing channel and build small concrete drains	22,005 USD	1 - Short-term 2025	

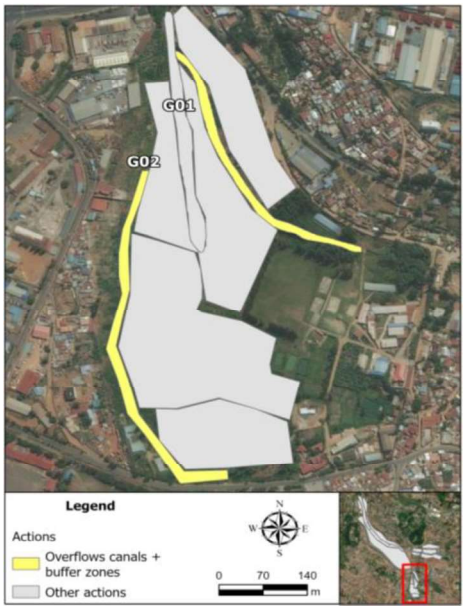
Comments	Renvoi vers plans détaillés si besoin
Maintenance need	- Maintenance of the concrete drains (provent from solid waste accumulation): twice per year (including one before the rainy season) - Other needs to be defined according to the management monitoring report
Management monitoring	The work will be the subject of a technical file of the works carried out with the plans of the built installations. A follow-up of the profile of the restored banks and the minor bed will be carried out 6 months after the end of the work and then the year that follows. The frequency will be adapted according to the possible disorders observed and the results of this follow-up. On the basis of the technical file, the following will be identified - Possible movements, departures or contributions of blocks; - All possible traces of erosion, scouring on the resumed zones as well as on the transition zones and the zones peripheral to the development not impacted by the works. All the elements of this follow-up will be recorded in a report. In conclusion, recommendations will be made on possible rework, the frequency of monitoring, and on future developments.

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

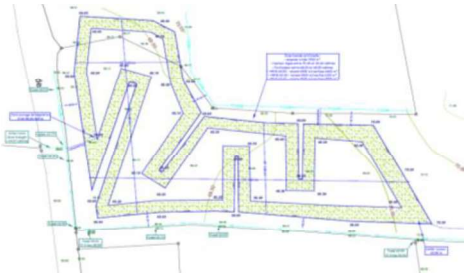
Action sheet

Action 3-G	Name	Creation of buffer zones (filtering wetlands)
	Action target	Biodiversity and Water Quality
	Wetland	Gikondo

Location (map) G01 - G02



Photos / examples







Characteristics	Rough cost estimate	Priority	Objectives
G01 Surface : 6 300 m²	128,790	1 - Short-term 2025	The structure will have the same operating principles as a retention basin with the difference that the leakage rate will be variable according to the water level. It will be fed by rainwater and overflows from peripheral outfalls. The preliminary studies require a detailed analysis of the contributing catchment area (surface area of the catchment area, land use, etc.). In summary, the creation of a buffer zone is carried out in 3 stages - Feasibility study to identify the environmental issues and take them into account in the design: topographic surveys, soil studies, hydraulic studies of the watershed... - Design study including: execution plans of the buffer zone, hydraulic dimensioning of the works and integration of the educational supports... - Works and follow-up of the construction site requiring the intervention of qualified partners for the realization of the civil engineering (earthworks to create the various compartments, creation of dikes to lengthen the hydraulic path...), of the ecological engineering (choice of materials, planting of the vegetable species...) and of a qualified work manager. A safety margin of 0.30m (minimum difference between the highest water level and the top of the compartment crest) is provided for during periods of maximum compartment filling. To achieve this objective, overflows will be installed at the top of the compartment crest.
G02 Surface : 9 600 m²	128,790	1 - Short-term 2025	

Comments	- The wetland buffer cannot be effective if it collects untreated wastewater. - Maximum depth of the compartments fixed at 1,20m

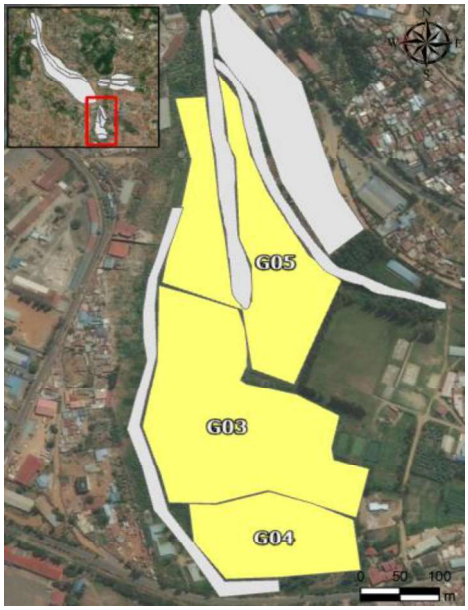
Maintenance need	Annual management by mowing in August, before the rainy season The management of the buffer zone leads to be vigilant on the following hydraulic phenomena - Creation of hydraulic plugs at the level of hydraulic structures that can lead to overflows (loading of the system) and a reduction in residence time. - Reduction of the residence time and the treatment capacity of the system by short circuits and the filling of the volume of the basins. - Risk of invasive plants or plant dieback. A management plan also aims to - Ensure the cutting of plants with export of green waste - Maintain a high level of biodiversity in the water compartments by applying a differentiated vegetation management method. - Perpetuate the landscape quality of the site and its potential to welcome the public.
Management monitoring	Monitoring of the evolution of vegetation and hydraulics twice a year, during dry and rainy seasons, by an expert in ecological engineering, for 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30)

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

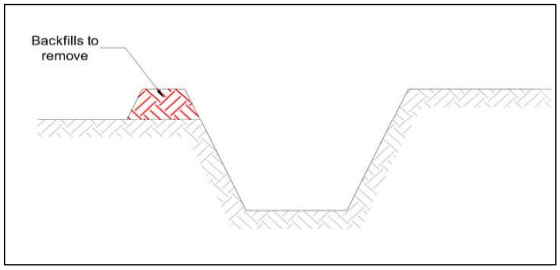
Action sheet

Action 4.G	Name	Removal of existing backfills
	Action target	Water filtration, Biodiversity
	Wetland	Gikondo

Location (map) - G03 - G04 - G05



Photos / examples





Characteristics	Rough cost estimate	Priority	Objectives
G03: Removal of 67 m3 of existing backfills	287,145 USD	1 - Short-term 2025	- Ground levelling - Enhance the storage capacity of the wetland - Reduce the water quantity and velocity downstream, limit the peak discharge
G04: Removal of 53 m3 of existing backfills	287,145 USD	1 - Short-term 2025	
G05: Removal of 420 m3 of existing backfills	287,145 USD	1 - Short-term 2025	

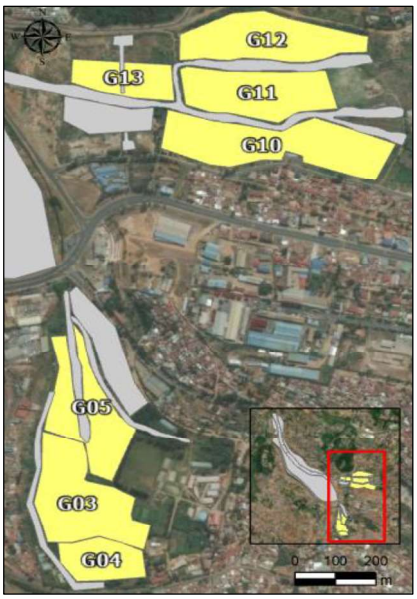
Comments	
Maintenance need	No needs
Management monitoring	No needs

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

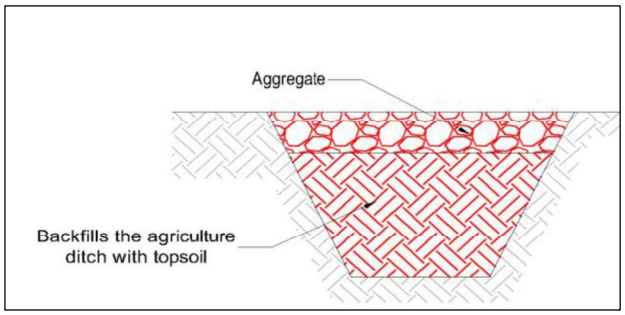
Action 5.G	Name	Blocking of surface and subsurface drains
	Action target	Water filtration, Biodiversity
	Wetland	Gikondo

Location (map) G03 - G04 - G05 - G10 - G11 - G12 - G13



Photos / examples





Characteristics	Rough cost estimate	Priority	Objectives
G03: backfill the agricultural drains with approximately 830 m3	153,090 USD	1 - Short-term 2025	- Limit the lowering of the groundwater - Increase the residence time of the water in the wetland - Homogenise the wetland ground - Enhance the storage capacity of the wetland - Reduce the water quantity and velocity downstream
G04: backfill the agricultural drains with approximately 1 500 m3	153,090 USD	1 - Short-term 2025	
G05: backfill the agricultural drains with approximately 1 12 000 m3	153,090 USD	1 - Short-term 2025	
G10: backfill the agricultural drains with approximately 1 10 000 m3	110,565 USD	2 - Medium-term 2035	
G11: backfill the agricultural drains with approximately 1 15 000 m3	154,508 USD	2 - Medium-term 2035	
G12: backfill the agricultural drains with approximately 7 800 m3	85,253 USD	2 - Medium-term 2035	
G13: backfill the agricultural drains with approximately 11 000 m3	101,048 USD	2 - Medium-term 2035	

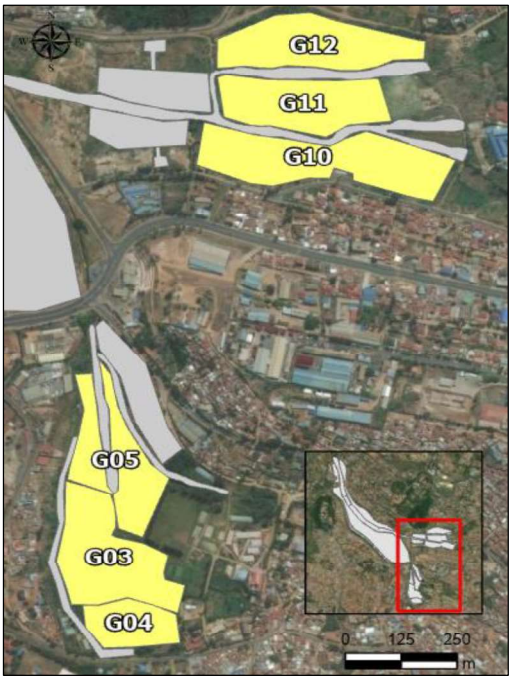
Comments	
Maintenance need	No needs
Management monitoring	No needs

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

Action 6.G	Name	Planting of native plant species adapted to the wetland environment
	Action target	Biodiversity
	Wetland	Gikondo

Location (map) G03 - G04 - G05 - G10 - G11 - G12



Photos / examples



Characteristics	Rough cost estimate	Priority	Objectives
G03 Surface : 51 600 m²	195,048 USD	1 - Short-term 2025	This action aims at recovering a herbaceous cover on all these surfaces, composed of a characteristic flora of wetlands and typical of Rwandan wetlands. For that, the first step consists in a preparation of the ground, with a decompacting of the ground in place on the first 15 centimeters in order to reactivate the seed bank and to support the rooting. The second step consists of planting with native species typical of local wetlands, such as Indian pennywort (*Centella asiatica*), Urugaga (*Cyperus dives*), Urukanganga/Epiphytic flatsedge (*Cyperus latifolius*), Carolina dichondra (*Dichondra micrantha*), Ubwungo/Heartleaf drymary (*Drymaria cordata*), Urufunzo/Papyrus (*Cyperus papyrus*), Umuberanya/Southern Cattail (*Typha domingensis*), Carex mildbraediana, Urukirakenja/Jointed flatsedge (*Cyperus articulatus*), Umujangaja/winged sedge (*Cyperus denudatus*), Carolina dichondra (Dichondra micrantha), Urujenone (*Enhydra fluctuans*), Gutwikumwe/Floating pennywort (*Hydrocotyle ranunculoides*), Ubusuna/Common rush (*Juncus effusus*), Urukembagufa/Cut grass (*Leersia hexandra*), Ikirogora (*Brillantaisia cicatricosa*), Umuzigangore (*Ludwigia abyssinica*), Igorogonzo/Watersmart weed *(Persicaria decipiens*), Igorogonzo/Watersmart weed (*Persicaria pulchra*), Urutaretare/ (*Pycreus macrostachys*). The plantings will aim to adapt the location of the species according to their need for water and the water conditions of the soil, in order to favour their development. The seedlings must come from a local source, which is necessary both ecologically and economically: ecologically, because the plants present in a given territory necessarily have the appropriate genetics for that land and are therefore adapted to local
G04 Surface : 20 600 m²	77,868 USD	1 - Short-term 2025	
G05 Surface : 39 100 m²	147,798 USD	1 - Short-term 2025	
G10 Surface : 60 600 m²	229,068 USD	2 - Medium-term 2035	

G11 Surface : 43 400 m²	164,052 USD	2 - Medium-term 2035	conditions, and economically, because local actors are more in demand than foreign suppliers. The planting will take place in December, once the rainy season is over. The clods will be installed in a hole made with a tiller, a planter or a pickaxe and carefully positioned in the hole thus made. Before planting, the plants will be soaked in water before installation and then packed in the soil. The plants in cups will be distributed by spots at a rate of 2 plants per m². All plants supplied by the landscaper shall be of the species and variety requested, free of wounds and pest attacks. They shall be separated by destination compartment and by species to facilitate distribution and verification. The plants must be replanted as soon as possible after delivery.
G12 Surface : 45 800 m²	173,124 USD	2 - Medium-term 2035	
Comments			
Maintenance need	Annual management by mowing in August, before the rainy season		
Management monitoring	Monitoring the evolution of the vegetation twice a year, during the dry seasons, by botanical expert, over 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30).		

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

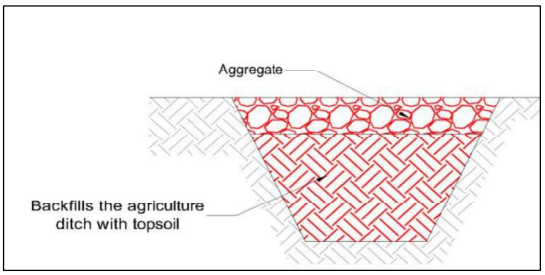
Action sheet		
Action 8.G	Name	Recharge of the river bed with aggregate
	Action target	Water filtration, Biodiversity
	Wetland	Gikondo

Location (map) G06 - G09 - G15



Photos / examples





Characteristics	Rough cost estimate	Priority	Objectives
G06 : filling the watercourse with aggregates of different diameter and topsoil	17,739 USD	1 - Short-term 2025	- Recover a space favorable for planting - Development of natural habitats
G09 : filling the watercourse with aggregates of different diameter	112,752 USD	2 - Medium-term 2035	
G15 : filling the watercourse with aggregates of different diameter	330,804 USD	3 - Long-term 2050	

Comments	
Maintenance need	Needs to be defined according to the monitoring management report
Management monitoring	The work will be the subject of a technical file of the works carried out with the plans of the built installations. A follow-up of the profile of the restored banks and the minor bed will be carried out 6 months after the end of the work and then the year that follows. The frequency will be adapted according to the possible disorders observed and the results of this follow-up. On the basis of the technical file, the following will be identified - Possible movements, departures or contributions of blocks; - All possible traces of erosion, scouring on the resumed zones as well as on the transition zones and the zones peripheral to the development not impacted by the works. All the elements of this follow-up will be recorded in a report. In conclusion, recommendations will be made on possible rework, the frequency of monitoring, and on future developments.

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

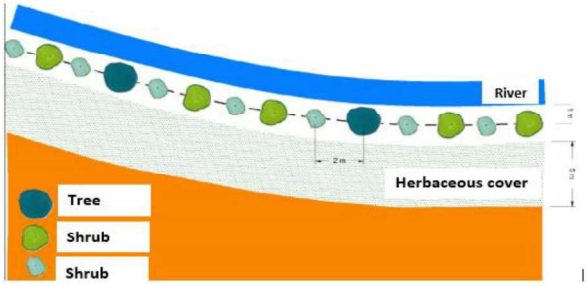
Action sheet

Action 9.G	Name	Planting the banks with native plant species
	Action target	Biodiversity
	Wetland	Gikondo

Location (map) G06 - G09 - G15



Photos / examples





Characteristics	Rough cost estimate	Priority	Objectives
G06 Surface : 7 700 m²	29,106 USD	1 - Short-term 2025	This action aims at recovering a herbaceous cover composed of a flora characteristic of wetlands and typical of Rwandan wetlands on all the banks and edges of the main rivers. To do this, the first step consists of soil preparation, with decompaction of the soil in place on the first 15 centimeters to reactivate the seed bank and promote rooting. The second step consists of planting native species typical of local wetlands, matching the water requirements of these species with the water conditions of the soil or the frequency of overflowing of the stream (depending on the stream levels). The species planted could be : Indian pennywort (*Centella asiatica*), Urugaga (*Cyperus dives*), Urukanganga/Epiphytic flatsedge (*Cyperus latifolius*), Carolina dichondra (*Dichondra micrantha*), Ubwungo/Heartleaf drymary (*Drymaria cordata*), Urufunzo/Papyrus (*Cyperus papyrus*), Umuberanya/Southern Cattail (*Typha domingensis*), Carex mildbraediana, Urukirakenja/Jointed flatsedge (*Cyperus articulatus*), Umujangaja/winged sedge (*Cyperus denudatus*), Carolina dichondra (Dichondra micrantha), Urujenone (*Enhydra fluctuans*), Gutwikumwe/Floating pennywort (*Hydrocotyle ranunculoides*), Ubusuna/Common rush (*Juncus effusus*), Urukembagufa/Cut grass (*Leersia hexandra*), Ikirogora (*Brillantaisia cicatricosa*), Umuzigangore (*Ludwigia abyssinica*), Igorogonzo/Watersmart weed *(Persicaria decipiens*), Igorogonzo/Watersmart weed (*Persicaria pulchra*), Urutaretare/ (*Pycreus macrostachys*). In addition, on the banks, it will be possible to plant shrub or tree species, adapted to wetlands, in order to form a rypisilve along the stream. This will stabilize the banks and strengthen the ecological corridor. This riparian buffer will be created on one side of the stream only, in order to maintain sufficient light and facilitate stream maintenance. The plants must come from a local source, which is necessary both ecologically and economically: ecologically, because the plants present in a given territory necessarily have the appropriate genetics for that
G09 Surface : 42 000 m²	158,760 USD	2 - Medium-term 2035	

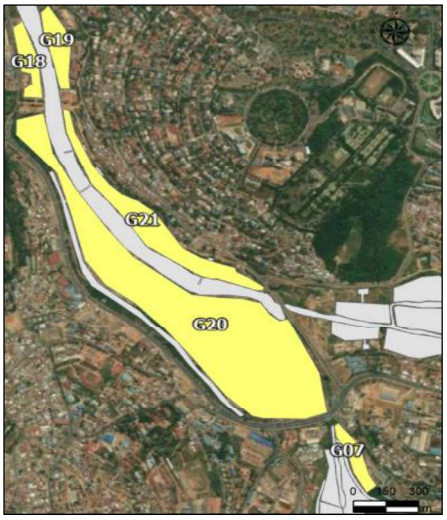
G15 Surface : 158 200 m²	597,996 USD	3 - Long-term 2050	a given territory necessarily have the appropriate genetics for that land and are therefore adapted to local conditions, and economically, because local actors are more in demand than foreign suppliers. The planting will take place in December, once the rainy season is over. For the herbaceous species, the clods will be installed in a hole made with a rototiller, a planter or a pickaxe and carefully positioned in the hole thus made. Before being planted, the plants will be soaked in water before being installed, then tamped into the soil. The plants in the cups will be distributed in patches at a rate of 2 plants per m². For trees and shrubs, plants shall be placed in a hole at least 40 cm deep and staked. All plants supplied by the landscaper must be of the species and variety requested, free of wounds and pest attacks. They shall be separated by destination compartment and species for ease of distribution and verification. Plants shall be replanted as soon as possible after delivery.
Comments			
Maintenance need	Annual management by mowing in August, before the rainy season. Maintenance of the rypisilve every year : removal of dead wood, pruning as needed, …		
Management monitoring	Monitoring the evolution of the vegetation twice a year, during the dry seasons, by botanical expert, over 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30).		

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

Action 10.G	Name	Possible development of recreational activities: Gikondo Eco-Valley
	Action target	Landscape / Recreational activities
	Wetland	Gikondo

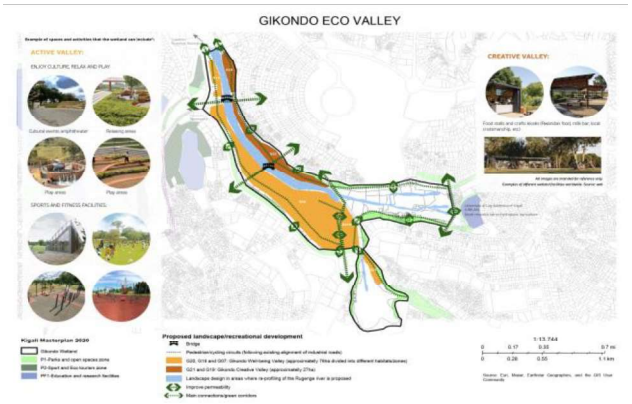
Location (map) G07, G18, G20, G19, G21



Photos / examples







Characteristics	Rough cost estimate	Priority	Objectives
G7, G18, G20, G19, G21 : GIKONDO ECO VALLEY Divided into different habitats/zones			To create an attractive recreational area with multiple uses: sports, nature preservation, walking, food, culture, etc. Economic activities managed by private operators are included in the programme in order to contribute to the sustainability and durability of investments.
Package 1 - Allowing access and delimitating spaces: - Pedestrian/cycling circuits 4m wide (5km linear, gravel paving) - Benches every 500m (10x) - Accessible pedestrian bridges (2x) - Solar light poles every 20m (250x) - Planting of native species (5 000m2) - Interpretation trail (natural habitat awareness signage)	468,315 USD	1 - Short-term 2025	
Package 2 : Economic activities (attracting private actors) - Playgrounds (5x) - Food kiosks (5x) - Picnic tables (20x) - Bike rental kiosk - Toilets - Crafts/souvenir kiosks (5x) - Visitor centre point with gift shop	119,543 USD	2 - Medium-term 2035	
Package 3 : Boosting attractiveness and quality of spaces - Outdoor gym areas (5 areas of 60m2) - Open air amphitheater for cultural events - Sports grounds - football (FIFA), volleyball, basketball (NBA) - Bird watching decks (2x)	284,445 USD	3 - Long-term 2050	

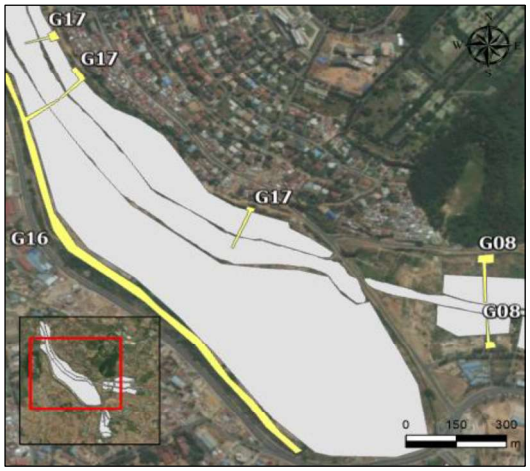
Comments	- See detailed plan provided in annex - Some of the existing pipelines implemented in the wetland will be reused for the water supply of the reacreational activities
Maintenance need	Annual for equipments and infrastructures and quarterly for green spaces with nature evolution
Management monitoring	Involvement of private operators for the day-to-day management of certain facilities (food stalls, craft stalls). Possibility of private operation also for sports grounds and events areas. Involvement of public players (site cleanliness, waste collection and management, etc.), to manage and enforce contracts, ensure coordination for the management of the site (internal regulations) and ensure security of the site

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

Action 11.G	Name	Riprap at the outlet of urban discharge
	Action target	Flood control / Water filtration
	Wetland	Gikondo

Location (map) G08 - G16 - G17



Photos / examples





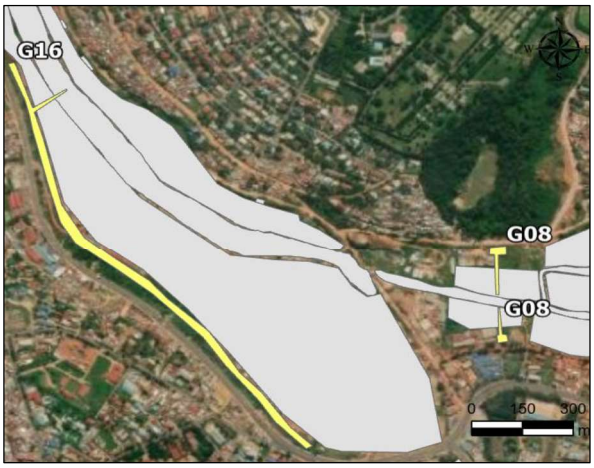
Characteristics	Rough cost estimate	Priority	Objectives
G08 Number of riprap : 2 Volume : 100 m3	40,500 USD	2 - Medium-term 2035	This action consists of placing boulders just at the outlet of the urban drains, in order to break the incoming flow and improve the diffusion of water towards the downstream wetland and other hydraulic outlets. These riprap will be made of stones of size between 200 and 1000 mm, depending on the flow of water arriving and the speed of flow, so that they can ensure their anti-erosion role. For each riprap, it will be used stones of different dimensions so that the small stones occupy the empty spaces between the larger stones. They will be placed one on top of the other, so as to form a homogeneous entity and in phase with the width of the drains. The installation of the riprap will take place in dry periods, outside of rainy periods.
G16 Number of riprap : 10 Volume : 500 m3	202,500 USD	3 - Long-term 2050	
G17 Number of riprap : 3 Volume : 150 m3	60,750 USD	3 - Long-term 2050	
Maintenance need	/		
Management monitoring	Visual inspection of riprap twice a year and removal of any waste or plant debris that may be present.		

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

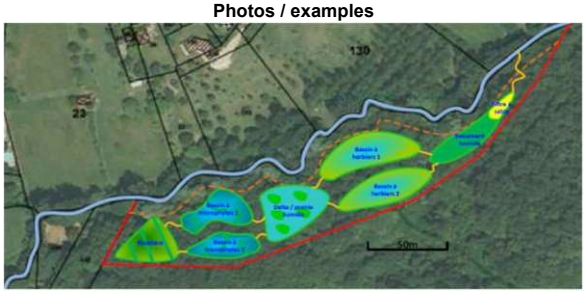
Action sheet

Action 12.G	Name	Creation of a constructed wetland - buffer zone
	Action target	Biodiversity and Water Quality
	Wetland	Gikondo

Location (map) G08 - G16



Photos / examples









Characteristics	Rough cost estimate	Priority	Objectives
G08 Surface : 4 000 m²	99,900 USD	2 - Medium-term 2035	The design approach of the buffer wetland leaves an important part to the study of the contributing watershed in order to know precisely the characteristics of the incoming effluents and of the contributing watershed (flow rate, surface of the watershed, quality, frequency of feeding...). This ecological engineering project is based on different components such as hydraulics, purification, wetlands ecology and plant engineering. In summary, the creation of a wetland buffer zone is carried out in 3 stages - Feasibility study to identify the environmental issues and take them into account in the design: topographic surveys, soil studies, hydraulic studies of the watershed... - Design study including: execution plans of the wetland buffer zone compartments, ecological engineering design, hydraulic sizing of the works and integration of educational supports... - Works and follow-up of the construction site requiring the intervention of qualified partners for the realization of the civil engineering (earthworks to create the various compartments, the overflows...), ecological engineering (choice of materials, planting of the vegetable species...) and a qualified site manager. A safety margin of 0.30m (minimum difference between the highest water level and the top of the compartment crest) is provided for during periods of maximum compartment filling. To achieve this objective, overflows will be installed at the top of the compartment crest.
G16 Surface : 37 000 m²	924,075 USD	3 - Long-term 2050	

Comments	"- The wetland buffer cannot be effective if it collects untreated wastewater. - Maximum depth of the compartments fixed at 1,20m

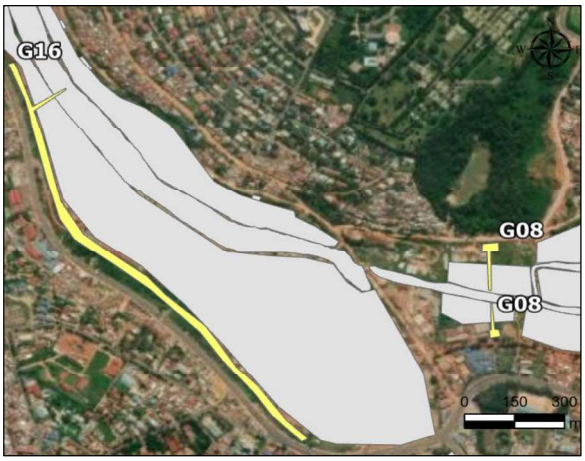
Maintenance need	Annual management by mowing in August, before the rainy season A wetland buffer reproduces, on a smaller scale, mechanisms that occur naturally in the natural environment. The evolution of the habitats and the sustainability of the objectives targeted by the wetland buffer (purification, biodiversity, education, etc.) are directly linked to the quality of its management from the moment it is put in water. The management of the buffer wetland leads to be vigilant on the following hydraulic phenomena - Creation of hydraulic plugs at the level of the hydraulic structures that can lead to overflows (loading of the system) and a reduction in the residence time. - Reduction of the residence time and the treatment capacity of the system by short-circuits and filling of the volume of the basins. - Risk of invasive plants or plant dieback. A management plan also has the following objectives - Ensure the cutting of plants with export of green waste - Maintain a high level of biodiversity in the water compartments by applying a differentiated vegetation management method. - To perpetuate the landscape quality of the site and its potential to welcome the public.
Management monitoring	Monitoring of the evolution of vegetation and hydraulics twice a year, during dry and rainy seasons, by an expert in ecological engineering, for 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30)

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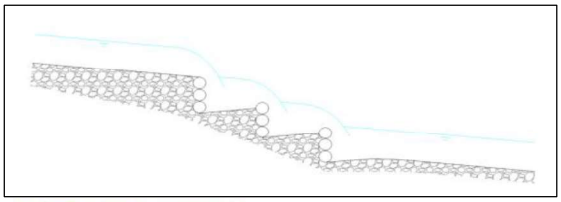
Action sheet

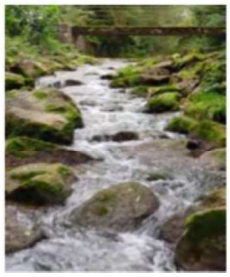
Action 13.G	Name	Re-profiling of the hydraulic outlets from the discharge
	Action target	Water filtration, Biodiversity
	Wetland	Gikondo

Location (map) G08 - G16



Photos / examples







Characteristics	Rough cost estimate	Priority	Objectives
G08: Riprap at the outlet with creation of different river bed ground level over 230 m	14,175 USD	2 - Medium-term 2035	- limit erosion - enhance biodiversity with diversification of natural habitats
G16: Riprap at the outlet with creation of different river bed ground level over 112 m	6,885 USD	3 - Long-term 2050	

Comments	
Maintenance need	- Maintenance of the outlets (provent from solid waste accumulation): twice per year (including one before the rainy season) - Other needs to be defined according to the management monitoring report
Management monitoring	The work will be the subject of a technical file of the works carried out with the plans of the built installations. A follow-up of the profile of the restored banks and the minor bed will be carried out 6 months after the end of the work and then the year that follows. The frequency will be adapted according to the possible disorders observed and the results of this follow-up. On the basis of the technical file, the following will be identified - Possible movements, departures or contributions of blocks; - All possible traces of erosion, scouring on the resumed zones as well as on the transition zones and the zones peripheral to the development not impacted by the works. All the elements of this follow-up will be recorded in a report. In conclusion, recommendations will be made on possible rework, the frequency of monitoring, and on future developments.

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

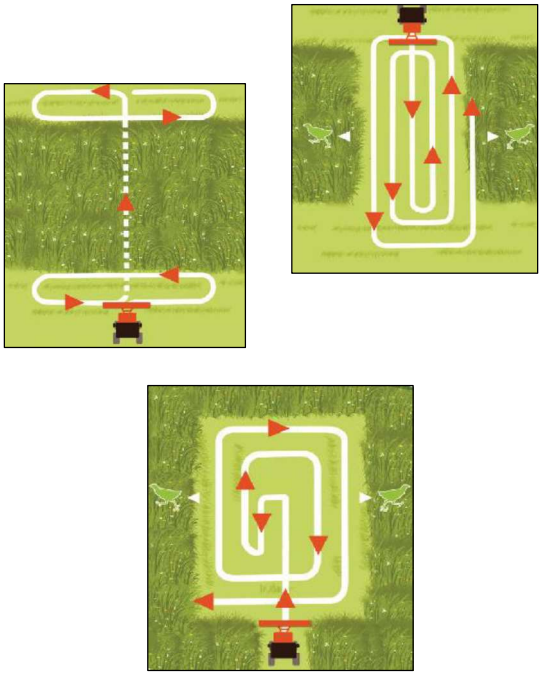
Action sheet

Action 14.G	Name	Differentiated management according to natural habitats
	Action target	Biodiversity
	Wetland	Gikondo

Location (map) G13 - G14



Photos / examples



Characteristics	Rough cost estimate	Priority	Objectives
G13 Surface : 22 000 m²	35,640 USD	2 - Medium-term 2035	Herbaceous habitats will be managed by annual mowing. Mowing will be mechanized or manual, in dry periods to facilitate access, promote reseeding and limit impacts on wildlife. They will be carried out at a minimum height of 10 cm, and centrifugal so as to push the fauna towards the refuge zones of the non mowed sectors (in accordance with the mowing principle illustrated in the diagrams above). The refuge zones, corresponding to the non mowed areas, will represent approximately 5% of the mowed surface. The speed of the self-propelled mowing machines will be moderate to allow time for insects and other fauna to move. Mowing residues will be systematically exported to limit soil eutrophication and the development of nitrophilic vegetation.
G14 Surface :16 000 m²	25,920 USD	2 - Medium-term 2035	For low herbaceous formations, management by grazing as an alternative to differentiated mowing may be considered, if there is an opportunity for a territorial agricultural project in the medium to long term. The necessary conditions are: sufficiently dry soil, a grazing period limited to about 3 months and a stocking rate limited to 0.5 to 0.8 LU per hectare. Eco-grazing can be implemented after an initial period of management by mowing to establish the cover. Chemical weeding and the use of phytosanitary products is prohibited. As for the shrub and tree environments, management consists of selective clearing and removal of the shoots of any invasive species by manual or mechanical removal of the feet (with export).

Comments	
Maintenance need	/
Management monitoring	Annual botanical monitoring, during the dry seasons, by botanical expert, over 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30) to identify the development and evolution of plant formations, in order to adapt the objectives and methods of maintenance, in particular the frequency of mowing, and to perpetuate the most suitable hygrophilous formations.

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

Action 15.G	Name	Clearance over a large width to facilitate the overflow
	Action target	Flood mitigation, water storage
	Wetland	Gikondo

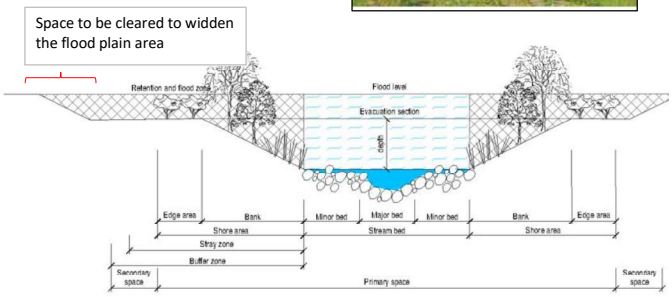
Location (map) G15



Photos / examples







Characteristics	Rough cost estimate	Priority	Objectives
G15 : creation of a larger flooding plain along the extend of the river (meander and banks)	580,365 USD	3 - Long-term 2050	

Comments	
Maintenance need	Cleaning of waste
Management monitoring	No needs

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

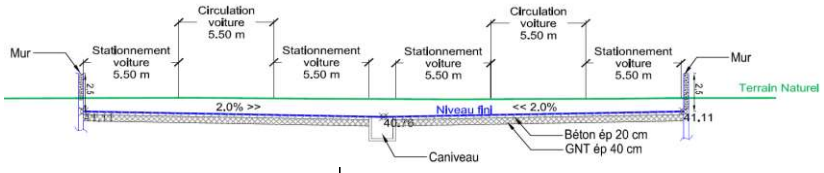
Action 16.G	Name	Groud levelling and vegetation to create an urban green space
	Action target	
	Wetland	Gikondo

Location (map) G18 - G19 - G20 - G21



Photos / examples





Characteristics	Rough cost estimate	Priority	Objectives
Package 1 - Pedestrian/cycling circuits 4m wide (5km linear, gravel paving)	92,000 USD	1 - Short-term 2025	- Landscaping - Planting vegetation
Package 2 : - Playgrounds (5x) - Food kiosks (5x) - Bike rental kiosk - Toilets - Crafts/souvenir kiosks (5x) - Visitor centre point with gift shop	11,400 USD	2 - Medium-term 2035	
Package 3 : - Outdoor gym areas (5 areas of 60m2) - Open air amphitheater for cultural events - Sports grounds - Bird watching decks (2x)	200,340 USD	3 - Long-term 2050	

Comments	See Action 10.G for details planed recreational activities
Maintenance need	No needs
Management monitoring	No needs

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

Action 20-G	Name	Stream protection zone with a vegetated riparian buffer
	Action target	Biodiversity and Water Quality
	Wetland	Gikondo

Location (map) G06 - G09 - G15



Photos / examples







Characteristics	Rough cost estimate	Priority	Objectives
G06 Vegetated buffer strip of approximately 12m wide on each side of the watercourse, i.e. an area of approximately : 7 800m² for a total of 300m	747,495 USD	1 - Short-term 2025	In order to limit the transfer of pollutants to the watercourse via runoff, vegetated buffer strips are positioned between agricultural plots and the watercourse network. In this action sheet, a vegetated buffer strip is defined as any vegetated surface that intercepts diffuse or concentrated surface runoff and therefore reduces the transfer of pollutants and/or sediments. These vegetated buffer strips are translated as grassy strips, permanent grasslands, fallow land, hedges, woods or copses. Their implementation requires : - Tillage to level and decompact the land; - Revegetation, which is either seeding of grassland or planting of shrubs/trees; - A choice of local plant species. This vegetated buffer strip, whose width will have to be refined according to the intercepted watershed, will also be a support for the migration of animal species.
G09 Vegetated buffer strip of approximately 12m wide on each side of the watercourse, i.e. an area of approximately : 42 000m² for a total of 1 700m	99,900 USD	2 - Medium-term 2035	
G15 Vegetated buffer strip of approximately 25m wide on each side of the watercourse, i.e. an area of approximately : 100 000 m² for a total of 2 000m	34,830 USD	3 - Long-term 2050	

Comments	Developments must be carried out outside of rainy periods to avoid soil compaction and degradation caused by erosion (uprooting of plantations, seeds washed away by runoff...)
Maintenance need	Annual management by mowing in August, before the rainy season
Management monitoring	Monitoring the evolution of the vegetation twice a year, during the dry seasons, by botanical expert, over 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30).

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

Action 24.G	Name	Protection and conservation of typical wetland habitats
	Action target	Biodiversity
	Wetland	Gikondo

Location (map) G13 - G14



Photos / examples





Characteristics	Rough cost estimate	Priority	Objectives
G13 Linear of fences : 600 ml	97,200 USD	2 - Medium-term 2035	This action aims to protect the wetlands of good plant quality and the most biologically sensitive (breeding grounds for heritage fauna, protected plant species, ...). For this, several solutions are proposed: - the installation of fences or wooden barriers, positioned all around the area of interest, in order to prohibit any pedestrian or vehicle access (except for maintenance). These protective elements must be well integrated into the landscape, so wooden elements are recommended. Awareness signs may also be installed. - the classification of the zone of interest in a protection zoning (reserves, protected areas, ..), allowing to limit the uses to those favorable to the maintenance of the fauna and the present flora. The classification in protection zoning induces administrative procedures but proves to be a very relevant tool to guarantee the durability of the area and the actions carried out, and to maintain quality habitats. In addition, thorough biological monitoring must be carried out on these areas by experts in ecology or environmental associations. The objective of this monitoring is to identify the fauna and flora issues in these areas, to follow the evolution of the habitats and to propose and adapt the management modalities in order to enhance the environment. This monitoring must be carried out at all times of the year, with more frequent visits during the period of activity of the fauna and development of the flora, and carried out according to a precise protocol repeated over several years.
G14 Linear of fences : 500 ml	81,000 USD	2 - Medium-term 2035	
Comments			
Maintenance need	/		
Management monitoring	Annual verification of the state of deterioration of the fences.		

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

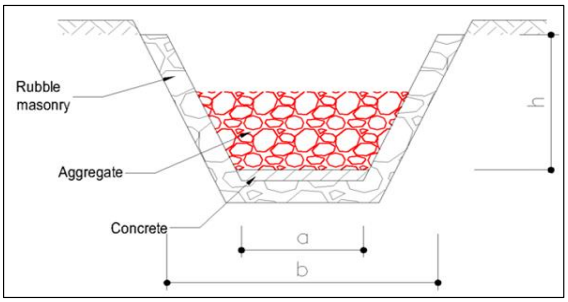
Action sheet

Action 1.K	Name	Raising the water level in the river
	Action target	Water filtration, Biodiversity, Flood mitigation
	Wetland	Kibumba

Location (map) K03



Photos / examples





Characteristics	Rough cost estimate	Priority	Objectives
K03 : recharge partially the river bed over 25 cm with different grain size aggregates	51,921 USD	1 - Short-term 2025	- Limit the drainage of the wetland - Favor overflow over the concrete channel and the river beds - Reduce the water quantity and velocity downstream - Favor aquatic environment in the wetland

Comments	
Maintenance need	To be defined according to the management monitoring report
Management monitoring	The work will be the subject of a technical file of the works carried out with the plans of the built installations. A follow-up of the profile of the restored banks and the minor bed will be carried out 6 months after the end of the work and then the year that follows. The frequency will be adapted according to the possible disorders observed and the results of this follow-up. On the basis of the technical file, the following will be identified - Possible movements, departures or contributions of blocks; - All possible traces of erosion, scouring on the resumed zones as well as on the transition zones and the zones peripheral to the development not impacted by the works. All the elements of this follow-up will be recorded in a report. In conclusion, recommendations will be made on possible rework, the frequency of monitoring, and on future developments.

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

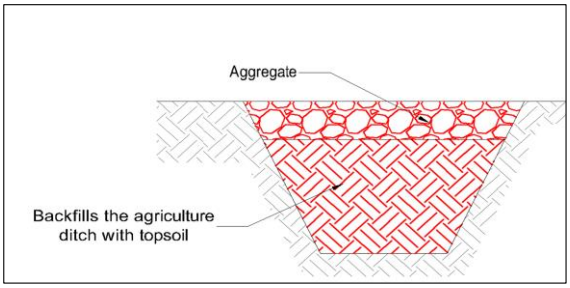
Action 5.G	Name	Blocking of surface and subsurface drains
	Action target	Water filtration, Biodiversity
	Wetland	Kibumba

Location (map) K01 - K03 - K04 - K05 - K07



Photos / examples





Characteristics	Rough cost estimate	Priority	Objectives
K01: backfill the agricultural drains with approximately 3 600 m3	9,771 USD	2 - Medium-term 2035	- Limit the lowering of the groundwater - Increase the residence time of the water in the wetland - Homogenise the wetland ground - Enhance the storage capacity of the wetland - Reduce the water quantity and velocity downstream
K01: backfill the agricultural drains with approximately 3 600 m3	29,312 USD	3 - Long-term 2050	
K03: backfill the agricultural drains with approximately 36 000 m3	385,358 USD	2 - Medium-term 2035	
K04: backfill the agricultural drains with approximately 4 500 m3	61,155 USD	3 - Long-term 2050	
K05: backfill the agricultural drains with approximately 2 600 m3	27,945 USD	1 - Short-term 2025	
K07: backfill the agricultural drains with approximately 12 000 m3	127,170 USD	1 - Short-term 2025	

Comments	
Maintenance need	No needs
Management monitoring	No needs

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

Action 6.K	Name	Planting of native plant species adapted to the wetland environment
	Action target	Biodiversity
	Wetland	Kibumba

Location (map) K01 - K03 - K04 - K06 - K07



Photos / examples



Characteristics	Rough cost estimate	Priority	Objectives
K01 Surface : 43 600 m²	41,202 USD	2 - Medium-term 2035	This action aims at recovering a herbaceous cover on all these surfaces, composed of a characteristic flora of wetlands and typical of Rwandan wetlands. For that, the first step consists in a preparation of the ground, with a decompacting of the ground in place on the first 15 centimeters in order to reactivate the seed bank and to support the rooting. The second step consists of planting with native species typical of local wetlands, such as Indian pennywort (*Centella asiatica*), Urugaga (*Cyperus dives*), Urukanganga/Epiphytic flatsedge (*Cyperus latifolius*), Carolina dichondra (*Dichondra micrantha*), Ubwungo/Heartleaf drymary (*Drymaria cordata*), Urufunzo/Papyrus (*Cyperus papyrus*), Umuberanya/Southern Cattail (*Typha domingensis*), Carex mildbraediana, Urukirakenja/Jointed flatsedge (*Cyperus articulatus*), Umujangaja/winged sedge (*Cyperus denudatus*), Carolina dichondra (Dichondra micrantha), Urujenone (*Enhydra fluctuans*), Gutwikumwe/Floating pennywort (*Hydrocotyle ranunculoides*), Ubusuna/Common rush (*Juncus effusus*), Urukembagufa/Cut grass (*Leersia hexandra*), Ikirogora (*Brillantaisia cicatricosa*), Umuzigangore (*Ludwigia abyssinica*), Igorogonzo/Watersmart weed *(Persicaria decipiens*), Igorogonzo/Watersmart weed (*Persicaria pulchra*), Urutaretare/ (*Pycreus macrostachys*). The plantings will aim to adapt the location of the species according to their need for water and the water conditions of the soil, in order to favour their development. The seedlings must come from a local source, which is necessary both ecologically and economically: ecologically, because the plants present in a given territory necessarily have the appropriate genetics for that land and are therefore adapted to local conditions, and economically, because local actors are more in demand than foreign suppliers. The planting will take place in December, once the rainy season is over. The clods will be installed in a hole made with a tiller, a planter or a pickaxe and carefully positioned in the hole thus made. Before planting, the plants will be soaked in water before installation and then packed in the soil. The plants in cups will be distributed by spots at a rate of 2 plants per m². All plants supplied by the landscaper shall be of the species and variety requested, free of wounds and pest attacks. They shall be separated by destination compartment and by species to facilitate distribution and verification. The plants must be replanted as soon as possible after delivery.
K01 Surface : 43 600 m²	123,606 USD	3 - Long-term 2050	
K03 Surface : 115 600 m²	436,968 USD	3 - Long-term 2050	
K04 Surface : 42 400 m²	160,272 USD	2 - Medium-term 2035	
K06 Surface : 25 300 m²	95,634 USD	1 - Short-term 2025	
K07 Surface : 60 200 m²	227,556 USD	1 - Short-term 2025	
Comments			

Maintenance need	Annual management by mowing in August, before the rainy season.
Management monitoring	Monitoring the evolution of the vegetation twice a year, during the dry seasons, by botanical expert, over 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30).

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Action sheet

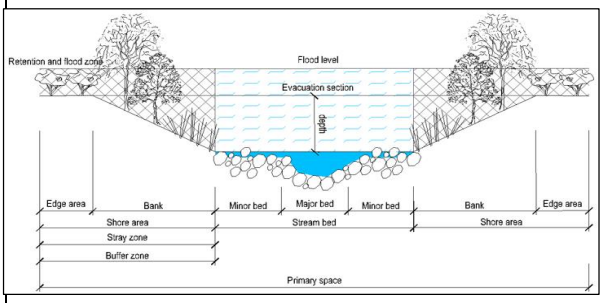
Action 7.G	Name	Re-profiling of the river with the creation of meanders and banks with different levels
	Action target	Water filtration, Biodiversity
	Wetland	Kibumba

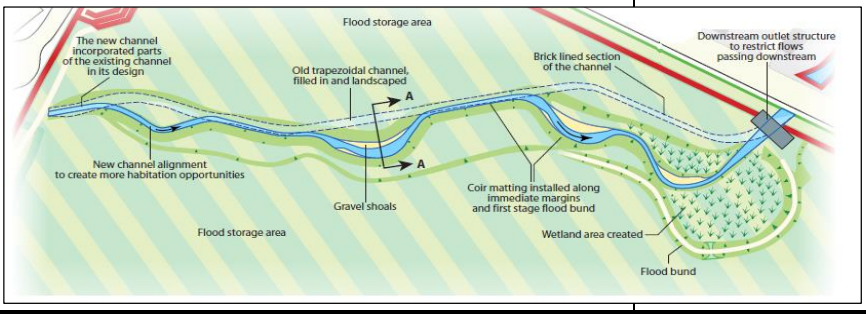
Location (map) K03 - K06 - K07



Photos / examples







Characteristics	Rough cost estimate	Priority	Objectives
K03 : Creation of meander and banks along 1 800 m	402,165 USD	1 - Short-term 2025	- Improve the water quality and decrease the water quantity flowing downstream (slowing the flow) - Improve the biodiversity - Promote recreational area
K06 : Creation of meander and banks along 480 m	67,716 USD	1 - Short-term 2025	
K07 : Creation of meander and banks along 640 m	113,400 USD	1 - Short-term 2025	

Comments	
Maintenance need	To be defined according to the management monitoring report
Management monitoring	The work will be the subject of a technical file of the works carried out with the plans of the built installations. A follow-up of the profile of the restored banks and the minor bed will be carried out 6 months after the end of the work and then the year that follows. The frequency will be adapted according to the possible disorders observed and the results of this follow-up. On the basis of the technical file, the following will be identified - Possible movements, departures or contributions of blocks; - All possible traces of erosion, scouring on the resumed zones as well as on the transition zones and the zones peripheral to the development not impacted by the works. All the elements of this follow-up will be recorded in a report. In conclusion, recommendations will be made on possible rework, the frequency of monitoring, and on future developments.

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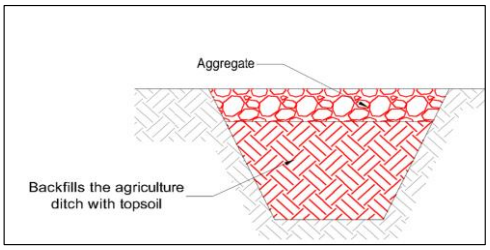
Action sheet		
Action 8.K	Name	Filling of the old minor bed of the watercourse
	Action target	Water filtration, Biodiversity
	Wetland	Gikondo

Location (map) K03 - K06 -K07



Photos / examples





Characteristics	Rough cost estimate	Priority	Objectives
K03 : filling the watercourse with aggregates of different diameter	58,644 USD	1 - Short-term 2025	- Recover a space favorable for planting - Development of natural habitats
K06: filling the watercourse with aggregates of different diameter	28,836 USD	1 - Short-term 2025	
K07: filling the watercourse with aggregates of different diameter	67,716 USD	1 - Short-term 2025	
Comments			
Maintenance need	No needs		
Management monitoring	No needs		

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

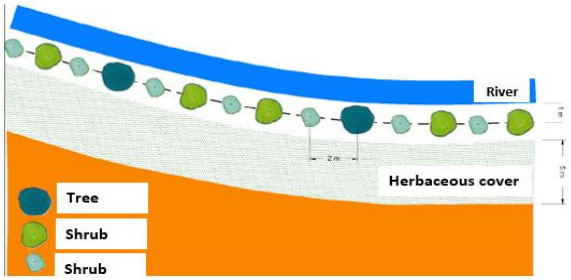
Action sheet

Action 9.K	Name	Planting the banks with native plant species
	Action target	Biodiversity
	Wetland	Kibumba

Location (map) K03 - K06 - K07



Photos / examples





Characteristics	Rough cost estimate	Priority	Objectives
K03 Surface : 45 000 m²	170,100 USD	2 - Medium-term 2035	This action aims at recovering a herbaceous cover composed of a flora characteristic of wetlands and typical of Rwandan wetlands on all the banks and edges of the main rivers. To do this, the first step consists of soil preparation, with decompaction of the soil in place on the first 15 centimeters to reactivate the seed bank and promote rooting. The second step consists of planting native species typical of local wetlands, matching the water requirements of these species with the water conditions of the soil or the frequency of overflowing of the stream (depending on the stream levels). The species planted could be : Indian pennywort (*Centella asiatica*), Urugaga (*Cyperus dives*), Urukanganga/Epiphytic flatsedge (*Cyperus latifolius*), Carolina dichondra (*Dichondra micrantha*), Ubwungo/Heartleaf drymary (*Drymaria cordata*), Urufunzo/Papyrus (*Cyperus papyrus*), Umuberanya/Southern Cattail (*Typha domingensis*), Carex mildbraediana, Urukirakenja/Jointed flatsedge (*Cyperus articulatus*), Umujangaja/winged sedge (*Cyperus denudatus*), Carolina dichondra (Dichondra micrantha), Urujenone (*Enhydra fluctuans*), Gutwikumwe/Floating pennywort (*Hydrocotyle ranunculoides*), Ubusuna/Common rush (*Juncus effusus*), Urukembagufa/Cut grass (*Leersia hexandra*), Ikirogora (*Brillantaisia cicatricosa*), Umuzigangore (*Ludwigia abyssinica*), Igorogonzo/Watersmart weed (*Persicaria decipiens*), Igorogonzo/Watersmart weed (*Persicaria pulchra*), Urutaretare/ (*Pycreus macrostachys*). In addition, on the banks, it will be possible to plant shrub or tree species, adapted to wetlands, in order to form a rypisilve along the stream. This will stabilize the banks and strengthen the ecological corridor. This riparian buffer will be created on one side of the stream only, in order to maintain sufficient light and facilitate stream maintenance. The plants must come from a local source, which is necessary both ecologically and economically: ecologically, because the plants present in a given territory necessarily have the appropriate genetics for that land
K06 Surface : 12 000 m²	45,360 USD	1 - Short-term 2025	

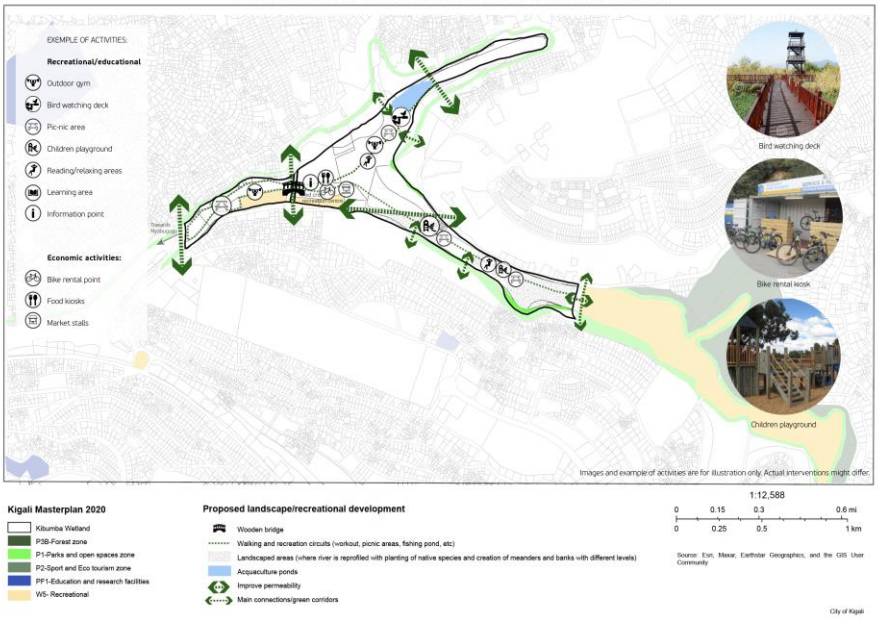
K07 Surface : 30 000 m²	113,400 USD	1 - Short-term 2025	and are therefore adapted to local conditions, and economically, because local actors are more in demand than foreign suppliers. The planting will take place in December, once the rainy season is over. For the herbaceous species, the clods will be installed in a hole made with a rototiller, a planter or a pickaxe and carefully positioned in the hole thus made. Before being planted, the plants will be soaked in water before being installed, then tamped into the soil. The plants in the cups will be distributed in patches at a rate of 2 plants per m². For trees and shrubs, plants shall be placed in a hole at least 40 cm deep and staked. All plants supplied by the landscaper must be of the species and variety requested, free of wounds and pest attacks. They shall be separated by destination compartment and species for ease of distribution and verification. Plants shall be replanted as soon as possible after delivery.
Comments			
Maintenance need	Annual management by mowing in August, before the rainy season. Maintenance of the rypisilve every year : removal of dead wood, pruning as needed, …		
Management monitoring	Monitoring the evolution of the vegetation twice a year, during the dry seasons, by botanical expert, over 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30).		

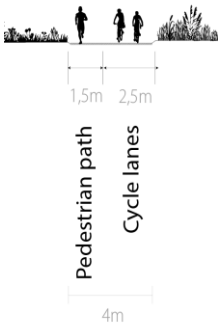
Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

Action 17.K	Name	Possible development of recreational activities: Creation of pedestrian/cycling circuits
	Action target	Landscape / Recreational activities
	Wetland	Kibumba

KIBUMBA WALKING AND RECREATION CIRCUITS





Characteristics		Rough cost estimate	Priority	Objectives
KIBUMBA WETLAND CENTRE				To create an attractive walking/cycling circuit that promotes awareness of natural habitats and an active lifestyle. Economic activities managed by private operators are included in the programme in order to contribute to the sustainability and durability of investments.
Package 1: Creation of walking/cycling circuits - Pedestrian/cycling circuits 4m wide (4km linear) - Benches every 500m (8x) - Solar light poles every 20m (200x) - Planting of native species (4km linear) - Interpretation trail (natural habitat awareness signage)		5,211 USD	1 - Short-term 2025	
Package 2 : Economic activities (attracting private actors) - Playgrounds (3x) - Bike rental kiosk - Picnic tables (10x) - Food kiosks (3x) - Toilets - Visitor information kiosk		18,765 USD	2 - Medium-term 2035	
Package 3 : Boosting attractiveness and quality of spaces - Water activities - Bird watching deck - Outdoor gym circuits (3x) - Landscaped areas (1000m2 planted with native species)		128,790 USD	3 - Long-term 2050	
Comments		See detailed plan provided in annex		
Maintenance need		Annual for equipments and infrastructures and quarterly for green spaces with nature evolution		
Management monitoring		Involvement of private operators for the day-to-day management of certain facilities (restaurant/cafe, bike rental kiosk, etc). Involvement of public players (site cleanliness, waste collection and management, etc.), to manage and enforce contracts, ensure coordination for the management of the site (internal regulations) and ensure security of the site		

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

Action 11.K	Name	Riprap at the outlet of urban discharge
	Action target	Flood control / Water filtration
	Wetland	Kibumba

Location (map) K08 - K09



Photos / examples





Characteristics	Rough cost estimate	Priority	Objectives
K08 Number of riprap : 1 Volume : 50 m3	20,250 USD	1 - Short-term 2025	This action consists of placing boulders just at the outlet of the urban drains, in order to break the incoming flow and improve the diffusion of water towards the downstream wetland and other hydraulic outlets. These riprap will be made of stones of size between 200 and 1000 mm, depending on the flow of water arriving and the speed of flow, so that they can ensure their anti-erosion role. For each riprap, it will be used stones of different dimensions so that the small stones occupy the empty spaces between the larger stones. They will be placed one on top of the other, so as to form a homogeneous entity and in phase with the width of the drains. The installation of the riprap will take place in dry periods, outside of rainy periods.
K09 Number of riprap : 4 Volume : 200 m3	8,548 USD	1 - Short-term 2025	

Maintenance need	/
Management monitoring	Visual inspection of riprap twice a year and removal of any waste or plant debris that may be present.

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

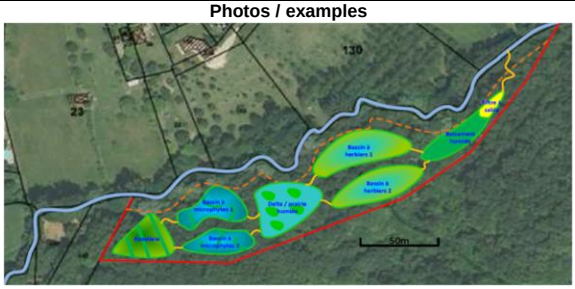
Action sheet

Action 12.K	Name	Creation of a constructed wetland - buffer zone
	Action target	Biodiversity and Water Quality
	Wetland	Kibumba

Location (map) K08 - K09



Photos / examples









Characteristics	Rough cost estimate	Priority	Objectives
K08 Surface : 1 000 m²	24,975 USD	1 - Short-term 2025	The design approach of the buffer wetland leaves an important part to the study of the contributing watershed in order to know precisely the characteristics of the incoming effluents and of the contributing watershed (flow rate, surface of the watershed, quality, frequency of feeding...). This ecological engineering project is based on different components such as hydraulics, purification, wetlands ecology and plant engineering.
K09 Total surface : 5 100 m²	42,033 USD	1 - Short-term 2025	In summary, the creation of a wetland buffer zone is carried out in 3 stages - Feasibility study to identify the environmental issues and take them into account in the design: topographic surveys, soil studies, hydraulic studies of the watershed... - Design study including: execution plans of the wetland buffer zone compartments, ecological engineering design, hydraulic sizing of the works and integration of educational supports... - Works and follow-up of the construction site requiring the intervention of qualified partners for the realization of the civil engineering (earthworks to create the various compartments, the overflows...), ecological engineering (choice of materials, planting of the vegetable species...) and a qualified site manager. A safety margin of 0.30m (minimum difference between the highest water level and the top of the compartment crest) is provided for during periods of maximum compartment filling. To achieve this objective, overflows will be installed at the top of the compartment crest.

Comments	- The wetland buffer cannot be effective if it collects untreated wastewater. - Maximum depth of the compartments fixed at 1,20m

Maintenance need	Annual management by mowing in August, before the rainy season A wetland buffer reproduces, on a smaller scale, mechanisms that occur naturally in the natural environment. The evolution of the habitats and the sustainability of the objectives targeted by the wetland buffer (purification, biodiversity, education, etc.) are directly linked to the quality of its management from the moment it is put in water. The management of the buffer wetland leads to be vigilant on the following hydraulic phenomena - Creation of hydraulic plugs at the level of the hydraulic structures that can lead to overflows (loading of the system) and a reduction in the residence time. - Reduction of the residence time and the treatment capacity of the system by short-circuits and filling of the volume of the basins. - Risk of invasive plants or plant dieback. A management plan also has the following objectives - Ensure the cutting of plants with export of green waste - Maintain a high level of biodiversity in the water compartments by applying a differentiated vegetation management method. - To perpetuate the landscape quality of the site and its potential to welcome the public.
Management monitoring	Monitoring of the evolution of vegetation and hydraulics twice a year, during dry and rainy seasons, by an expert in ecological engineering, for 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30)

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

Action 13.K	Name	Re-profiling of the hydraulic outlets from the discharge
	Action target	Water filtration, Biodiversity
	Wetland	Kibumba

Location (map) K08 - K09



Photos / examples

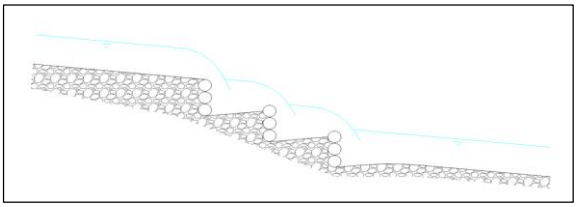




Abb. 2 a



Abb. 2 b

Characteristics	Rough cost estimate	Priority	Objectives
K08: Riprap at the outlet with creation of different river bed ground level over 206 m	3,240 USD	1 - Short-term 2025	- limit erosion - enhance biodiversity with diversification of natural habitats
K09: Riprap at the outlet with creation of different river bed ground level over 50 m	8,548 USD	1 - Short-term 2025	

Comments	
Maintenance need	- Maintenance of the outlets (provent from solid waste accumulation): twice per year (including one before the rainy season) - Other Maintenance needs to be defined according to the management monitoring report
Management monitoring	The work will be the subject of a technical file of the works carried out with the plans of the built installations. A follow-up of the profile of the restored banks and the minor bed will be carried out 6 months after the end of the work and then the year that follows. The frequency will be adapted according to the possible disorders observed and the results of this follow-up. On the basis of the technical file, the following will be identified - Possible movements, departures or contributions of blocks; - All possible traces of erosion, scouring on the resumed zones as well as on the transition zones and the zones peripheral to the development not impacted by the works. All the elements of this follow-up will be recorded in a report. In conclusion, recommendations will be made on possible rework, the frequency of monitoring, and on future developments

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

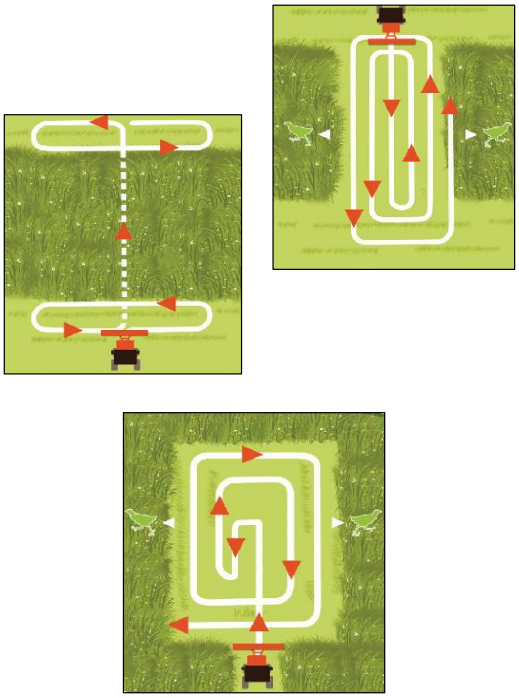
Action sheet

Action 14.K	Name	Differentiated management according to natural habitats
	Action target	Biodiversity
	Wetland	Kibumba

Location (map) K05



Photos / examples



Characteristics	Rough cost estimate	Priority	Objectives
K05 Surface : 8 500 m²	13,770 USD	1 - Short-term 2025	Herbaceous habitats will be managed by annual mowing. Mowing will be mechanized or manual, in dry periods to facilitate access, promote reseeding and limit impacts on wildlife. They will be carried out at a minimum height of 10 cm, and centrifugal so as to push the fauna towards the refuge zones of the non mowed sectors (in accordance with the mowing principle illustrated in the diagrams above). The refuge zones, corresponding to the non mowed areas, will represent approximately 5% of the mowed surface. The speed of the self-propelled mowing machines will be moderate to allow time for insects and other fauna to move. Mowing residues will be systematically exported to limit soil eutrophication and the development of nitrophilic vegetation. For low herbaceous formations, management by grazing as an alternative to differentiated mowing may be considered, if there is an opportunity for a territorial agricultural project in the medium to long term. The necessary conditions are: sufficiently dry soil, a grazing period limited to about 3 months and a stocking rate limited to 0.5 to 0.8 LU per hectare. Eco-grazing can be implemented after an initial period of management by mowing to establish the cover. Chemical weeding and the use of phytosanitary products is prohibited. As for the shrub and tree environments, management consists of selective clearing and removal of the shoots of any invasive species by manual or mechanical removal of the feet (with export).

Comments	
Maintenance need	/
Management monitoring	Annual botanical monitoring, during the dry seasons, by botanical expert, over 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30) to identify the development and evolution of plant formations, in order to adapt the objectives and methods of maintenance, in particular the frequency of mowing, and to perpetuate the most suitable hygrophilous formations.

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

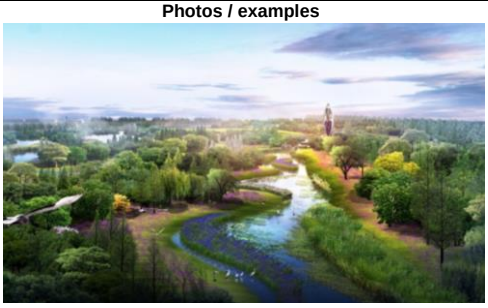
Action sheet

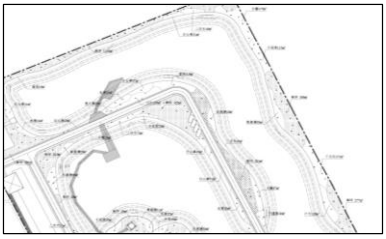
Action 18-K	Name	Creation of a depression disconnected from the river
	Action target	Biodiversity and Water Quality
	Wetland	Kibumba

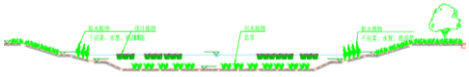
Location (map) K01



Photos / examples







Characteristics	Rough cost estimate	Priority	Objectives
K01 Surface : 40 000 m²	162,000 USD	3 - Long-term 2050	Before carrying out the earthworks, a design study phase will be necessary to refine the works to be carried out. These studies will make it possible to respect the following principles: - The arrival of water from urban drains must be accompanied by riprap to limit erosion in the depression; - The "project elevation" (longitudinal profile) must be determined on the basis of a good knowledge of the level of the river and of the water table (and its variations); - The slopes of the banks must be as low as possible; - The arm/depression can be materialized by multiple basins; - The recreation will not be uniform; - Excessive excavation may result in lowering of the water table (drainage). It can also cause a pollution of the water table by feeding with water of bad quality. These earthworks will have for objective to respect the criteria specified above. The use of mechanical shovel, bulldozer is necessary. The work must be carried out in such a way as to limit the compaction of the land: use machines with good bearing capacity ("marsh" shovels), avoid driving with the machines on the talweg, decompact the soil at the end of the work... The period of execution of the work is largely conditioned by hydraulic constraints (low water). It is important to underline the importance of the quality of the company and the project management in this type of work. It is advisable to choose companies that have already carried out this type of work, and to provide for very regular monitoring of the site by an ecologist. A safety margin of 0.30 m (minimum difference between the highest water level and the top of the compartment crest) is

Comments	"- The depression cannot be effective if it collects untreated wastewater. - Maximum depth of the compartments fixed at 1,20m
Maintenance need	Annual management by mowing in August, before the rainy season The management of depression to be vigilant on the following hydraulic phenomena - Creation of hydraulic plugs at the level of hydraulic structures that can lead to overflows (loading of the system) and a reduction in residence time. - Reduction of the residence time and the treatment capacity of the system by short circuits and the filling of the volume of the basins. - Risk of invasive plants or plant dieback. A management plan also aims to - Ensure the cutting of plants with export of green waste - Maintain a high level of biodiversity in the water compartments by applying a differentiated vegetation management method. - Perpetuate the landscape quality of the site and its potential to welcome the public.

Management monitoring	Monitoring of the evolution of vegetation and hydraulics twice a year, during dry and rainy seasons, by an expert in ecological engineering, for 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30)

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

Action 19-K	Name	Diversification of natural habitats typical of wetlands
	Action target	Biodiversity
	Wetland	Kibumba

Location (map) K01



Photos / examples







Characteristics	Rough cost estimate	Priority	Objectives
K01 Surface : 40 000 m²	194,400 USD	3 - Long-term 2050	This action aims at recovering a herbaceous cover composed of a flora characteristic of wetlands and typical of Rwandan wetlands on all the depressions up to the banks. To do this, the first step consists in preparing the soil, with decompacting the soil in place on the first 15 centimeters to reactivate the seed bank and promote rooting. The second step is to plant native species typical of local wetlands, matching the water needs of these species with the water conditions of the soil. Indeed, in order to accelerate the vegetation, it will be interesting to plant semi-aquatic and aquatic plants: sedges, reeds...In time, the planted plants will be more or less completed/replaced progressively by species spontaneously colonizing the site. The zones regularly in water will generally be well colonized by natural vegetation; it is thus little useful to sow them. This will involve proposing an adapted plant life with the following plant species: Centella asiatica (Centella asiatica), Urugaga (Cyperus dives), Urukanganga/Cyperus latifolius (Cyperus latifolius), Carolina Dichondra (Dichondra micrantha), Ubwungo/ Drymaria cordata (Drymaria cordata), Urufunzo/Papyrus (Cyperus papyrus), Umuberanya/Southern cattail (Typha domingensis), Carex mildbraediana, Urukirakenja/Cyperus articulatus, Umujangaja/Cyperus denudatus, Dichondra Carolina (Dichondra micrantha), Urujenone (Enhydra fluctuans), Gutwikumwe/ Hydrocotyle ranunculoides, Ubusuna/ Common rush (Juncus effusus), Urukembagufa/ Cutting grass (Leersia hexandra), Ikirogora (Brillantaisia cicatricosa), Umuzigangore (Ludwigia abyssinica), Igorogonzo/Water weed (Persicaria decipiens).

Comments	"- Developments must be carried out outside of rainy periods to avoid soil compaction and degradation caused by erosion (uprooting of plantations, seeds washed away by runoff...) - It is imperative to carry out the revegetation as soon as the earthworks are completed at the favourable period in order to avoid the proliferation of invasive species invasive species and erosion by runoff
Maintenance need	"- Annual management by mowing in August, before the rainy season - Ensure the cutting of plants with export of green waste
Management monitoring	Monitoring the evolution of the vegetation twice a year, during the dry seasons, by botanical expert, over 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30).

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

Action 20-K	Name	Stream protection zone with a vegetated riparian buffer
	Action target	Biodiversity and Water Quality
	Wetland	Kibumba

Location (map) K01-K03-K06-K07



Photos / examples







Characteristics	Rough cost estimate	Priority	Objectives
K03 Vegetated buffer strip of approximately 25m wide on each side of the watercourse, i.e. an area of approximately : 37 500m² for a total of 750m	12,150 USD	1 - Short-term 2025	In order to limit the transfer of pollutants to the watercourse via runoff, vegetated buffer strips are positioned between agricultural plots and the watercourse network. In this action sheet, a vegetated buffer strip is defined as any vegetated surface that intercepts diffuse or concentrated surface runoff and therefore reduces the transfer of pollutants and/or sediments. These vegetated buffer strips are translated as grassy strips, permanent grasslands, fallow land, hedges, woods or copses. Their implementation requires : - Tillage to level and decompact the land; - Revegetation, which is either seeding of grassland or planting of shrubs/trees; - A choice of local plant species. This vegetated buffer strip, whose width will have to be refined according to the intercepted watershed, will also be a support for the migration of animal species.
K06 Vegetated buffer strip of approximately 25m wide on each side of the watercourse, i.e. an area of approximately : 17 500m² for a total of 390m	264,735 USD	1 - Short-term 2025	
K07 Vegetated buffer strip of approximately 25m wide on each side of the watercourse, i.e. an area of approximately : 32 500 m² for a total of 650m	117,855 USD	1 - Short-term 2025	

Comments	Developments must be carried out outside of rainy periods to avoid soil compaction and degradation caused by erosion (uprooting of plantations, seeds washed away by runoff...)
Maintenance need	Annual management by mowing in August, before the rainy season
Management monitoring	Monitoring the evolution of the vegetation twice a year, during the dry seasons, by botanical expert, over 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30).

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

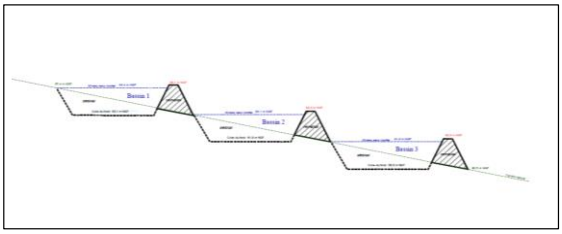
Action sheet

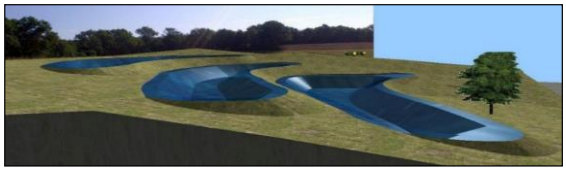
Action 21.K	Name	Natural weirs in cascade
	Action target	Flood control / Water filtration
	Wetland	Kibumba

Location (map) K04



Photos / examples





Characteristics	Rough cost estimate	Priority	Objectives
K04 A quarter of the surface was considered for this action Surface : 1,06 ha	317,682 USD	3 - Long-term 2050	This action consists of creating cascading water retention areas along the flow axis of the hydraulic outfalls. These retention areas will be in the form of basins, with a water surface area of less than 500 m² and a maximum depth of 1.5 m. Before carrying out the earthworks, a design study phase will be necessary to refine the works to be carried out. The basins will be positioned in such a way that the first basin is fed directly by the upstream water (arrival of water), then the others fed successively by overflow of the previous one. Once the water has passed into the last basin, the water will then be directed towards the wetland. Each basin will have a dike to maintain a water level before overflowing to the downstream basin to ensure their watertightness and the dikes will be anchored to the compact and impermeable substratum. They will therefore be made with waterproof materials (clay, etc.) and then recharged with a layer of topsoil to encourage vegetation. The basins will be positioned according to the topography of the sector, but it will be important that the banks are gently sloping (20%) to promote the development of a hygrophilic plant cover and the reception of fauna (amphibians, insects, ..). A safety margin of 0.30m (minimum difference between the highest water level and the top of the basins crest) iwill be provided for during periods of maximum basins filling. To achieve this objective, overflows will be installed at the top of the basins crest. The work will have to be carried out in dry periods and avoid rainy periods.

Comments	The basins cannot be effective if it collects untreated wastewater.
Maintenance need	Cleaning of the ponds every 5 years, during the dry season. Removal of floating materials (waste, plant debris) in the ponds. It will also be necessary to be vigilant about the appearance of any invasive plant species or plant dieback. A management plan also aims at - Ensure the cutting of plants with export of green waste - Maintain a high level of biodiversity in the water compartments by applying a differentiated vegetation management method - To perpetuate the landscape quality of the site and its potential to welcome the public.
Management monitoring	Monitoring of the evolution of vegetation and hydraulics twice a year, during dry and rainy seasons, by an expert in ecological engineering, for 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30).

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

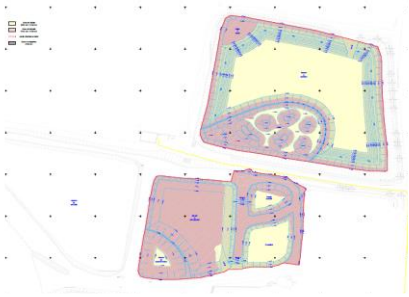
Action 22-K	Name	Modify the banks of aquaculture ponds by creating levels
	Action target	Biodiversity and Water Quality
	Wetland	Kibumba

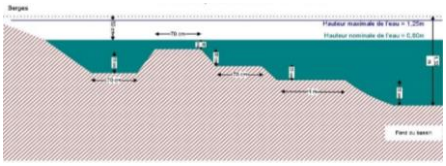
Location (map) K02



Photos / examples







Characteristics	Rough cost estimate	Priority	Objectives
K02 Surface : 22 000 m²	285,120 USD	1 - Short-term 2025	Before carrying out the earthworks, a design study phase will be necessary to refine the works to be carried out. These earthworks will have for objective to model the banks of the ponds of aquaculture so as to improve their ecological potential and to ensure a flow of water of the first to the last compartment in a gravitational way. After leveling of the banks, the installations will have to be compacted by layer of 30 cm in order to limit the effects of settlement in time. The bottoms and edges of the different elements will be adjusted. The earthworks must be carried out during periods that are favourable for these works (periods without rainfall and without water in the basins) so that the site is practicable and the works can be carried out in due form. A top layer of topsoil, without compaction and to a thickness of approximately 0.20m, will be applied after these earthworks. As shown on the above documents, the banks will be shaped in levels. The submerged banks will have a minimum slope of 1:3, except for localized constraints, in order to ensure their mechanical stability in the face of wave action, and to promote the maintenance and development of plants. A safety margin of 0.30m (minimum difference between the highest water level and the top of the compartment crest) is provided for during periods of maximum compartment filling. To achieve this objective, overflows will be installed at the top of the compartment crest.

Comments	The ponds cannot be effective if it collects untreated wastewater.

Maintenance need	Annual management by mowing in August, before the rainy season The management of ponds to be vigilant on the following hydraulic phenomena - Creation of hydraulic plugs at the level of hydraulic structures that can lead to overflows (loading of the system) and a reduction in residence time. - Reduction of the residence time and the treatment capacity of the system by short circuits and the filling of the volume of the basins. - Risk of invasive plants or plant dieback. A management plan also aims to - Ensure the cutting of plants with export of green waste - Maintain a high level of biodiversity in the water compartments by applying a differentiated vegetation management method. - Perpetuate the landscape quality of the site and its potential to welcome the public.
Management monitoring	Monitoring of the evolution of vegetation and hydraulics twice a year, during dry and rainy seasons, by an expert in ecological engineering, for 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30)

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

Action 23-K	Name	Diversification of natural habitats
	Action target	Biodiversity
	Wetland	Kibumba

Location (map) K02



Photos / examples





Characteristics	Rough cost estimate	Priority	Objectives
K02 Revegetation will occur only on the reshaped banks. Areas in water will not be planted. The total linear of banks to be planted is 1 500m, that is to say a total surface of 7 500m² for a planted strip of 5m width	60,750 USD	1 - Short-term 2025	This action aims to revegetate the banks of water bodies that have been previously reshaped. The work consists of planting native species typical of local wetlands, matching the water requirements of these species with the water conditions of the soil and the water level. It will be necessary to propose an adapted vegetation with the following plant species: Centella asiatica (Centella asiatica), Urugaga (Cyperus dives), Urukanganga/Cyperus latifolius (Cyperus latifolius), Carolina Dichondra (Dichondra micrantha), Ubwungo/ Drymaria cordata (Drymaria cordata), Urufunzo/Papyrus (Cyperus papyrus), Umuberanya/Southern quest (Typha domingensis), Carex mildbraediana, Urukirakenja/Cyperus articulatus, Umujangaja/Cyperus denudatus, Dichondra Carolina (Dichondra micrantha), Urujenone (Enhydra fluctuans), Gutwikumwe/ Hydrocotyle ranunculoides, Ubusuna/ Common rush (Juncus effusus), Urukembagufa/ Cutting grass (Leersia hexandra), Ikirogora (Brillantaisia cicatricosa), Umuzigangore (Ludwigia abyssinica), Igorogonzo/Water weed (Persicaria decipiens), Igorogonzo/Water weed (Persicaria pulchra), Urutaretare/ (Pycreus macrostachys). On the upper part of the banks, it will be possible to plant shrub or tree species, adapted to wetlands, in order to form a hedge or a riparian woodland. The plants will have to come from a local supply, which is necessary both ecologically and economically: ecologically, because the plants present in a given area necessarily have a genetics appropriate to that terrain and are therefore adapted to local conditions, and economically, because local actors are

Comments	"- Developments must be carried out outside of rainy periods to avoid soil compaction and degradation caused by erosion (uprooting of plantations, seeds washed away by runoff...) - It is imperative to carry out the revegetation as soon as the earthworks are completed at the favourable period in order to avoid the proliferation of invasive species invasive species and erosion by runoff
Maintenance need	"- Annual management by mowing in August, before the rainy season - Ensure the cutting of plants with export of green waste
Management monitoring	Monitoring the evolution of the vegetation twice a year, during the dry seasons, by botanical expert, over 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30).

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

Action 24.K	Name	Protection and conservation of typical wetland habitats
	Action target	Biodiversity
	Wetland	Kibumba

Location (map) K05



Photos / examples





Characteristics	Rough cost estimate	Priority	Objectives
K05 Linear of fences : 400 ml	64,800 USD	1 - Short-term 2025	This action aims to protect the wetlands of good plant quality and the most biologically sensitive (breeding grounds for heritage fauna, protected plant species, ...). For this, several solutions are proposed: - the installation of fences or wooden barriers, positioned all around the area of interest, in order to prohibit any pedestrian or vehicle access (except for maintenance). These protective elements must be well integrated into the landscape, so wooden elements are recommended. Awareness signs may also be installed. - the classification of the zone of interest in a protection zoning (reserves, protected areas, ..), allowing to limit the uses to those favorable to the maintenance of the fauna and the present flora. The classification in protection zoning induces administrative procedures but proves to be a very relevant tool to guarantee the durability of the area and the actions carried out, and to maintain quality habitats. In addition, thorough biological monitoring must be carried out on these areas by experts in ecology or environmental associations. The objective of this monitoring is to identify the fauna and flora issues in these areas, to follow the evolution of the habitats and to propose and adapt the management modalities in order to enhance the environment. This monitoring must be carried out at all times of the year, with more frequent visits during the period of activity of the fauna and development of the flora, and carried out according to a precise protocol repeated over several years.

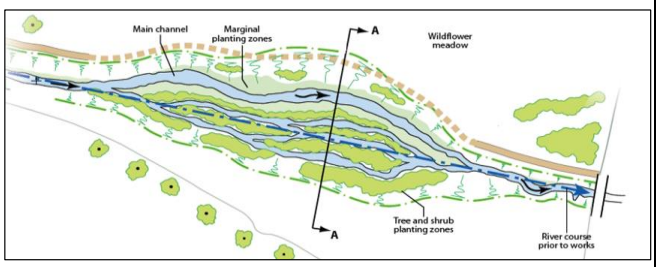
Comments	
Maintenance need	/
Management monitoring	Annual verification of the state of deterioration of the fences.

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

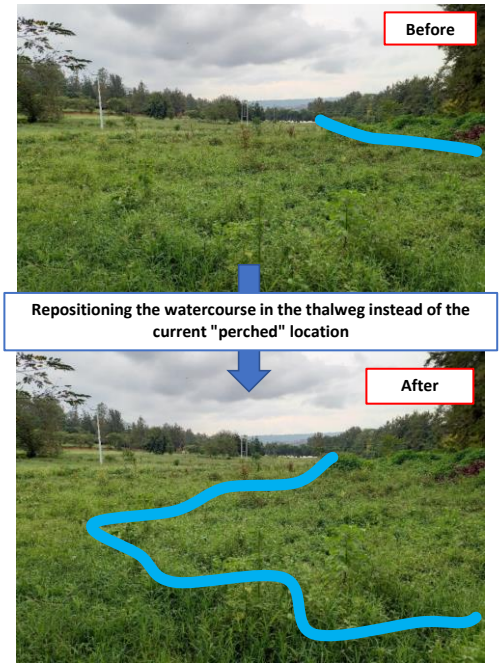
Action sheet		
Action 25.K	Name	Diversion of the river into the original flow - creation of small delta
	Action target	Flood mitigation, Biodiversity
	Wetland	Kibumba

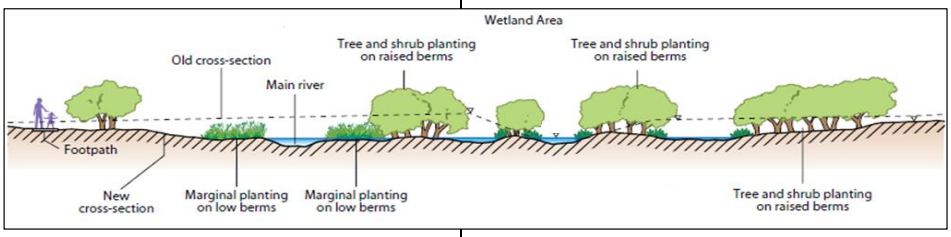
Location (map) - K06 - K07





Photos / examples





Characteristics	Rough cost estimate	Priority	Objectives
K06 Length of watercourse to be repositioned in the thalweg : 475 m	38,475 USD	1 - Short-term 2025	Before carrying out the earthworks, a design study phase will be necessary to refine the work to be carried out. These studies will make it possible to ensure that the water level is respected in order to create lentic and lotic zones: - The "project grade" (longitudinal profile) must be determined based on a good knowledge of the current slope of the river, the natural terrain and the water table (and its variations); - The recreation will not be uniform to create different flow facies. The use of mechanical shovel, bulldozer is necessary. The work will have to be carried out in such a way as to limit soil compaction: use machines with good bearing capacity ("marsh" shovels), avoid driving with machines on the talweg, decompact the soil at the end of the work.... The period of execution of the work is largely conditioned by the hydraulic constraints (low water). It is important to underline the importance of the quality of the company and the project management in this type of work. It is advisable to choose companies that have already carried out this type of work, and to provide for very regular monitoring of the site by an ecologist.
K07 Length of watercourse to be repositioned in the thalweg : 900 m	72,900 USD	1 - Short-term 2025	
Comments	Renvoi vers plans détaillés si besoin		

Maintenance need	Annual management by mowing in August, before the rainy season The management of the new minor bed must be vigilant on the following hydraulic phenomena: - Creation of hydraulic plugs at the level of the flows; - Departure of boulders positioned in the minor bed; - Presence of erosion of the banks and the bottom of the watercourse. A management plan also aims to ensure the cutting of vegetation with export of green waste
Management monitoring	Monitoring of the evolution of vegetation and hydraulics twice a year, during dry and rainy seasons, by an expert in ecological engineering, for 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30)

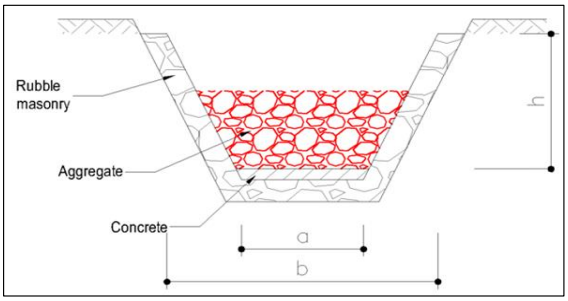
Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet		
Action 1.RW	Name	Raising the water level in the outfalls or the river
	Action target	Water filtration, Biodiversity, Flood mitigation
	Wetland	Rwampara

Location (map) RW01 - RW02



Photos / examples





Characteristics	Rough cost estimate	Priority	Objectives
RW02 : recharge the end of the channel over 200 m with aggregates	9,882 USD	1 - Short-term 2025	

Comments	
Maintenance need	To be defined according to the management monitoring report
Management monitoring	The work will be the subject of a technical file of the works carried out with the plans of the built installations. A follow-up of the profile of the restored banks and the minor bed will be carried out 6 months after the end of the work and then the year that follows. The frequency will be adapted according to the possible disorders observed and the results of this follow-up. On the basis of the technical file, the following will be identified - Possible movements, departures or contributions of blocks; - All possible traces of erosion, scouring on the resumed zones as well as on the transition zones and the zones peripheral to the development not impacted by the works. All the elements of this follow-up will be recorded in a report. In conclusion, recommendations will be made on possible rework, the frequency of monitoring, and on future developments

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

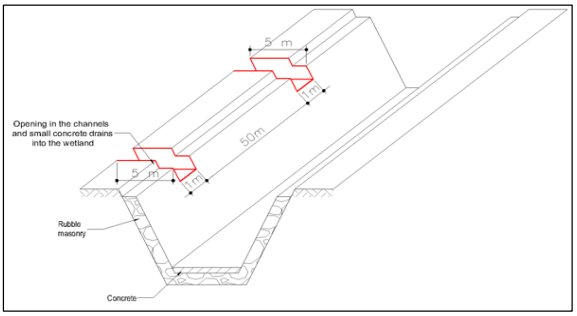
Action 2.RW	Name	Creation of overflows on the two concrete canals to ensure overflow of water into the wetland during rainfall
	Action target	Water filtration, Biodiversity
	Wetland	Rwampara

Location (map) RW02



Photos / examples





Characteristics	Rough cost estimate	Priority	Objectives
RW02: make 10 openings (each 50 m) in the existing channel and build small concrete drains	4,725 USD	1 - Short-term 2025	- Limit the drainage of the wetland - Favor overflow the concrete channel and the river beds - Reduce the water quantity and velocity downstream

Comments	
Maintenance need	Maintenance of the concrete drains (provent from solid waste accumulation): Once per 2 month Other maintenance needs to be defined according to the management monitoring report
Management monitoring	The work will be the subject of a technical file of the works carried out with the plans of the built installations. A follow-up of the profile of the restored banks and the minor bed will be carried out 6 months after the end of the work and then the year that follows. The frequency will be adapted according to the possible disorders observed and the results of this follow-up. On the basis of the technical file, the following will be identified - Possible movements, departures or contributions of blocks; - All possible traces of erosion, scouring on the resumed zones as well as on the transition zones and the zones peripheral to the development not impacted by the works. All the elements of this follow-up will be recorded in a report. In conclusion, recommendations will be made on possible rework, the frequency of monitoring, and on future developments.

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

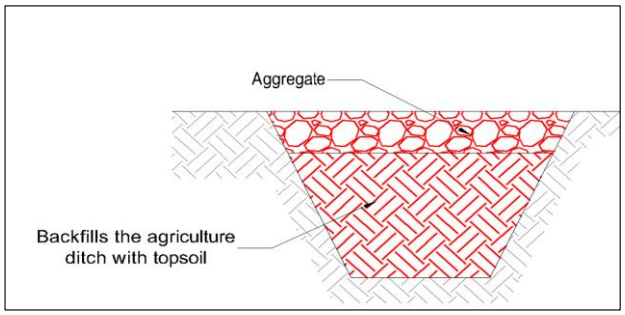
Action 5.RW	Name	Blocking of surface and subsurface drains
	Action target	Water filtration, Biodiversity
	Wetland	Rwampara

Location (map) RW06



Photos / examples





Characteristics	Rough cost estimate	Priority	Objectives
RW06: backfill the agricultural drains with approximately 76 000 m3	455,858 USD	1 - Short-term 2025	- Limit the lowering of the groundwater - Increase the residence time of the water in the wetland - Homogenise the wetland ground - Enhance the storage capacity of the wetland - Reduce the water quantity and velocity downstream

Comments	
Maintenance need	No needs
Management monitoring	No needs

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

Action 6.RW	Name	Planting of native plant species adapted to the wetland environment
	Action target	Biodiversity
	Wetland	Rwampara

Location (map) RW06



Photos / examples



Characteristics	Rough cost estimate	Priority	Objectives
RW06 Surface : 156 500 m²	325 364 US Dollar	1 - Short-term 2025	This action aims at recovering a herbaceous cover on all these surfaces, composed of a characteristic flora of wetlands and typical of Rwandan wetlands. For that, the first step consists in a preparation of the ground, with a decompacting of the ground in place on the first 15 centimeters in order to reactivate the seed bank and to support the rooting. The second step consists of planting with native species typical of local wetlands, such as Indian pennywort (*Centella asiatica*), Urugaga (*Cyperus dives*), Urukanganga/Epiphytic flatsedge (*Cyperus latifolius*), Carolina dichondra (*Dichondra micrantha*), Ubwungo/Heartleaf drymary (*Drymaria cordata*), Urufunzo/Papyrus (*Cyperus papyrus*), Umuberanya/Southern Cattail (*Typha domingensis*), Carex mildbraediana, Urukirakenja/Jointed flatsedge (*Cyperus articulatus*), Umujangaja/winged sedge (*Cyperus denudatus*), Carolina dichondra (*Dichondra micrantha*), Urujenone (*Enhydra fluctuans*), Gutwikumwe/Floating pennywort (*Hydrocotyle ranunculoides*), Ubusuna/Common rush (*Juncus effusus*), Urukembagufa/Cut grass *(Leersia hexandra)*, Ikirogora (*Brillantaisia cicatricosa*), Umuzigangore (*Ludwigia abyssinica*), Igorogonzo/Watersmart weed (*Persicaria decipiens*), Igorogonzo/Watersmart weed (*Persicaria pulchra*), Urutaretare/ (*Pycreus macrostachys*). The plantings will aim to adapt the location of the species according to their need for water and the water conditions of the soil, in order to favour their development. The seedlings must come from a local source, which is necessary both ecologically and economically: ecologically, because the plants present in a given territory necessarily have the appropriate genetics for that land and are therefore adapted to local conditions, and economically, because local actors are more in demand than foreign suppliers. The planting will take place in December, once the rainy season is over. The clods will be installed in a hole made with a tiller, a planter or a pickaxe and carefully positioned in the hole thus made. Before planting, the plants will be soaked in water before installation and then packed in the soil. The plants in cups will be distributed by spots at a rate of 2 plants per m². All plants supplied by the landscaper shall be of the species and variety requested, free of wounds and pest attacks. They shall be separated by destination compartment and by species to facilitate distribution and verification. The plants must be replanted as soon as possible after delivery.

Comments	
Maintenance need	Annual management by mowing in August, before the rainy season.
Management monitoring	Monitoring the evolution of the vegetation twice a year, during the dry seasons, by botanical expert, over 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30).

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

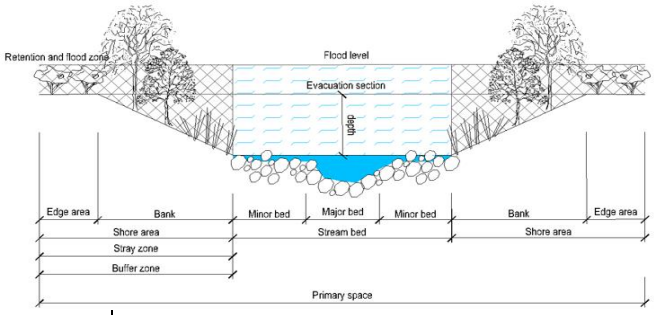
Action 7.RW	Name	Re-profiling of the river with the creation of meanders and banks with different levels
	Action target	Water filtration, Biodiversity
	Wetland	Gikondo

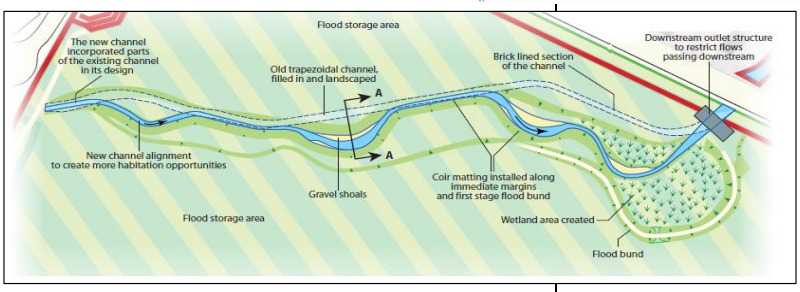
Location (map) RW01 - RW06



Photos / examples







Characteristics	Rough cost estimate	Priority	Objectives
R01 : Creation of meander and banks along 1800 m	282,083 USD	3 - Long-term 2050	- Improve the water quality and decrease the water quantity flowing downstream (slowing the flow) - Improve the biodiversity - Promote recreational area
R06 : Creation of meander and banks	332,009 USD	1 - Short-term 2025	
R06 : Creation of meander and banks along	271,644 USD	2 - Medium-term 2035	

Comments	- The existing water supply pipelines implemented into the wetland will be included and considered during the further studies and works
Maintenance need	To be defined according to the management monitoring report
Management monitoring	The work will be the subject of a technical file of the works carried out with the plans of the built installations. A follow-up of the profile of the restored banks and the minor bed will be carried out 6 months after the end of the work and then the year that follows. The frequency will be adapted according to the possible disorders observed and the results of this follow-up. On the basis of the technical file, the following will be identified - Possible movements, departures or contributions of blocks; - All possible traces of erosion, scouring on the resumed zones as well as on the transition zones and the zones peripheral to the development not impacted by the works. All the elements of this follow-up will be recorded in a report. In conclusion, recommendations will be made on possible rework, the frequency of monitoring, and on future developments

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

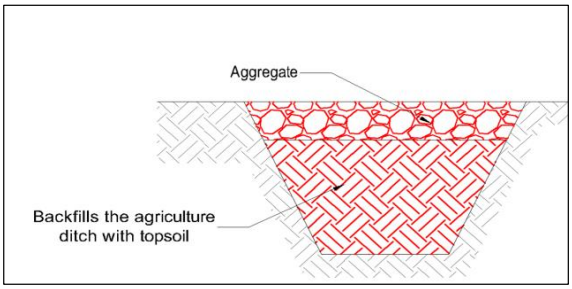
Action 8.RW	Name	Recharge of the river bed with aggregate
	Action target	Water filtration, Biodiversity
	Wetland	Rwampara

Location (map) RW01 - RW06



Photos / examples





Characteristics	Rough cost estimate	Priority	Objectives
RW01 : Filling the watercourse with aggregates of different diameter over 1 800 m	1,365,822 USD	3 - Long-term 2050	- recover a space favorable for planting - development of natural habitats
RW06: : filling the watercourse with aggregates of different diameter	1,082,565 USD	1 - Short-term 2025	
RW06: : filling the watercourse with aggregates of different diameter	885,735 USD	2 - Medium-term 2035	

Comments	
Maintenance need	To be defined according to the management monitoring report
Management monitoring	The work will be the subject of a technical file of the works carried out with the plans of the built installations. A follow-up of the profile of the restored banks and the minor bed will be carried out 6 months after the end of the work and then the year that follows. The frequency will be adapted according to the possible disorders observed and the results of this follow-up. On the basis of the technical file, the following will be identified - Possible movements, departures or contributions of blocks; - All possible traces of erosion, scouring on the resumed zones as well as on the transition zones and the zones peripheral to the development not impacted by the works. All the elements of this follow-up will be recorded in a report. In conclusion, recommendations will be made on possible rework, the frequency of monitoring, and on future developments

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

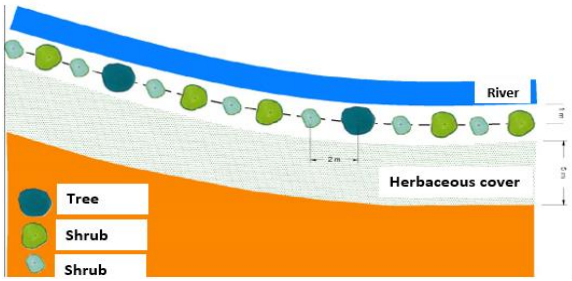
Action sheet

Action 9.RW	Name	Planting the banks with native plant species
	Action target	Biodiversity
	Wetland	Rwampara

Location (map) RW01 - RW06



Photos / examples





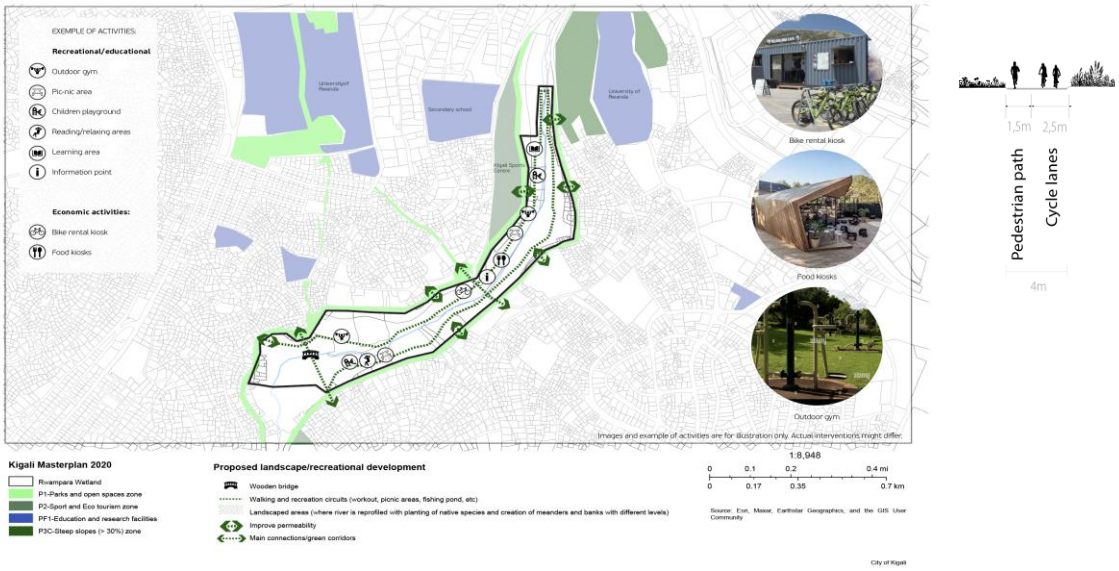
Characteristics	Rough cost estimate	Priority	Objectives
RW01 Surface : 187 200 m²	707 616 US Dollar	3 - Long-term 2050	This action aims at recovering a herbaceous cover composed of a flora characteristic of wetlands and typical of Rwandan wetlands on all the banks and edges of the main rivers. To do this, the first step consists of soil preparation, with decompaction of the soil in place on the first 15 centimeters to reactivate the seed bank and promote rooting. The second step consists of planting native species typical of local wetlands, matching the water requirements of these species with the water conditions of the soil or the frequency of overflowing of the stream (depending on the stream levels). The species planted could be : Indian pennywort (*Centella asiatica*), Urugaga (*Cyperus dives*), Urukanganga/Epiphytic flatsedge (*Cyperus latifolius*), Carolina dichondra (*Dichondra micrantha*), Ubwungo/Heartleaf drymary (*Drymaria cordata*), Urufunzo/Papyrus (*Cyperus papyrus*), Umuberanya/Southern Cattail (*Typha domingensis*), Carex mildbraediana, Urukirakenja/Jointed flatsedge (*Cyperus articulatus*), Umujangaja/winged sedge (*Cyperus denudatus*), Carolina dichondra (Dichondra micrantha), Urujenone (*Enhydra fluctuans*), Gutwikumwe/Floating pennywort (*Hydrocotyle ranunculoides*), Ubusuna/Common rush (*Juncus effusus*), Urukembagufa/Cut grass (*Leersia hexandra*), Ikirogora (*Brillantaisia cicatricosa*), Umuzigangore (*Ludwigia abyssinica*), Igorogonzo/Watersmart weed (*Persicaria decipiens*), Igorogonzo/Watersmart weed (*Persicaria pulchra*), Urutaretare/ (*Pycreus macrostachys*). In addition, on the banks, it will be possible to plant shrub or tree species, adapted to wetlands, in order to form a rypisilve along the stream. This will stabilize the banks and strengthen the ecological corridor. This riparian buffer will be created on one side of the stream only, in order to maintain sufficient light and facilitate stream maintenance. The plants must come from a local source, which is necessary both ecologically and economically: ecologically, because the plants present in
RW06 Surface : 65 000 m²	249 480 US Dollar	1 - Short-term 2025	

RW06 Surface : 55 000 m²	204 120 US Dollar	2 - Medium-term 2035	a given territory necessarily have the appropriate genetics for that land and are therefore adapted to local conditions, and economically, because local actors are more in demand than foreign suppliers. The planting will take place in December, once the rainy season is over. For the herbaceous species, the clods will be installed in a hole made with a rototiller, a planter or a pickaxe and carefully positioned in the hole thus made. Before being planted, the plants will be soaked in water before being installed, then tamped into the soil. The plants in the cups will be distributed in patches at a rate of 2 plants per m². For trees and shrubs, plants shall be placed in a hole at least 40 cm deep and staked. All plants supplied by the landscaper must be of the species and variety requested, free of wounds and pest attacks. They shall be separated by destination compartment and species for ease of distribution and verification. Plants shall be replanted as soon as possible after delivery.
Comments			
Maintenance need	Annual management by mowing in August, before the rainy season. Maintenance of the rypisilve every year : removal of dead wood, pruning as needed, …		
Management monitoring	Monitoring the evolution of the vegetation twice a year, during the dry seasons, by botanical expert, over 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30).		

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet		
Action 10.RW	Name	Possible development of recreational activities: Creation of pedestrian/cycling circuits
	Action target	Landscape / Recreational activities
	Wetland	Rwampara

RWAMPARA WALKING AND RECREATION CIRCUITS



Characteristics	Rough cost estimate	Priority	Objectives
RWAMPARA WETLAND CENTRE			To create an attractive walking/cycling circuit that promotes awareness of natural habitats and an active lifestyle. Economic activities managed by private operators are included in the programme in order to contribute to the sustainability and durability of investments.
Package 1: Creation of walking/cycling circuits - Pedestrian/cycling circuits 4m wide (3km linear) - Benches every 500m (6x) - Accessible pedestrian bridge - Solar light poles every 20m (150x) - Planting of native species (3km linear) - Interpretation trail (natural habitat awareness signage)	**243 810 USD**	1 - Short-term 2025	
Package 2 : Economic activities (attracting private actors) - Playgrounds (3x) - Bike rental kiosk - Picnic tables (10x) - Food kiosks (3x) - Toilets - Visitor information kiosk	**97 335 USD**	2 - Medium-term 2035	
Package 3 : Boosting attractiveness and quality of spaces - Water activities - Bird watching deck - Outdoor gym circuits (3x) - Landscaped areas (1000m2 planted with native species)	**184 748 USD**	3 - Long-term 2050	

Comments	See detailed plan provided in annex
Maintenance need	Annual for equipments and infrastructures and quarterly for green spaces with nature evolution
Management monitoring	Involvement of private operators for the day-to-day management of certain facilities (restaurant/cafe, bike rental kiosk, etc). Involvement of public players (site cleanliness, waste collection and management, etc.), to manage and enforce contracts, ensure coordination for the management of the site (internal regulations) and ensure security of the site

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

Action 11.RW	Name	Riprap at the outlet of urban discharge
	Action target	Flood control / Water filtration
	Wetland	Rwampara

Location (map) RW01 - RW03 - RW04 - RW05



Photos / examples





Characteristics	Rough cost estimate	Priority	Objectives
RW01 Number of riprap : 15 Volume : 1 000 m3	303 750 USD	3 - Long-term 2050	This action consists of placing boulders just at the outlet of the urban drains, in order to break the incoming flow and improve the diffusion of water towards the downstream wetland and other hydraulic outlets. These riprap will be made of stones of size between 200 and 1000 mm, depending on the flow of water arriving and the speed of flow, so that they can ensure their anti-erosion role. For each riprap, it will be used stones of different dimensions so that the small stones occupy the empty spaces between the larger stones. They will be placed one on top of the other, so as to form a homogeneous entity and in phase with the width of the drains. The installation of the riprap will take place in dry periods, outside of rainy periods.
RW03 Number of riprap : 2 Volume : 100 m3	40 500 USD	1 - Short-term 2025	
RW04 Number of riprap : 5 Volume : 250 m3	50 625 USD	1 - Short-term 2025	
RW05 Number of riprap : 3 Volume : 150 m3	20 048 USD	1 - Short-term 2025	

Maintenance need	/
Management monitoring	Visual inspection of riprap twice a year and removal of any waste or plant debris that may be present.

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

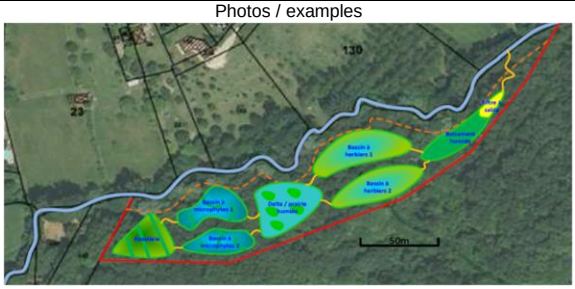
Action sheet

Action 12-RW	Name	Creation of a constructed wetland - buffer zone
	Action target	Biodiversity and Water Quality
	Wetland	Rwampara

Location (map) RW01 - RW02 - RW04



Photos / examples









Characteristics	Rough cost estimate	Priority	Objectives
RW01 Given the configuration of the valley floor, only one fifth of the area could be used for this type of action Surface : 37 500 m²	936 563 USD	3 - Long-term 2050	The design approach of the buffer wetland leaves an important part to the study of the contributing watershed in order to know precisely the characteristics of the incoming effluents and of the contributing watershed (flow rate, surface of the watershed, quality, frequency of feeding...). This ecological engineering project is based on different components such as hydraulics, purification, wetlands ecology and plant engineering. In summary, the creation of a wetland buffer zone is carried out in 3 stages - Feasibility study to identify the environmental issues and take them into account in the design: topographic surveys, soil studies, hydraulic studies of the watershed... - Design study including: execution plans of the wetland buffer zone compartments, ecological engineering design, hydraulic sizing of the works and integration of educational supports... - Works and follow-up of the construction site requiring the intervention of qualified partners for the realization of the civil engineering (earthworks to create the various compartments, the overflows...), ecological engineering (choice of materials, planting of the vegetable species...) and a qualified site manager. A safety margin of 0.30m (minimum difference between the highest water level and the top of the compartment crest) is provided for during periods of maximum compartment filling. To achieve this objective, overflows will be installed at the top of the compartment crest.
RW02 Surface : 10 600 m²	264 735 USD	1 - Short-term 2025	
RW04 Surface : 4 800 m²	59 940 USD	2 - Medium-term 2035	

Comments	"- The wetland buffer cannot be effective if it collects untreated wastewater. - Maximum depth of the compartments fixed at 1,20m
Maintenance need	Annual management by mowing in August, before the rainy season A wetland buffer reproduces, on a smaller scale, mechanisms that occur naturally in the natural environment. The evolution of the habitats and the sustainability of the objectives targeted by the wetland buffer (purification, biodiversity, education, etc.) are directly linked to the quality of its management from the moment it is put in water. The management of the buffer wetland leads to be vigilant on the following hydraulic phenomena - Creation of hydraulic plugs at the level of the hydraulic structures that can lead to overflows (loading of the system) and a reduction in the residence time. - Reduction of the residence time and the treatment capacity of the system by short-circuits and filling of the volume of the basins. - Risk of invasive plants or plant dieback. A management plan also has the following objectives - Ensure the cutting of plants with export of green waste - Maintain a high level of biodiversity in the water compartments by applying a differentiated vegetation management method. - To perpetuate the landscape quality of the site and its potential to welcome the public.
Management monitoring	Monitoring of the evolution of vegetation and hydraulics twice a year, during dry and rainy seasons, by an expert in ecological engineering, for 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30)

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

Action 13.RW	Name	Re-profiling of the hydraulic outlets from the discharge
	Action target	Water filtration, Biodiversity
	Wetland	Rwampara

Location (map) RW01 - RW05



Photos / examples

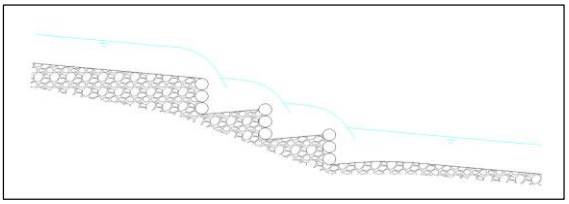






Abb. 2 a Abb. 2 b

Characteristics	Rough cost estimate	Priority	Objectives
RW01 : Riprap at the outlet with creation of different river bed ground level	4,210 USD	1 - Short-term 2025	- limit erosion - enhance biodiversity with diversification of natural habitats
RW05: Riprap at the outlet with creation of different river bed ground level	8,548 USD	2 - Medium-term 2035	

Comments	
Maintenance need	- Maintenance of the outlets (provent from solid waste accumulation): twice per year (including one before the rainy season) - Other maintenance needs to be defined according to the management monitoring report - The existing water supply pipelines implemented into the wetland will be included and considered during the further studies and works
Management monitoring	The work will be the subject of a technical file of the works carried out with the plans of the built installations. A follow-up of the profile of the restored banks and the minor bed will be carried out 6 months after the end of the work and then the year that follows. The frequency will be adapted according to the possible disorders observed and the results of this follow-up. On the basis of the technical file, the following will be identified - Possible movements, departures or contributions of blocks; - All possible traces of erosion, scouring on the resumed zones as well as on the transition zones and the zones peripheral to the development not impacted by the works. All the elements of this follow-up will be recorded in a report. In conclusion, recommendations will be made on possible rework, the frequency of monitoring, and on future developments

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

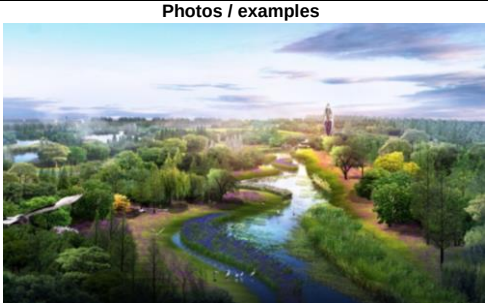
Action sheet

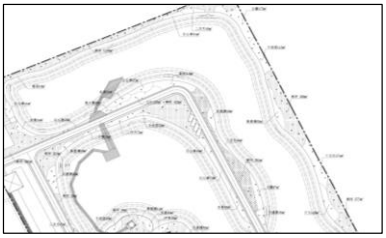
Action 18.RW	Name	Creation of a depression disconnected from the river
	Action target	Biodiversity and Water Quality
	Wetland	Rwampara

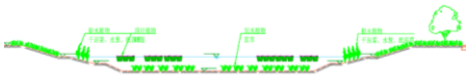
Location (map) RW06



Photos / examples







Characteristics	Rough cost estimate	Priority	Objectives
RW06 One quarter of the total area developed for the creation of depressions Surface : 70 000 m²	207 900 USD	2 - Medium-term 2035	Before carrying out the earthworks, a design study phase will be necessary to refine the works to be carried out. These studies will make it possible to respect the following principles: - The arrival of water from urban drains must be accompanied by riprap to limit erosion in the depression; - The "project elevation" (longitudinal profile) must be determined on the basis of a good knowledge of the level of the river and of the water table (and its variations); - The slopes of the banks must be as low as possible; - The arm/depression can be materialized by multiple basins; - The recreation will not be uniform; - Excessive excavation may result in lowering of the water table (drainage). It can also cause a pollution of the water table by feeding with water of bad quality. These earthworks will have for objective to respect the criteria specified above. The use of mechanical shovel, bulldozer is necessary. The work must be carried out in such a way as to limit the compaction of the land: use machines with good bearing capacity ("marsh" shovels), avoid driving with the machines on the talweg, decompact the soil at the end of the work... The period of execution of the work is largely conditioned by hydraulic constraints (low water). It is important to underline the importance of the quality of the company and the project management in this type of work. It is advisable to choose companies that have already carried out this type of work, and to provide for very regular monitoring of the site by an ecologist. A safety margin of 0.30 m (minimum difference between the highest water level and the top of the compartment crest) is

Comments	- The depression cannot be effective if it collects untreated wastewater. - Maximum depth of the compartments fixed at 1,20m - The existing water supply pipelines implemented into the wetland will be included and considered during the further studies and works

Maintenance need	Annual management by mowing in August, before the rainy season The management of depression to be vigilant on the following hydraulic phenomena - Creation of hydraulic plugs at the level of hydraulic structures that can lead to overflows (loading of the system) and a reduction in residence time. - Reduction of the residence time and the treatment capacity of the system by short circuits and the filling of the volume of the basins. - Risk of invasive plants or plant dieback. A management plan also aims to - Ensure the cutting of plants with export of green waste - Maintain a high level of biodiversity in the water compartments by applying a differentiated vegetation management method. - Perpetuate the landscape quality of the site and its potential to welcome the public.
Management monitoring	Monitoring of the evolution of vegetation and hydraulics twice a year, during dry and rainy seasons, by an expert in ecological engineering, for 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30)

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

Action 19.RW	Name	Diversification of natural habitats typical of wetlands
	Action target	Biodiversity
	Wetland	Rwampara

Location (map) RW06



Photos / examples







Characteristics	Rough cost estimate	Priority	Objectives
RW06 One quarter of the total area developed for the creation of depressions. Therefore, the area to be vegetated is the same. Surface : 70 000 m²	204 120 USD	2 - Medium-term 2035	This action aims at recovering a herbaceous cover composed of a flora characteristic of wetlands and typical of Rwandan wetlands on all the depressions up to the banks. To do this, the first step consists in preparing the soil, with decompacting the soil in place on the first 15 centimeters to reactivate the seed bank and promote rooting. The second step is to plant native species typical of local wetlands, matching the water needs of these species with the water conditions of the soil. Indeed, in order to accelerate the vegetation, it will be interesting to plant semi-aquatic and aquatic plants: sedges, reeds...In time, the planted plants will be more or less completed/replaced progressively by species spontaneously colonizing the site. The zones regularly in water will generally be well colonized by natural vegetation; it is thus little useful to sow them. This will involve proposing an adapted plant life with the following plant species: Centella asiatica (Centella asiatica), Urugaga (Cyperus dives), Urukanganga/Cyperus latifolius (Cyperus latifolius), Carolina Dichondra (Dichondra micrantha), Ubwungo/ Drymaria cordata (Drymaria cordata), Urufunzo/Papyrus (Cyperus papyrus), Umuberanya/Southern cattail (Typha domingensis), Carex mildbraediana, Urukirakenja/Cyperus articulatus, Umujangaja/Cyperus denudatus, Dichondra Carolina (Dichondra micrantha), Urujenone (Enhydra fluctuans), Gutwikumwe/ Hydrocotyle ranunculoides, Ubusuna/ Common rush (Juncus effusus), Urukembagufa/ Cutting grass (Leersia hexandra), Ikirogora (Brillantaisia cicatricosa), Umuzigangore (Ludwigia abyssinica), Igorogonzo/Water weed (Persicaria decipiens).

Comments	"- Developments must be carried out outside of rainy periods to avoid soil compaction and degradation caused by erosion (uprooting of plantations, seeds washed away by runoff...) - It is imperative to carry out the revegetation as soon as the earthworks are completed at the favourable period in order to avoid the proliferation of invasive species invasive species and erosion by runoff
Maintenance need	"- Annual management by mowing in August, before the rainy season - Ensure the cutting of plants with export of green waste
Management monitoring	Monitoring the evolution of the vegetation twice a year, during the dry seasons, by botanical expert, over 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30).

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

Action 20-RW	Name	Stream protection zone with a vegetated riparian buffer
	Action target	Biodiversity and Water Quality
	Wetland	Rwampara

Location (map) RW01-RW06



Photos / examples







Characteristics	Rough cost estimate	Priority	Objectives
RW01 Vegetated buffer strip of approximately 12m wide on each side of the watercourse, i.e. an area of approximately : 47 500m² for a total of 1 900m	567 000 USD	3 - Long-term 2050	In order to limit the transfer of pollutants to the watercourse via runoff, vegetated buffer strips are positioned between agricultural plots and the watercourse network. In this action sheet, a vegetated buffer strip is defined as any vegetated surface that intercepts diffuse or concentrated surface runoff and therefore reduces the transfer of pollutants and/or sediments. These vegetated buffer strips are translated as grassy strips, permanent grasslands, fallow land, hedges, woods or copses. Their implementation requires : - Tillage to level and decompact the land; - Revegetation, which is either seeding of grassland or planting of shrubs/trees; - A choice of local plant species. This vegetated buffer strip, whose width will have to be refined according to the intercepted watershed, will also be a support for the migration of animal species.
RW06 Vegetated buffer strip of approximately 25m wide on each side of the watercourse	264 516 USD	1 - Short-term 2025	
RW06 Vegetated buffer strip of approximately 25m wide on each side of the watercourse	216 422 USD	2 - Medium-term 2035	

Comments	Developments must be carried out outside of rainy periods to avoid soil compaction and degradation caused by erosion (uprooting of plantations, seeds washed away by runoff...)
Maintenance need	Annual management by mowing in August, before the rainy season
Management monitoring	Monitoring the evolution of the vegetation twice a year, during the dry seasons, by botanical expert, over 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30).

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

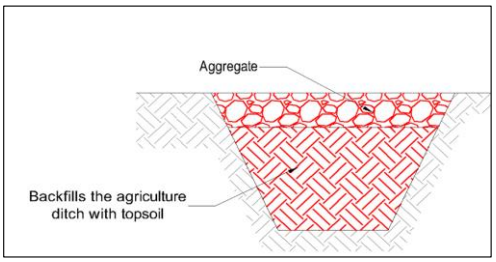
Action 5.RU	Name	Blocking of surface drains (agriculture ditch)
	Action target	Water filtration, Biodiversity
	Wetland	Rugenge-Rwintare

Location (map) RU02 - RU03 - RU04 - RU07



Photos / examples





Characteristics	Rough cost estimate	Priority	Objectives
RU02: backfill the agricultural drains with approximately 22 000 m3	76 515 USD	2 - Medium-term 2035	
RU02: backfill the agricultural drains with approximately 22 000 m3	155 348 USD	3 - Long-term 2050	- Limit the lowering of the groundwater - Increase the residence time of the water in the wetland - Homogenise the wetland ground - Enhance the storage capacity of the wetland - Reduce the water quantity and velocity downstream
RU03: backfill the agricultural drains with approximately 29 000 m3	312 255 USD	1 - Short-term 2025	
RU04: backfill the agricultural drains with approximately 5 600 m3	16 808 USD	2 - Medium-term 2035	
RU07: backfill the agricultural drains with approximately 14 000 m3	151 673 USD	1 - Short-term 2025	

Comments	- The existing water supply pipelines implemented into the wetland (RU02) will be included and considered during the further studies and works
Maintenance need	No needs
Management monitoring	No needs

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

Action 6.RU	Name	Planting of native plant species adapted to the wetland environment
	Action target	Biodiversity
	Wetland	Rugenge-Rwintare

Location (map) RU02 - RU03 - RU07



Photos / examples



Characteristics	Rough cost estimate	Priority	Objectives
RU02 Surface : 114 200 m²	142 453 USD	2 - Medium-term 2035	This action aims at recovering a herbaceous cover on all these surfaces, composed of a characteristic flora of wetlands and typical of Rwandan wetlands. For that, the first step consists in a preparation of the ground, with a decompacting of the ground in place on the first 15 centimeters in order to reactivate the seed bank and to support the rooting. The second step consists of planting with native species typical of local wetlands, such as Indian pennywort (*Centella asiatica*), Urugaga *(Cyperus dives*), Urukanganga/Epiphytic flatsedge (*Cyperus latifolius*), Carolina dichondra (*Dichondra micrantha*), Ubwungo/Heartleaf drymary (*Drymaria cordata*), Urufunzo/Papyrus (*Cyperus papyrus*), Umuberanya/Southern Cattail (*Typha domingensis*), Carex mildbraediana, Urukirakenja/Jointed flatsedge (*Cyperus articulatus*), Umujangaja/winged sedge *(Cyperus denudatus*), Carolina dichondra (*Dichondra micrantha*), Urujenone (*Enhydra fluctuans*), Gutwikumwe/Floating pennywort (*Hydrocotyle ranunculoides*), Ubusuna/Common rush (*Juncus effusus*), Urukembagufa/Cut grass (*Leersia hexandra*), Ikirogora (*Brillantaisia cicatricosa*), Umuzigangore (*Ludwigia abyssinica*), Igorogonzo/Watersmart weed (*Persicaria decipiens*), Igorogonzo/Watersmart weed (*Persicaria pulchra)*, Urutaretare/ (*Pycreus macrostachys*). The plantings will aim to adapt the location of the species according to their need for water and the water conditions of the soil, in order to favour their development. The seedlings must come from a local source, which is necessary both ecologically and economically: ecologically, because the plants present in a given territory necessarily have the appropriate genetics for that land and are therefore adapted to local conditions, and economically, because local actors are more in demand than foreign suppliers. The planting will take place in December, once the rainy season is over. The clods will be installed in a hole made with a tiller, a planter or a pickaxe and carefully positioned in the hole thus made. Before planting, the plants will be soaked in water before installation and then packed in the soil. The plants in cups will be distributed by spots at a rate of 2 plants per m². All plants supplied by the landscaper shall be of the species and variety requested, free of wounds and pest attacks. They shall be separated by destination compartment and by species to facilitate distribution and verification. The plants must be replanted as soon as possible after delivery.
RU02 Surface : 114 200 m²	289 222 USD	3 - Long-term 2050	
RU07 Surface : 80 200 m²	303 156 USD	1 - Short-term 2025	

Comments	
Maintenance need	Annual management by mowing in August, before the rainy season.
Management monitoring	Monitoring the evolution of the vegetation twice a year, during the dry seasons, by botanical expert, over 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30).

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

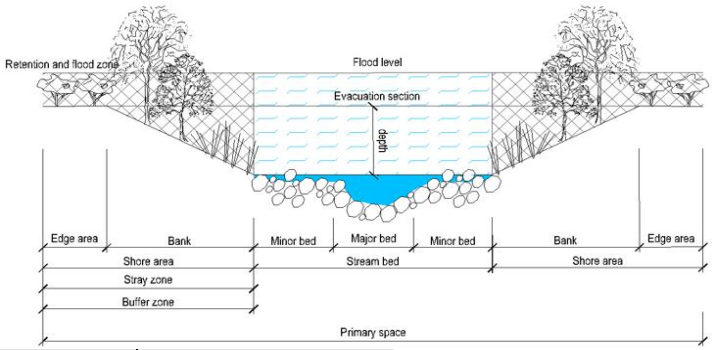
Action 7.RU	Name	Re-profiling of the river with the creation of meanders and banks with different levels
	Action target	Water filtration, Biodiversity
	Wetland	Rugenge-Rwintare

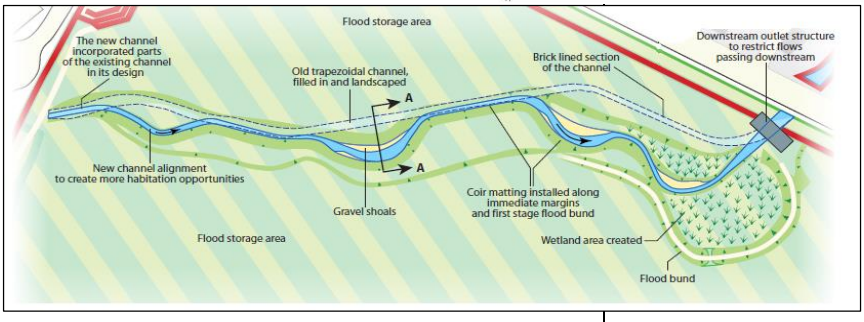
Location (map) RU5



Photos / examples







Characteristics	Rough cost estimate	Priority	Objectives
RU05 : Creation of meander and banks along 1 100 m	164 633 USD	1 - Short-term 2025	- Improve the water quality and decrease the water quantity flowing downstream (slowing the flow) - Improve the biodiversity - Promote recreational area

Comments	
Maintenance need	Needs to be defined according to the monitoring management report
Management monitoring	The work will be the subject of a technical file of the works carried out with the plans of the built installations. A follow-up of the profile of the restored banks and the minor bed will be carried out 6 months after the end of the work and then the year that follows. The frequency will be adapted according to the possible disorders observed and the results of this follow-up. On the basis of the technical file, the following will be identified - Possible movements, departures or contributions of blocks; - All possible traces of erosion, scouring on the resumed zones as well as on the transition zones and the zones peripheral to the development not impacted by the works. All the elements of this follow-up will be recorded in a report. In conclusion, recommendations will be made on possible rework, the frequency of monitoring, and on future developments.

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

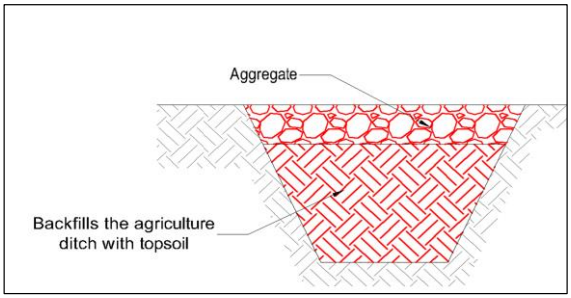
Action 8.RU	Name	Recharge of the river bed with aggregate
	Action target	Water filtration, Biodiversity
	Wetland	Rugenge-Rwintare

Location (map) RU05



Photos / examples





Characteristics	Rough cost estimate	Priority	Objectives
RU05: filling the watercourse with aggregates of different diameter and topsoil	87 399 USD	1 - Short-term 2025	- Recover a space favorable for planting - Development of natural habitats

Comments	
Maintenance need	Needs to be defined according to the monitoring management report
Management monitoring	The work will be the subject of a technical file of the works carried out with the plans of the built installations. A follow-up of the profile of the restored banks and the minor bed will be carried out 6 months after the end of the work and then the year that follows. The frequency will be adapted according to the possible disorders observed and the results of this follow-up. On the basis of the technical file, the following will be identified - Possible movements, departures or contributions of blocks; - All possible traces of erosion, scouring on the resumed zones as well as on the transition zones and the zones peripheral to the development not impacted by the works. All the elements of this follow-up will be recorded in a report. In conclusion, recommendations will be made on possible rework, the frequency of monitoring, and on future developments.

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

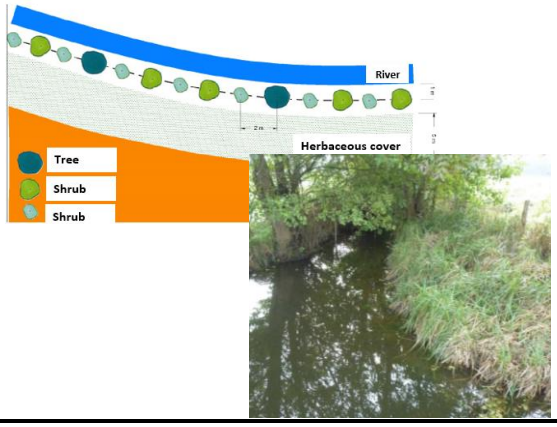
Action sheet

Action 9.RU	Name	Planting the banks with native plant species
	Action target	Biodiversity
	Wetland	Rugenge-Rwintare

Location (map) RU04 - RU05



Photos / examples



Characteristics	Rough cost estimate	Priority	Objectives
RU03 Surface : 38 400 m²	145 152 USD	1 - Short-term 2025	This action aims at recovering a herbaceous cover composed of a flora characteristic of wetlands and typical of Rwandan wetlands on all the banks and edges of the main rivers. To do this, the first step consists of soil preparation, with decompaction of the soil in place on the first 15 centimeters to reactivate the seed bank and promote rooting. The second step consists of planting native species typical of local wetlands, matching the water requirements of these species with the water conditions of the soil or the frequency of overflowing of the stream (depending on the stream levels). The species planted could be : Indian pennywort (*Centella asiatica*), Urugaga (*Cyperus dives*), Urukanganga/Epiphytic flatsedge (*Cyperus latifolius*), Carolina dichondra (*Dichondra micrantha*), Ubwungo/Heartleaf drymary (*Drymaria cordata*), Urufunzo/Papyrus (*Cyperus papyrus*), Umuberanya/Southern Cattail (*Typha domingensis*), Carex mildbraediana, Urukirakenja/Jointed flatsedge (*Cyperus articulatus*), Umujangaja/winged sedge (*Cyperus denudatus*), Carolina dichondra (Dichondra micrantha), Urujenone (*Enhydra fluctuans*), Gutwikumwe/Floating pennywort (*Hydrocotyle ranunculoides*), Ubusuna/Common rush (*Juncus effusus*), Urukembagufa/Cut grass (*Leersia hexandra*), Ikirogora (*Brillantaisia cicatricosa*), Umuzigangore (*Ludwigia abyssinica*), Igorogonzo/Watersmart weed (*Persicaria decipiens*), Igorogonzo/Watersmart weed (*Persicaria pulchra*), Urutaretare/ (*Pycreus macrostachys*). In addition, on the banks, it will be possible to plant shrub or tree species, adapted to wetlands, in order to form a rypisilve along the stream. This will stabilize the banks and strengthen the ecological corridor. This riparian buffer will be created on one side of the stream only, in order to maintain sufficient light and facilitate stream maintenance. The plants must come from a local source, which is necessary both ecologically and economically: ecologically, because the plants present in a given territory necessarily have the appropriate genetics for that land and are therefore adapted to local conditions, and economically, because local actors are more in demand than foreign suppliers. The planting will take place in December, once the rainy season is over. For the herbaceous species, the clods will be installed in a hole made with a rototiller, a planter or a pickaxe and carefully positioned in the hole thus made. Before being planted, the plants will be soaked in water before being installed, then tamped into the soil. The plants in the cups will be distributed in patches at a rate of 2 plants per m². For trees and shrubs, plants shall be placed in a hole at least 40 cm deep and staked. All plants supplied by the landscaper must be of the species and variety requested, free of wounds and pest attacks. They shall be separated by destination compartment and species for ease of distribution and verification. Plants shall be replanted as soon as possible after delivery.
RU04 Surface : 23 800 m²	89 964 USD	2 - Medium-term 2035	
RU05 Surface : 119 900 m²	453 222 USD	1 - Short-term 2025	

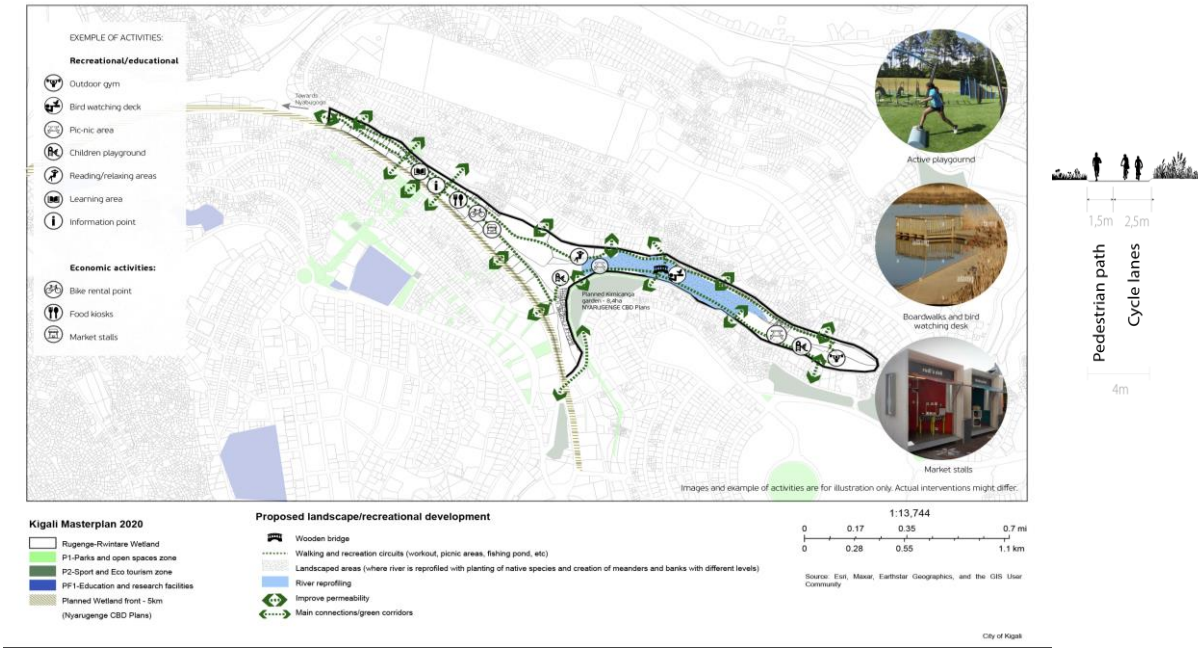
Comments	
Maintenance need	Annual management by mowing in August, before the rainy season. Maintenance of the rypisilve every year : removal of dead wood, pruning as needed, …
Management monitoring	Monitoring the evolution of the vegetation twice a year, during the dry seasons, by botanical expert, over 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30).

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

Action 10.RU	Name	Possible development of recreational activities: Creation of pedestrian/cycling circuits
	Action target	Landscape / Recreational activities
	Wetland	Rugenge-Rwintare

RUGENGE-RWINTARE WALKING AND RECREATION CIRCUITS



Characteristics	Rough cost estimate	Priority	Objectives
RUGENGE-RWINTARE WETLAND CENTRE			To create an attractive walking/cycling circuit that promotes awareness of natural habitats and an active lifestyle. Economic activities managed by private operators are included in the programme in order to contribute to the sustainability and durability of investments.
Package 1: Creation of walking/cycling circuits - Pedestrian/cycling circuits 4m wide (5km linear) - Benches every 500m (10x) - Accessible pedestrian bridge - Solar light poles - Planting of native species - Interpretation trail (natural habitat awareness signage)	**USD 87 750**	1 - Short-term 2025	
Package 2 : Economic activities (attracting private actors) - Bike rental kiosk - Picnic tables (10x) - Food kiosks (3x) - Toilets - Visitor information kiosk	**USD 48 465**	2 - Medium-term 2035	
Package 3 : Boosting attractiveness and quality of spaces - Water activities - Bird watching deck - Landscaped areas (planted with native species)	**USD 57 375**	3 - Long-term 2050	

Comments	See detailed plan provided in annex
Maintenance need	Annual for equipments and infrastructures and quarterly for green spaces with nature evolution
Management monitoring	Involvement of private operators for the day-to-day management of certain facilities (restaurant/cafe, bike rental kiosk, etc). Involvement of public players (site cleanliness, waste collection and management, etc.), to manage and enforce contracts, ensure coordination for the management of the site (internal regulations) and ensure security of the site

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

Action 11.RU	Name	Riprap at the outlet of urban discharge
	Action target	Flood control / Water filtration
	Wetland	Rugenge-Rwintare

Location (map) RU01 - RU06



Photos / examples





Characteristics	Rough cost estimate	Priority	Objectives
RU01 Number of riprap : 5 Volume : 250 m3	101 250 USD	2 - Medium-term 2035	This action consists of placing boulders just at the outlet of the urban drains, in order to break the incoming flow and improve the diffusion of water towards the downstream wetland and other hydraulic outlets. These riprap will be made of stones of size between 200 and 1000 mm, depending on the flow of water arriving and the speed of flow, so that they can ensure their anti-erosion role. For each riprap, it will be used stones of different dimensions so that the small stones occupy the empty spaces between the larger stones. They will be placed one on top of the other, so as to form a homogeneous entity and in phase with the width of the drains. The installation of the riprap will take place in dry periods, outside of rainy periods.
RU06 Number of riprap : 8 Volume : 400 m3	162 000 USD	1 - Short-term 2025	
Maintenance need	/		
Management monitoring	Visual inspection of riprap twice a year and removal of any waste or plant debris that may be present.		

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

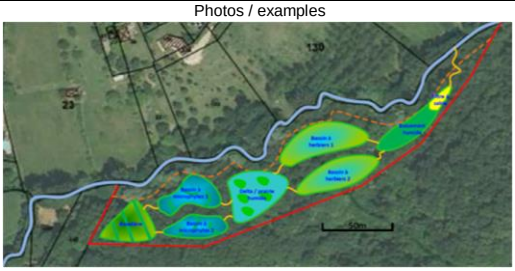
Action sheet

Action 12.RU	Name	Creation of a constructed wetland - buffer zone
	Action target	Biodiversity and Water Quality
	Wetland	Rugenge-Rwintare

Location (map) RU01 - RU06



Photos / examples









Characteristics	Rough cost estimate	Priority	Objectives
RU01 Total surface : 10 000 m²	249 750 USD	2 - Medium-term 2035	The design approach of the buffer wetland leaves an important part to the study of the contributing watershed in order to know precisely the characteristics of the incoming effluents and of the contributing watershed (flow rate, surface of the watershed, quality, frequency of feeding...). This ecological engineering project is based on different components such as hydraulics, purification, wetlands ecology and plant engineering. In summary, the creation of a wetland buffer zone is carried out in 3 stages - Feasibility study to identify the environmental issues and take them into account in the design: topographic surveys, soil studies, hydraulic studies of the watershed... - Design study including: execution plans of the wetland buffer zone compartments, ecological engineering design, hydraulic sizing of the works and integration of educational supports... - Works and follow-up of the construction site requiring the intervention of qualified partners for the realization of the civil engineering (earthworks to create the various compartments, the overflows...), ecological engineering (choice of materials, planting of the vegetable species...) and a qualified site manager. A safety margin of 0.30m (minimum difference between the highest water level and the top of the compartment crest) is provided for during periods of maximum compartment filling. To achieve this objective, overflows will be installed at the top of the compartment crest.
RU06 Surface : 1 200 m²	29 970 USD	1 - Short-term 2025	

Comments	"- The wetland buffer cannot be effective if it collects untreated wastewater. - Maximum depth of the compartments fixed at 1,20m
Maintenance need	Annual management by mowing in August, before the rainy season A wetland buffer reproduces, on a smaller scale, mechanisms that occur naturally in the natural environment. The evolution of the habitats and the sustainability of the objectives targeted by the wetland buffer (purification, biodiversity, education, etc.) are directly linked to the quality of its management from the moment it is put in water. The management of the buffer wetland leads to be vigilant on the following hydraulic phenomena - Creation of hydraulic plugs at the level of the hydraulic structures that can lead to overflows (loading of the system) and a reduction in the residence time. - Reduction of the residence time and the treatment capacity of the system by short-circuits and filling of the volume of the basins. - Risk of invasive plants or plant dieback. A management plan also has the following objectives - Ensure the cutting of plants with export of green waste - Maintain a high level of biodiversity in the water compartments by applying a differentiated vegetation management method. - To perpetuate the landscape quality of the site and its potential to welcome the public.
Management monitoring	Monitoring of the evolution of vegetation and hydraulics twice a year, during dry and rainy seasons, by an expert in ecological engineering, for 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30)

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

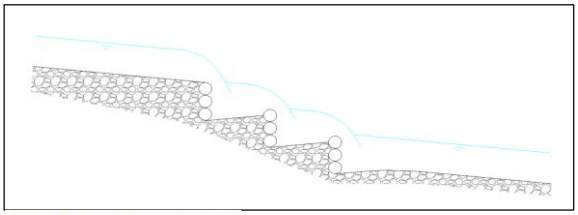
Action sheet

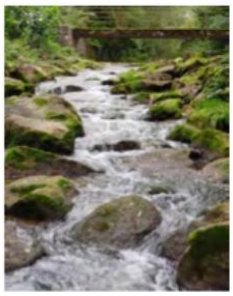
Action 13.RU	Name	Re-profiling of the hydraulic outlets from the discharge
	Action target	Water filtration, Biodiversity
	Wetland	Rugenge-Rwintare

Location (map) RU01 - RU06



Photos / examples







Characteristics	Rough cost estimate	Priority	Objectives
RU01: Riprap at the outlet with creation of different river bed ground level over 300 m	18 833 USD	2 - Medium-term 2035	- limit erosion - enhance biodiversity with diversification of natural habitats
RU06: Riprap at the outlet with creation of different river bed ground level over 500 m	30 375 USD	1 - Short-term 2025	

Comments	
Maintenance need	- Maintenance of the outlets (provent from solid waste accumulation): twice per year (including one before the rainy season) - Other needs to be defined according to the management monitoring report
Management monitoring	The work will be the subject of a technical file of the works carried out with the plans of the built installations. A follow-up of the profile of the restored banks and the minor bed will be carried out 6 months after the end of the work and then the year that follows. The frequency will be adapted according to the possible disorders observed and the results of this follow-up. On the basis of the technical file, the following will be identified - Possible movements, departures or contributions of blocks; - All possible traces of erosion, scouring on the resumed zones as well as on the transition zones and the zones peripheral to the development not impacted by the works. All the elements of this follow-up will be recorded in a report. In conclusion, recommendations will be made on possible rework, the frequency of monitoring, and on future developments.

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

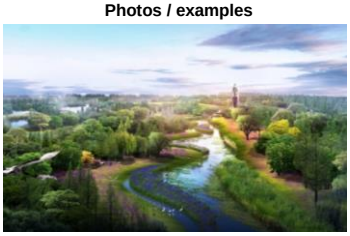
Action sheet

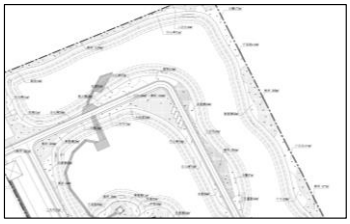
Action 18-RU	Name	Creation of a depression disconnected from the river
	Action target	Biodiversity and Water Quality
	Wetland	Rugenge-Rwintare

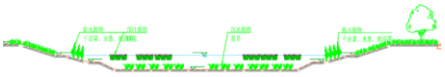
Location (map) RU2



Photos / examples







Characteristics	Rough cost estimate	Priority	Objectives
RU02 Half of the total area developed for the creation of depressions Surface : 18 000 m²	98 010 USD	2 - Medium-term 2035	Before carrying out the earthworks, a design study phase will be necessary to refine the works to be carried out. These studies will make it possible to respect the following principles: - The arrival of water from urban drains must be accompanied by riprap to limit erosion in the depression; - The "project elevation" (longitudinal profile) must be determined on the basis of a good knowledge of the level of the river and of the water table (and its variations); - The slopes of the banks must be as low as possible; - The arm/depression can be materialized by multiple basins; - The recreation will not be uniform; - Excessive excavation may result in lowering of the water table (drainage). It can also cause a pollution of the water table by feeding with water of bad quality. These earthworks will have for objective to respect the criteria specified above. The use of mechanical shovel, bulldozer is necessary. The work must be carried out in such a way as to limit the compaction of the land: use machines with good bearing capacity ("marsh" shovels), avoid driving with the machines on the talweg, decompact the soil at the end of the work... The period of execution of the work is largely conditioned by hydraulic constraints (low water). It is important to underline the importance of the quality of the company and the project management in this type of work. It is advisable to choose companies that have already carried out this type of work, and to provide for very regular monitoring of the site by an ecologist. A safety margin of 0.30 m (minimum difference between the highest water level and the top of the compartment crest) is provided for during the period of maximum compartment filling. To achieve this objective, weirs will be installed at the top of the compartment crest.
RU02 Half of the total area developed for the creation of depressions Surface : 37 000 m²	198 990 USD	3 - Long-term 2050	

Comments	"- The depression cannot be effective if it collects untreated wastewater. - Maximum depth of the compartments fixed at 1,20m
Maintenance need	Annual management by mowing in August, before the rainy season The management of depression to be vigilant on the following hydraulic phenomena - Creation of hydraulic plugs at the level of hydraulic structures that can lead to overflows (loading of the system) and a reduction in residence time. - Reduction of the residence time and the treatment capacity of the system by short circuits and the filling of the volume of the basins. - Risk of invasive plants or plant dieback. A management plan also aims to - Ensure the cutting of plants with export of green waste - Maintain a high level of biodiversity in the water compartments by applying a differentiated vegetation management method. - Perpetuate the landscape quality of the site and its potential to welcome the public.
Management monitoring	Monitoring of the evolution of vegetation and hydraulics twice a year, during dry and rainy seasons, by an expert in ecological engineering, for 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30)

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

Action 19-RU	Name	Diversification of natural habitats typical of wetlands
	Action target	Biodiversity
	Wetland	Rugenge-Rwintare

Location (map) RU02



Photos / examples







Characteristics	Rough cost estimate	Priority	Objectives
RU02 Half of the total area developed for the creation of depressions. Therefore, the area to be vegetated is the same. Surface : 55 000 m²	117 612 USD	2 - Medium-term 2035	This action aims at recovering a herbaceous cover composed of a flora characteristic of wetlands and typical of Rwandan wetlands on all the depressions up to the banks. To do this, the first step consists in preparing the soil, with decompacting the soil in place on the first 15 centimeters to reactivate the seed bank and promote rooting. The second step is to plant native species typical of local wetlands, matching the water needs of these species with the water conditions of the soil. Indeed, in order to accelerate the vegetation, it will be interesting to plant semi-aquatic and aquatic plants: sedges, reeds...In time, the planted plants will be more or less completed/replaced progressively by species spontaneously colonizing the site. The zones regularly in water will generally be well colonized by natural vegetation; it is thus little useful to sow them. This will involve proposing an adapted plant life with the following plant species: Centella asiatica (Centella asiatica), Urugaga (Cyperus dives), Urukanganga/Cyperus latifolius (Cyperus latifolius), Carolina Dichondra (Dichondra micrantha), Ubwungo/ Drymaria cordata (Drymaria cordata), Urufunzo/Papyrus (Cyperus papyrus), Umuberanya/Southern cattail (Typha domingensis), Carex mildbraediana, Urukirakenja/Cyperus articulatus, Umujangaja/Cyperus denudatus, Dichondra Carolina (Dichondra micrantha), Urujenone (Enhydra fluctuans), Gutwikumwe/ Hydrocotyle ranunculoides, Ubusuna/ Common rush (Juncus effusus), Urukembagufa/ Cutting grass (Leersia hexandra), Ikirogora (Brillantaisia cicatricosa), Umuzigangore (Ludwigia abyssinica), Igorogonzo/Water weed (Persicaria decipiens), Igorogonzo/Water weed (Persicaria pulchra), Urutaretare/

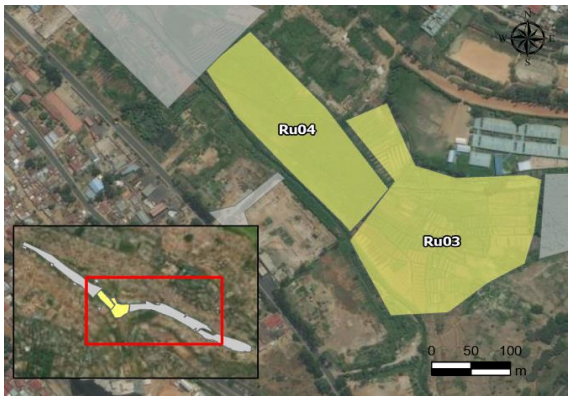
Comments	"- Developments must be carried out outside of rainy periods to avoid soil compaction and degradation caused by erosion (uprooting of plantations, seeds washed away by runoff...) - It is imperative to carry out the revegetation as soon as the earthworks are completed at the favourable period in order to avoid the proliferation of invasive species invasive species and erosion by runoff
Maintenance need	"- Annual management by mowing in August, before the rainy season - Ensure the cutting of plants with export of green waste
Management monitoring	Monitoring the evolution of the vegetation twice a year, during the dry seasons, by botanical expert, over 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30).

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

Action 20-RU	Name	Stream protection zone with a vegetated riparian buffer
	Action target	Biodiversity and Water Quality
	Wetland	Rugenge-Rwintare

Location (map) RU03 - RU04



Photos / examples







Characteristics	Rough cost estimate	Priority	Objectives
RU03 Vegetated buffer strip of approximately 25m wide on each side of the watercourse	24 300 USD	1 - Short-term 2025	In order to limit the transfer of pollutants to the watercourse via runoff, vegetated buffer strips are positioned between agricultural plots and the watercourse network. In this action sheet, a vegetated buffer strip is defined as any vegetated surface that intercepts diffuse or concentrated surface runoff and therefore reduces the transfer of pollutants and/or sediments. These vegetated buffer strips are translated as grassy strips, permanent grasslands, fallow land, hedges, woods or copses. Their implementation requires : - Tillage to level and decompact the land; - Revegetation, which is either seeding of grassland or planting of shrubs/trees; - A choice of local plant species. This vegetated buffer strip, whose width will have to be refined according to the intercepted watershed, will also be a support for the migration of animal species.
RU04 Vegetated buffer strip of approximately 25m wide on each side of the watercourse	10 665 USD	2 - Medium-term 2035	

Comments	Developments must be carried out outside of rainy periods to avoid soil compaction and degradation caused by erosion (uprooting of plantations, seeds washed away by runoff...)
Maintenance need	Annual management by mowing in August, before the rainy season
Management monitoring	Monitoring the evolution of the vegetation twice a year, during the dry seasons, by botanical expert, over 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30).

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

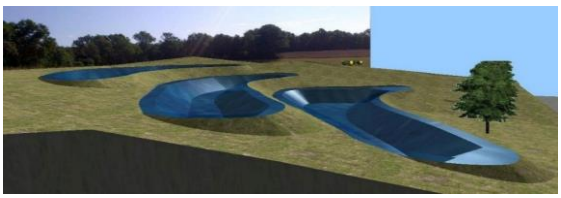
Action sheet

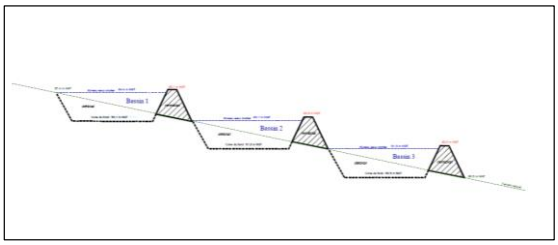
Action 21.RU	Name	Natural weirs in cascade
	Action target	Flood control / Water filtration
	Wetland	Rugenge-Rwintare

Location (map) RU07



Photos / examples





Characteristics	Rough cost estimate	Priority	Objectives
RU07 A quarter of the surface was considered for this action Surface : 2 ha	599 400 USD	1 - Short-term 2025	This action consists of creating cascading water retention areas along the flow axis of the hydraulic outfalls. These retention areas will be in the form of basins, with a water surface area of less than 500 m² and a maximum depth of 1.5 m. Before carrying out the earthworks, a design study phase will be necessary to refine the works to be carried out. The basins will be positioned in such a way that the first basin is fed directly by the upstream water (arrival of water), then the others fed successively by overflow of the previous one. Once the water has passed into the last basin, the water will then be directed towards the wetland. Each basin will have a dike to maintain a water level before overflowing to the downstream basin to ensure their watertightness and the dikes will be anchored to the compact and impermeable substratum. They will therefore be made with waterproof materials (clay, etc.) and then recharged with a layer of topsoil to encourage vegetation. The basins will be positioned according to the topography of the sector, but it will be important that the banks are gently sloping (20%) to promote the development of a hygrophilic plant cover and the reception of fauna (amphibians, insects, ..). A safety margin of 0.30m (minimum difference between the highest water level and the top of the basins crest) iwill be provided for during periods of maximum basins filling. To achieve this objective, overflows will be installed at the top of the basins crest. The work will have to be carried out in dry periods and avoid rainy periods.

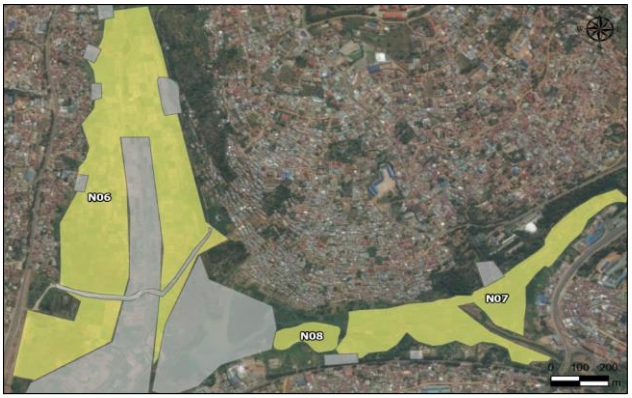
Comments	The basins cannot be effective if it collects untreated wastewater.
Maintenance need	Cleaning of the ponds every 5 years, during the dry season. Removal of floating materials (waste, plant debris) in the ponds. It will also be necessary to be vigilant about the appearance of any invasive plant species or plant dieback. A management plan also aims at - Ensure the cutting of plants with export of green waste - Maintain a high level of biodiversity in the water compartments by applying a differentiated vegetation management method - To perpetuate the landscape quality of the site and its potential to welcome the public.
Management monitoring	Monitoring of the evolution of vegetation and hydraulics twice a year, during dry and rainy seasons, by an expert in ecological engineering, for 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30).

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

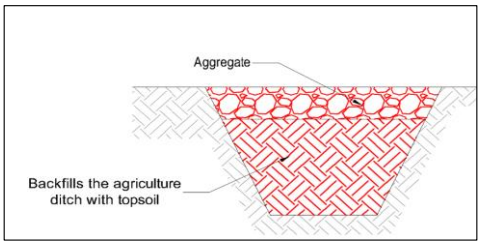
Action 5.N	Name	Blocking of surface and subsurface drains
	Action target	Water filtration, Biodiversity
	Wetland	Nyabugogo

Location (map) N06 - N07 - N08



Photos / examples





Characteristics	Rough cost estimate	Priority	Objectives
N06: backfill the agricultural drains with approximately 22 000 m3	279,450 USD	2 - Medium-term 2035	- Limit the lowering of the groundwater - Increase the residence time of the water in the wetland - Homogenise the wetland ground - Enhance the storage capacity of the wetland - Reduce the water quantity and velocity downstream
N07: backfill the agricultural drains with approximately 20 000 m3	51,891 USD	1 - Short-term 2025	
N08: backfill the agricultural drains with approximately 1 12 000 m3	6,683 USD	1 - Short-term 2025	

Comments	
Maintenance need	No needs
Management monitoring	No needs

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

Action 6.N	Name	Planting of native plant species adapted to the wetland environment
	Action target	Biodiversity
	Wetland	Nyabugogo

Location (map) N06- N07



Photos / examples



Characteristics	Rough cost estimate	Priority	Objectives
N06 Surface : 404 800 m²	1,530,144 USD	2 - Medium-term 2035	This action aims at recovering a herbaceous cover on all these surfaces, composed of a characteristic flora of wetlands and typical of Rwandan wetlands. For that, the first step consists in a preparation of the ground, with a decompacting of the ground in place on the first 15 centimeters in order to reactivate the seed bank and to support the rooting. The second step consists of planting with native species typical of local wetlands, such as Indian pennywort (*Centella asiatica*), Urugaga *(Cyperus dives*), Urukanganga/Epiphytic flatsedge (*Cyperus latifolius*), Carolina dichondra (*Dichondra micrantha*), Ubwungo/Heartleaf drymary (*Drymaria cordata*), Urufunzo/Papyrus (*Cyperus papyrus*), Umuberanya/Southern Cattail (*Typha domingensis*), Carex mildbraediana, Urukirakenja/Jointed flatsedge (*Cyperus articulatus*), Umujangaja/winged sedge *(Cyperus denudatus*), Carolina dichondra (*Dichondra micrantha*), Urujenone (*Enhydra fluctuans*), Gutwikumwe/Floating pennywort (*Hydrocotyle ranunculoides*), Ubusuna/Common rush (*Juncus effusus*), Urukembagufa/Cut grass (*Leersia hexandra*), Ikirogora (*Brillantaisia cicatricosa*), Umuzigangore (*Ludwigia abyssinica*), Igorogonzo/Watersmart weed (*Persicaria decipiens*), Igorogonzo/Watersmart weed (*Persicaria pulchra)*, Urutaretare/ (*Pycreus macrostachys*). The plantings will aim to adapt the location of the species according to their need for water and the water conditions of the soil, in order to favour their development. The seedlings must come from a local source, which is necessary both ecologically and economically: ecologically, because the plants present in a given territory necessarily have the appropriate genetics for that land and are therefore adapted to local conditions, and economically, because local actors are more in demand than foreign suppliers. The planting will take place in December, once the rainy season is over. The clods will be installed in a hole made with a tiller, a planter or a pickaxe and carefully positioned in the hole thus made. Before planting, the plants will be soaked in water before installation and then packed in the soil. The plants in cups will be distributed by spots at a rate of 2 plants per m². All plants supplied by the landscaper shall be of the species and variety requested, free of wounds and pest attacks. They shall be separated by destination compartment and by species to facilitate distribution and verification. The plants must be replanted as soon as possible after delivery.
N07 Surface : 148 900 m²	422,132 USD	2 - Medium-term 2035	

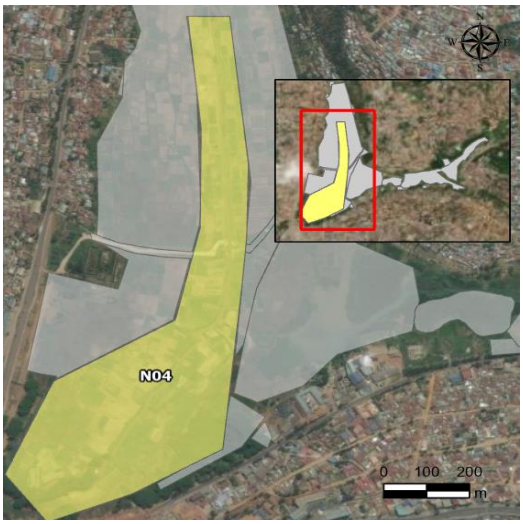
Comments	
Maintenance need	Annual management by mowing in August, before the rainy season.
Management monitoring	Monitoring the evolution of the vegetation twice a year, during the dry seasons, by botanical expert, over 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30).

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

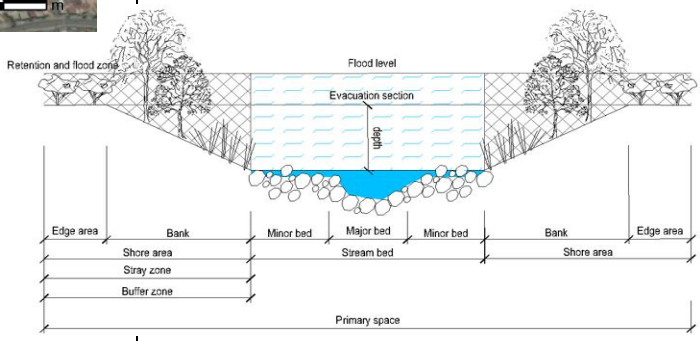
Action 7.N	Name	Re-profiling of the river with the creation of meanders and banks with different levels
	Action target	Water filtration, Biodiversity
	Wetland	Nyabugogo

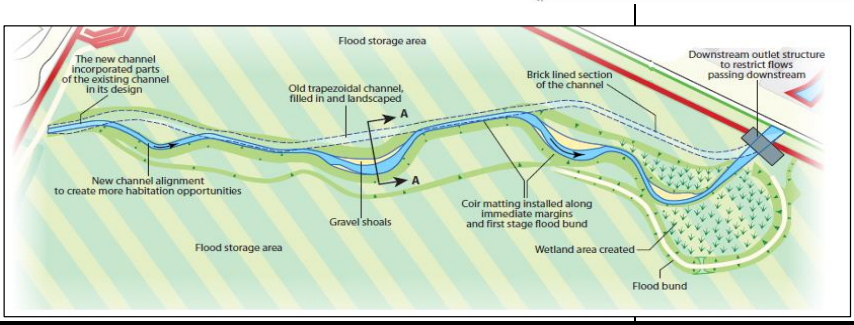
Location (map) N04



Photos / examples







Characteristics	Rough cost estimate	Priority	Objectives
N04 : Creation of meander and banks along 1 600 m	1,989,056 USD	1 - Short-term 2025	- Improve the water quality and decrease the water quantity flowing downstream (slowing the flow) - Improve the biodiversity - Promote recreational area
N04 : Creation of meander and banks along 1 600 m	1,989,056 USD	3 - Long-term 2050	
Comments			
Maintenance need	Needs to be defined according to the monitoring management report		

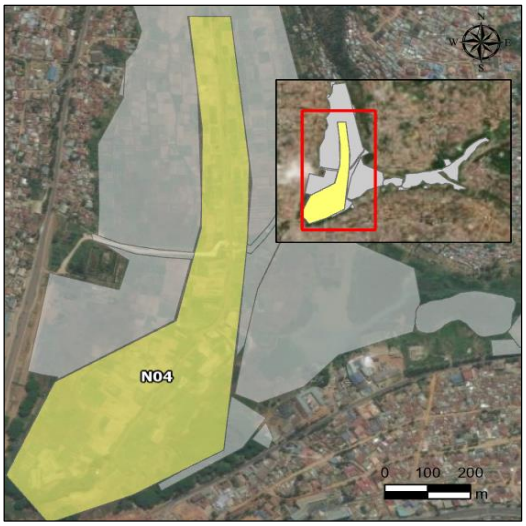
Management monitoring	The work will be the subject of a technical file of the works carried out with the plans of the built installations. A follow-up of the profile of the restored banks and the minor bed will be carried out 6 months after the end of the work and then the year that follows. The frequency will be adapted according to the possible disorders observed and the results of this follow-up. On the basis of the technical file, the following will be identified - Possible movements, departures or contributions of blocks; - All possible traces of erosion, scouring on the resumed zones as well as on the transition zones and the zones peripheral to the development not impacted by the works. All the elements of this follow-up will be recorded in a report. In conclusion, recommendations will be made on possible rework, the frequency of monitoring, and on future developments.

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

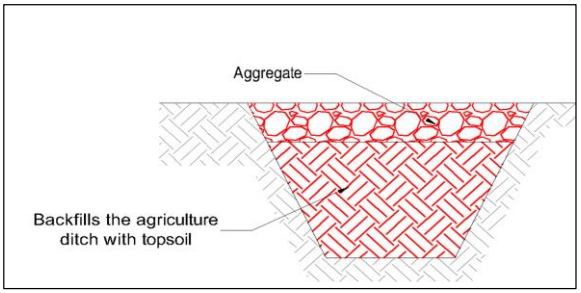
Action 8.N	Name	Recharge of the river bed with aggregate
	Action target	Water filtration, Biodiversity
	Wetland	Nyabugogo

Location (map) N04



Photos / examples





Characteristics	Rough cost estimate	Priority	Objectives
N04: filling the watercourse with aggregates of different diameter and topsoil	883,224 USD	1 - Short-term 2025	

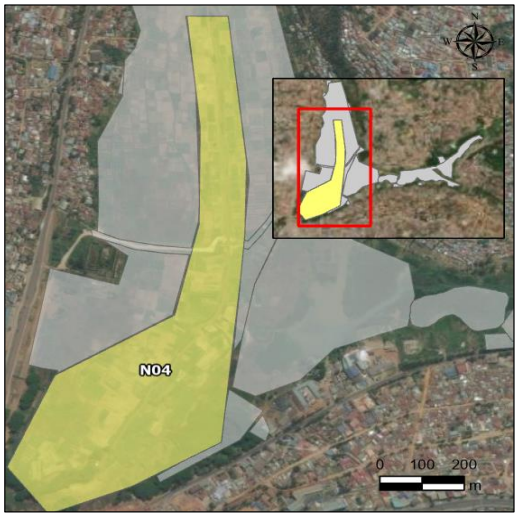
Comments	
Maintenance need	Needs to be defined according to the monitoring management report
Management monitoring	The work will be the subject of a technical file of the works carried out with the plans of the built installations. A follow-up of the profile of the restored banks and the minor bed will be carried out 6 months after the end of the work and then the year that follows. The frequency will be adapted according to the possible disorders observed and the results of this follow-up. On the basis of the technical file, the following will be identified - Possible movements, departures or contributions of blocks; - All possible traces of erosion, scouring on the resumed zones as well as on the transition zones and the zones peripheral to the development not impacted by the works. All the elements of this follow-up will be recorded in a report. In conclusion, recommendations will be made on possible rework, the frequency of monitoring, and on future developments.

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

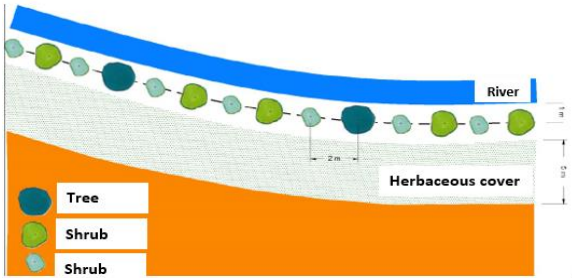
Action sheet

Action 9.N	Name	Planting the banks with native plant species
	Action target	Biodiversity
	Wetland	Nyabugogo

Location (map) N04



Photos / examples





Characteristics	Rough cost estimate	Priority	Objectives
N04 Surface : 260 400 m²	984,312 USD	2 - Medium-term 2035	This action aims at recovering a herbaceous cover composed of a flora characteristic of wetlands and typical of Rwandan wetlands on all the banks and edges of the main rivers. To do this, the first step consists of soil preparation, with decompaction of the soil in place on the first 15 centimeters to reactivate the seed bank and promote rooting. The second step consists of planting native species typical of local wetlands, matching the water requirements of these species with the water conditions of the soil or the frequency of overflowing of the stream (depending on the stream levels). The species planted could be : Indian pennywort (*Centella asiatica*), Urugaga (*Cyperus dives*), Urukanganga/Epiphytic flatsedge (*Cyperus latifolius*), Carolina dichondra (*Dichondra micrantha*), Ubwungo/Heartleaf drymary (*Drymaria cordata*), Urufunzo/Papyrus (*Cyperus papyrus*), Umuberanya/Southern Cattail (*Typha domingensis*), Carex mildbraediana, Urukirakenja/Jointed flatsedge (*Cyperus articulatus*), Umujangaja/winged sedge (*Cyperus denudatus*), Carolina dichondra (Dichondra micrantha), Urujenone (*Enhydra fluctuans*), Gutwikumwe/Floating pennywort (*Hydrocotyle ranunculoides*), Ubusuna/Common rush (*Juncus effusus*), Urukembagufa/Cut grass (*Leersia hexandra*), Ikirogora (*Brillantaisia cicatricosa*), Umuzigangore (*Ludwigia abyssinica*), Igorogonzo/Watersmart weed (*Persicaria decipiens*), Igorogonzo/Watersmart weed (*Persicaria pulchra*), Urutaretare/ (*Pycreus macrostachys*). In addition, on the banks, it will be possible to plant shrub or tree species, adapted to wetlands, in order to form a rypisilve along the stream. This

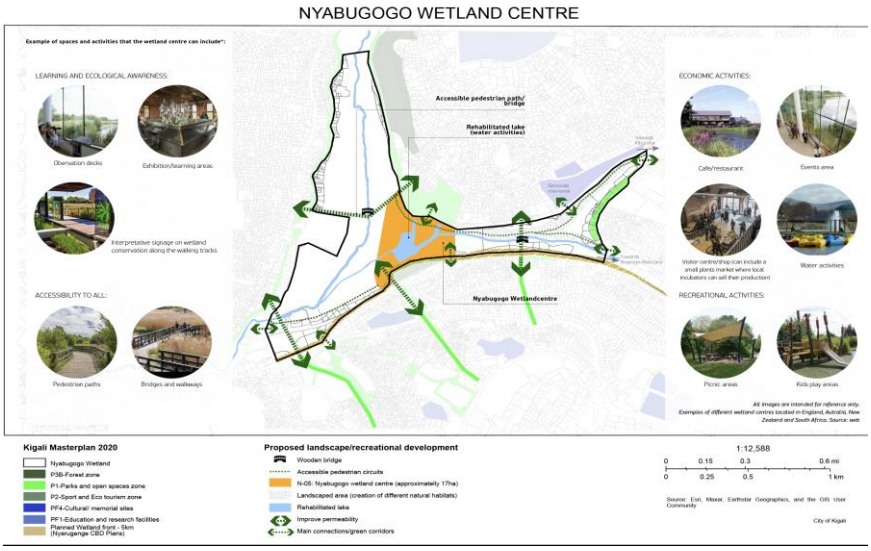
			will stabilize the banks and strengthen the ecological corridor. This riparian buffer will be created on one side of the stream only, in order to maintain sufficient light and facilitate stream maintenance. The plants must come from a local source, which is necessary both ecologically and economically: ecologically, because the plants present in a given territory necessarily have the appropriate genetics for that land and are therefore adapted to local conditions, and economically, because local actors are more in demand than foreign suppliers. The planting will take place in December, once the rainy season is over. For the herbaceous species, the clods will be installed in a hole made with a rototiller, a planter or a pickaxe and carefully positioned in the hole thus made. Before being planted, the plants will be soaked in water before being installed, then tamped into the soil. The plants in the cups will be distributed in patches at a rate of 2 plants per m^2. For trees and shrubs, plants shall be placed in a hole at least 40 cm deep and staked. All plants supplied by the landscaper must be of the species and variety requested, free of wounds and pest attacks. They shall be separated by destination compartment and species for ease of distribution and verification. Plants shall be replanted as soon as possible after delivery.
Comments			
Maintenance need	Annual management by mowing in August, before the rainy season. Maintenance of the rypisilve every year : removal of dead wood, pruning as needed, …		
Management monitoring	Monitoring the evolution of the vegetation twice a year, during the dry seasons, by botanical expert, over 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30).		

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

Action 10.N	Name	Possible development of recreational activities: Nyabugogo Wetland Centre
	Action target	Landscape / Recreational activities
	Wetland	Nyabugogo

Location / photos examples







Characteristics	Rough cost estimate	Priority	Objectives
N05 : NYABUGOGO WETLAND CENTRE			To create an attractive wetland centre with multiple uses: nature preservation, walking, food, etc. Economic activities managed by private operators are included in the programme in order to contribute to the sustainability and durability of investments.
Package 1 - Allowing access and delimitating spaces: - Pedestrian/cycling circuits 4m wide (3km linear) - Benches every 500m (10x) - Accessible pedestrian bridge - Solar light poles every 20m (150x) - Planting of native species (3km linear) - Interpretation trail (natural habitat awareness signage)	5,400 USD	1 - Short-term 2025	
Package 2 : Economic activities (attracting private actors) - Playgrounds (3x) - Cafe/restaurant - Events /market hall - Visitor centre point with gift shop - Toilets - Lighting - Bike rental kiosk - Picnic tables	86,940 USD	2 - Medium-term 2035	
Package 3 : Boosting attractiveness and quality of spaces - Water activities - Bird watching decks (2x) - Outdoor gym circuits (5x) - Landscaped areas (1000m2 planted with native species)	62,775 USD	3 - Long-term 2050	

Comments	See detailed plan provided in annex
Maintenance need	Annual for equipments and infrastructures and quarterly for green spaces with nature evolution
Management monitoring	Involvement of private operators for the day-to-day management of certain facilities (restaurant/cafe, bike rental kiosk, etc). Involvement of public players (site cleanliness, waste collection and management, etc.), to manage and enforce contracts, ensure coordination for the management of the site (internal regulations) and ensure security of the site

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

Action 11.N	Name	Riprap at the outlet of urban discharge
	Action target	Flood control / Water filtration
	Wetland	Nyabugogo

Location (map) N01 - N02 - N03



Photos / examples





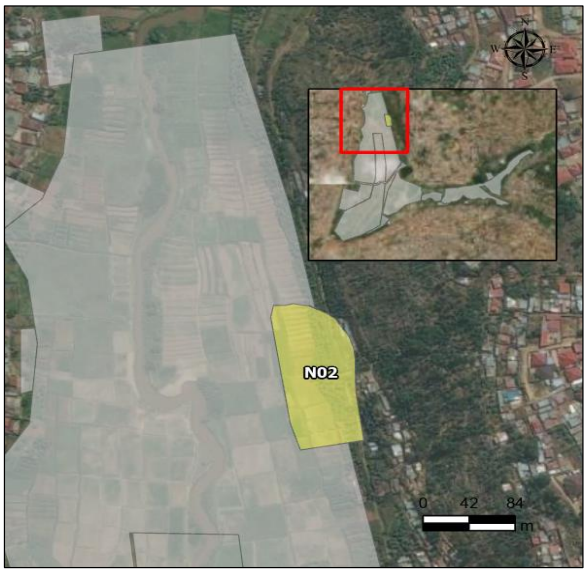
Characteristics	Rough cost estimate	Priority	Objectives
N01 Number of riprap : 4 Volume : 200 m3	81,000 USD	1 - Short-term 2025	This action consists of placing boulders just at the outlet of the urban drains, in order to break the incoming flow and improve the diffusion of water towards the downstream wetland and other hydraulic outlets. These riprap will be made of stones of size between 200 and 1000 mm, depending on the flow of water arriving and the speed of flow, so that they can ensure their anti-erosion role. For each riprap, it will be used stones of different dimensions so that the small stones occupy the empty spaces between the larger stones. They will be placed one on top of the other, so as to form a homogeneous entity and in phase with the width of the drains. The installation of the riprap will take place in dry periods, outside of rainy periods.
N02 Number of riprap : 1 Volume : 50 m3	20,250 USD	1 - Short-term 2025	
N03 Number of riprap : 5 Volume : 250 m3	101,250 USD	1 - Short-term 2025	
Maintenance need	/		
Management monitoring	Visual inspection of riprap twice a year and removal of any waste or plant debris that may be present.		

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

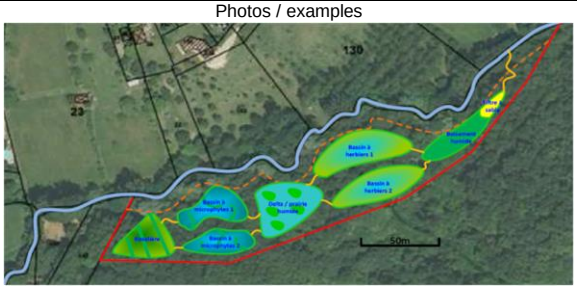
Action sheet

Action 12-N	Name	Creation of a constructed wetland - buffer zone
	Action target	Biodiversity and Water Quality
	Wetland	Nyabugogo

Location (map) N02



Photos / examples









Characteristics	Rough cost estimate	Priority	Objectives
N 02 Total surface : 9 000 m²	224,775 USD	1 - Short-term 2025	The design approach of the buffer wetland leaves an important part to the study of the contributing watershed in order to know precisely the characteristics of the incoming effluents and of the contributing watershed (flow rate, surface of the watershed, quality, frequency of feeding...). This ecological engineering project is based on different components such as hydraulics, purification, wetlands ecology and plant engineering. In summary, the creation of a wetland buffer zone is carried out in 3 stages - Feasibility study to identify the environmental issues and take them into account in the design: topographic surveys, soil studies, hydraulic studies of the watershed... - Design study including: execution plans of the wetland buffer zone compartments, ecological engineering design, hydraulic sizing of the works and integration of educational supports... - Works and follow-up of the construction site requiring the intervention of qualified partners for the realization of the civil engineering (earthworks to create the various compartments, the overflows...), ecological engineering (choice of materials, planting of the vegetable species...) and a qualified site manager. A safety margin of 0.30m (minimum difference between the highest water level and the top of the compartment crest) is provided for during periods of maximum compartment filling. To achieve this objective, overflows will be installed at the top of the compartment crest.

Comments	"- The wetland buffer cannot be effective if it collects untreated wastewater. - Maximum depth of the compartments fixed at 1,20m

Maintenance need	Annual management by mowing in August, before the rainy season A wetland buffer reproduces, on a smaller scale, mechanisms that occur naturally in the natural environment. The evolution of the habitats and the sustainability of the objectives targeted by the wetland buffer (purification, biodiversity, education, etc.) are directly linked to the quality of its management from the moment it is put in water. The management of the buffer wetland leads to be vigilant on the following hydraulic phenomena - Creation of hydraulic plugs at the level of the hydraulic structures that can lead to overflows (loading of the system) and a reduction in the residence time. - Reduction of the residence time and the treatment capacity of the system by short-circuits and filling of the volume of the basins. - Risk of invasive plants or plant dieback. A management plan also has the following objectives - Ensure the cutting of plants with export of green waste - Maintain a high level of biodiversity in the water compartments by applying a differentiated vegetation management method. - To perpetuate the landscape quality of the site and its potential to welcome the public.
Management monitoring	Monitoring of the evolution of vegetation and hydraulics twice a year, during dry and rainy seasons, by an expert in ecological engineering, for 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30)

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

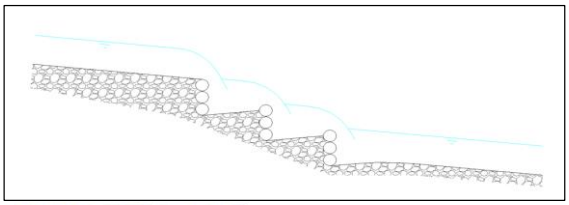
Action sheet

Action 13.N	Name	Re-profiling of the hydraulic outlets from the discharge
	Action target	Water filtration, Biodiversity
	Wetland	Nyabugogo

Location (map) N03



Photos / examples







Characteristics	Rough cost estimate	Priority	Objectives
N03: Riprap at the outlet with creation of different river bed ground level over 350 m	19,440 USD	1 - Short-term 2025	

Comments	
Maintenance need	- Maintenance of the outlets (provent from solid waste accumulation): twice per year (including one before the rainy season) - Other needs to be defined according to the management monitoring report
Management monitoring	The work will be the subject of a technical file of the works carried out with the plans of the built installations. A follow-up of the profile of the restored banks and the minor bed will be carried out 6 months after the end of the work and then the year that follows. The frequency will be adapted according to the possible disorders observed and the results of this follow-up. On the basis of the technical file, the following will be identified - Possible movements, departures or contributions of blocks; - All possible traces of erosion, scouring on the resumed zones as well as on the transition zones and the zones peripheral to the development not impacted by the works. All the elements of this follow-up will be recorded in a report. In conclusion, recommendations will be made on possible rework, the frequency of monitoring, and on future developments.

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

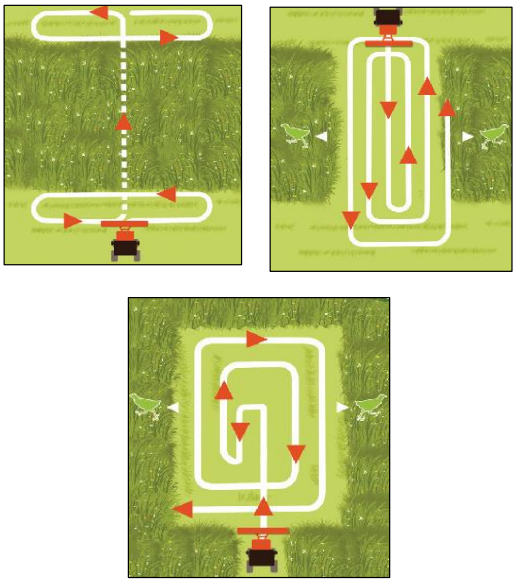
Action sheet

Action 14.N	Name	Differentiated management according to natural habitats
	Action target	Biodiversity
	Wetland	Nyabugogo

Location (map) N08 - N09



Photos / examples



Characteristics	Rough cost estimate	Priority	Objectives
N08 Surface : 19 500 m²	31,590 USD	1 - Short-term 2025	Herbaceous habitats will be managed by annual mowing. Mowing will be mechanized or manual, in dry periods to facilitate access, promote reseeding and limit impacts on wildlife. They will be carried out at a minimum height of 10 cm, and centrifugal so as to push the fauna towards the refuge zones of the non mowed sectors (in accordance with the mowing principle illustrated in the diagrams above). The refuge zones, corresponding to the non mowed areas, will represent approximately 5% of the mowed surface. The speed of the self-propelled mowing machines will be moderate to allow time for insects and other fauna to move. Mowing residues will be systematically exported to limit soil eutrophication and the development of nitrophilic vegetation.
N09 Surface :11 900 m²	19,278 USD	1 - Short-term 2025	For low herbaceous formations, management by grazing as an alternative to differentiated mowing may be considered, if there is an opportunity for a territorial agricultural project in the medium to long term. The necessary conditions are: sufficiently dry soil, a grazing period limited to about 3 months and a stocking rate limited to 0.5 to 0.8 LU per hectare. Eco-grazing can be implemented after an initial period of management by mowing to establish the cover. Chemical weeding and the use of phytosanitary products is prohibited. As for the shrub and tree environments, management consists of selective clearing and removal of the shoots of any invasive species by manual or mechanical removal of the feet (with export).

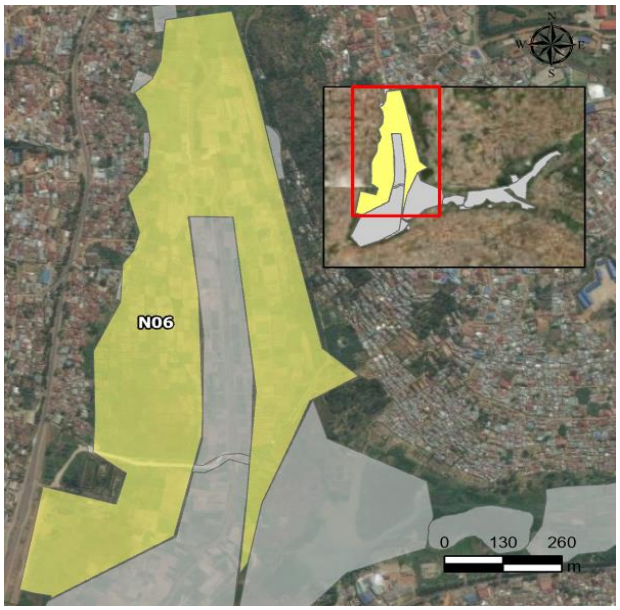
Comments	
Maintenance need	/
Management monitoring	Annual botanical monitoring, during the dry seasons, by botanical expert, over 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30) to identify the development and evolution of plant formations, in order to adapt the objectives and methods of maintenance, in particular the frequency of mowing, and to perpetuate the most suitable hygrophilous formations.

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

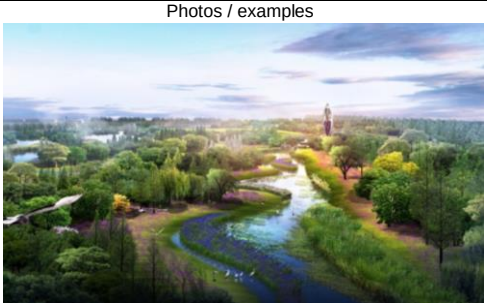
Action sheet

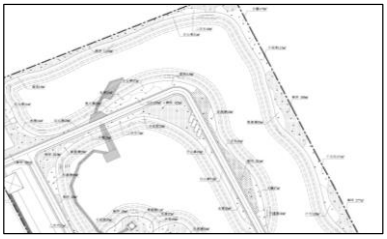
Action 18.N	Name	Creation of a depression disconnected from the river
	Action target	Biodiversity and Water Quality
	Wetland	Nyabugogo

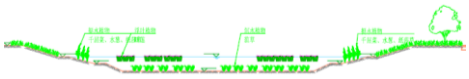
Location (map) N06



Photos / examples







Characteristics	Rough cost estimate	Priority	Objectives
N06 One quarter of the total area developed for the creation of depressions Surface : 100 000 m²	540,000 USD	2 - Medium-term 2035	Before carrying out the earthworks, a design study phase will be necessary to refine the works to be carried out. These studies will make it possible to respect the following principles: - The arrival of water from urban drains must be accompanied by riprap to limit erosion in the depression; - The "project elevation" (longitudinal profile) must be determined on the basis of a good knowledge of the level of the river and of the water table (and its variations); - The slopes of the banks must be as low as possible; - The arm/depression can be materialized by multiple basins; - The recreation will not be uniform; - Excessive excavation may result in lowering of the water table (drainage). It can also cause a pollution of the water table by feeding with water of bad quality. These earthworks will have for objective to respect the criteria specified above. The use of mechanical shovel, bulldozer is necessary. The work must be carried out in such a way as to limit the compaction of the land: use machines with good bearing capacity ("marsh" shovels), avoid driving with the machines on the talweg, decompact the soil at the end of the work... The period of execution of the work is largely conditioned by hydraulic constraints (low water). It is important to underline the importance of the quality of the company and the project management in this type of work. It is advisable to choose companies that have already carried out this type of work, and to provide for very regular monitoring of the site by an ecologist. A safety margin of 0.30 m (minimum difference between the highest water level and the top of the compartment crest) is

Comments	"- The depression cannot be effective if it collects untreated wastewater. - Maximum depth of the compartments fixed at 1,20m
Maintenance need	Annual management by mowing in August, before the rainy season The management of depression to be vigilant on the following hydraulic phenomena - Creation of hydraulic plugs at the level of hydraulic structures that can lead to overflows (loading of the system) and a reduction in residence time. - Reduction of the residence time and the treatment capacity of the system by short circuits and the filling of the volume of the basins. - Risk of invasive plants or plant dieback. A management plan also aims to - Ensure the cutting of plants with export of green waste - Maintain a high level of biodiversity in the water compartments by applying a differentiated vegetation management method. - Perpetuate the landscape quality of the site and its potential to welcome the public.

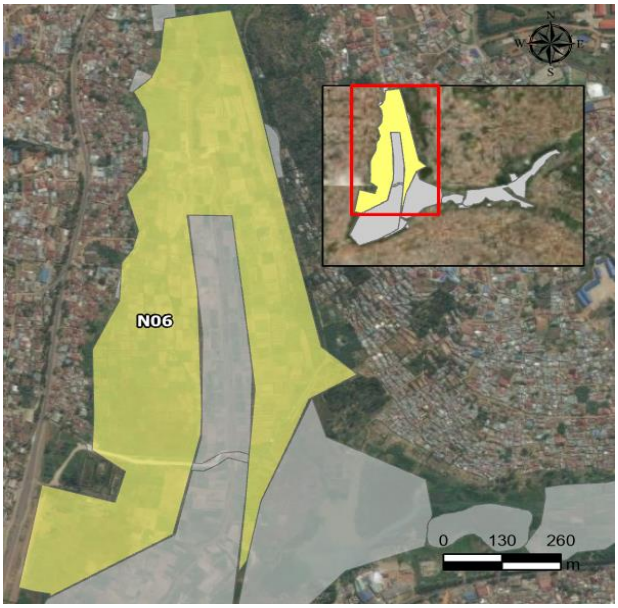
Management monitoring	Monitoring of the evolution of vegetation and hydraulics twice a year, during dry and rainy seasons, by an expert in ecological engineering, for 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30)

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

Action 19-N	Name	Diversification of natural habitats typical of wetlands
	Action target	Biodiversity
	Wetland	Nyabugogo

Location (map) N06



Photos / examples







Characteristics	Rough cost estimate	Priority	Objectives
N06 One quarter of the total area developed for the creation of depressions. Therefore, the area to be vegetated is the same. Surface : 100 000 m²	648,000 USD	2 - Medium-term 2035	This action aims at recovering a herbaceous cover composed of a flora characteristic of wetlands and typical of Rwandan wetlands on all the depressions up to the banks. To do this, the first step consists in preparing the soil, with decompacting the soil in place on the first 15 centimeters to reactivate the seed bank and promote rooting. The second step is to plant native species typical of local wetlands, matching the water needs of these species with the water conditions of the soil. Indeed, in order to accelerate the vegetation, it will be interesting to plant semi-aquatic and aquatic plants: sedges, reeds...In time, the planted plants will be more or less completed/replaced progressively by species spontaneously colonizing the site. The zones regularly in water will generally be well colonized by natural vegetation; it is thus little useful to sow them. This will involve proposing an adapted plant life with the following plant species: Centella asiatica (Centella asiatica), Urugaga (Cyperus dives), Urukanganga/Cyperus latifolius (Cyperus latifolius), Carolina Dichondra (Dichondra micrantha), Ubwungo/ Drymaria cordata (Drymaria cordata), Urufunzo/Papyrus (Cyperus papyrus), Umuberanya/Southern cattail (Typha domingensis), Carex mildbraediana, Urukirakenja/Cyperus articulatus, Umujangaja/Cyperus denudatus, Dichondra Carolina (Dichondra micrantha), Urujenone (Enhydra fluctuans), Gutwikumwe/ Hydrocotyle ranunculoides, Ubusuna/ Common rush (Juncus effusus), Urukembagufa/ Cutting grass (Leersia hexandra), Ikirogora (Brillantaisia cicatricosa), Umuzigangore (Ludwigia abyssinica), Igorogonzo/Water weed (Persicaria decipiens).

Comments	"- Developments must be carried out outside of rainy periods to avoid soil compaction and degradation caused by erosion (uprooting of plantations, seeds washed away by runoff...) - It is imperative to carry out the revegetation as soon as the earthworks are completed at the favourable period in order to avoid the proliferation of invasive species invasive species and erosion by runoff
Maintenance need	"- Annual management by mowing in August, before the rainy season - Ensure the cutting of plants with export of green waste
Management monitoring	Monitoring the evolution of the vegetation twice a year, during the dry seasons, by botanical expert, over 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30).

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

Action 20-N	Name	Stream protection zone with a vegetated riparian buffer
	Action target	Biodiversity and Water Quality
	Wetland	Nyabugogo

Location (map) N04



Photos / examples







Characteristics	Rough cost estimate	Priority	Objectives
N04 Vegetated buffer strip of approximately 25m wide on each side of the watercourse, i.e. an area of approximately : 75 000m² for a total of 1 500m	16,065 USD	2 - Medium-term 2035	In order to limit the transfer of pollutants to the watercourse via runoff, vegetated buffer strips are positioned between agricultural plots and the watercourse network. In this action sheet, a vegetated buffer strip is defined as any vegetated surface that intercepts diffuse or concentrated surface runoff and therefore reduces the transfer of pollutants and/or sediments. These vegetated buffer strips are translated as grassy strips, permanent grasslands, fallow land, hedges, woods or copses. Their implementation requires : - Tillage to level and decompact the land; - Revegetation, which is either seeding of grassland or planting of shrubs/trees; - A choice of local plant species. This vegetated buffer strip, whose width will have to be refined according to the intercepted watershed, will also be a support for the migration of animal species.

Comments	Developments must be carried out outside of rainy periods to avoid soil compaction and degradation caused by erosion (uprooting of plantations, seeds washed away by runoff...)
Maintenance need	Annual management by mowing in August, before the rainy season
Management monitoring	Monitoring the evolution of the vegetation twice a year, during the dry seasons, by botanical expert, over 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30).

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

Action 24.N	Name	Protection and conservation of typical wetland habitats
	Action target	Biodiversity
	Wetland	Nyabugogo

Location (map) N08 - N09



Photos / examples





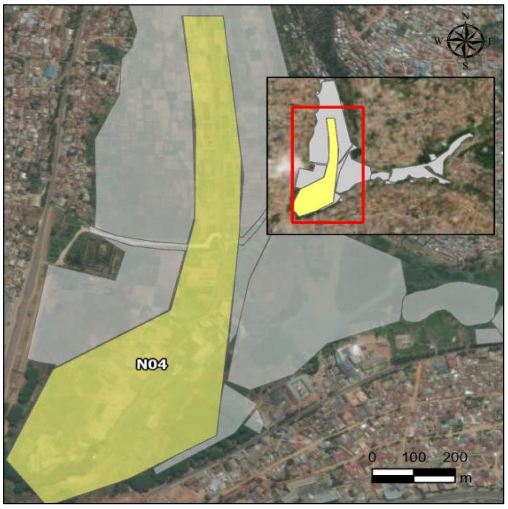
Characteristics	Rough cost estimate	Priority	Objectives
N08 Linear of fences : 650 ml	105,300 USD	1 - Short-term 2025	This action aims to protect the wetlands of good plant quality and the most biologically sensitive (breeding grounds for heritage fauna, protected plant species, ...). For this, several solutions are proposed: - the installation of fences or wooden barriers, positioned all around the area of interest, in order to prohibit any pedestrian or vehicle access (except for maintenance). These protective elements must be well integrated into the landscape, so wooden elements are recommended. Awareness signs may also be installed. - the classification of the zone of interest in a protection zoning (reserves, protected areas, ..), allowing to limit the uses to those favorable to the maintenance of the fauna and the present flora. The classification in protection zoning induces administrative procedures but proves to be a very relevant tool to guarantee the durability of the area and the actions carried out, and to maintain quality habitats. In addition, thorough biological monitoring must be carried out on these areas by experts in ecology or environmental associations. The objective of this monitoring is to identify the fauna and flora issues in these areas, to follow the evolution of the habitats and to propose and adapt the management modalities in order to enhance the environment. This monitoring must be carried out at all times of the year, with more frequent visits during the period of activity of the fauna and development of the flora, and carried out according to a precise protocol repeated over several years.
N09 Linear of fences : 550 ml	89,100 USD	1 - Short-term 2025	

Comments	
Maintenance need	/
Management monitoring	Annual verification of the state of deterioration of the fences.

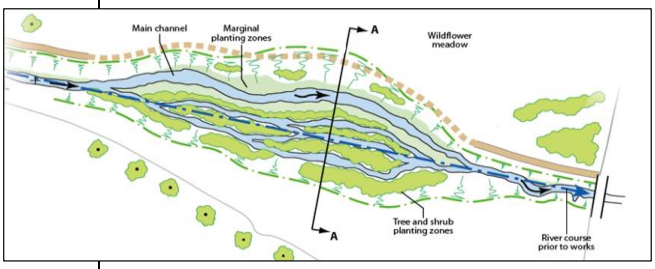
Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

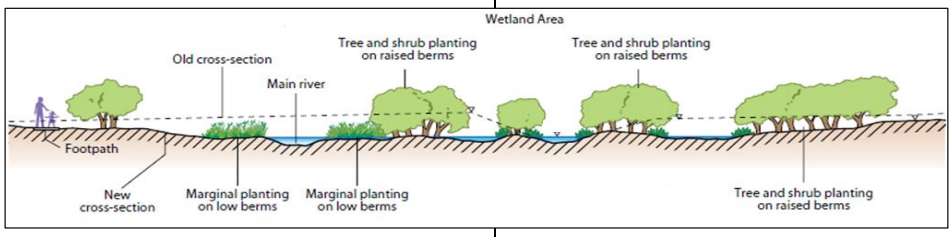
Action sheet		
Action 26.N	Name	Creation of a delta before the confluence of the Nyabugogo river
	Action target	Flood mitigation, Biodiversity
	Wetland	Nyabugogo

Location (map) - N04



Photos / examples





Characteristics	Rough cost estimate	Priority	Objectives
N04 Length of watercourse to be repositioned in the thalweg : 220 m	505,845 USD	3 - Long-term 2050	Before carrying out the earthworks, a design study phase will be necessary to refine the work to be carried out. These studies will make it possible to ensure that the water level is respected in order to create lentic and lotic zones: - The "project grade" (longitudinal profile) must be determined based on a good knowledge of the current slope of the river, the natural terrain and the water table (and its variations); - The recreation will not be uniform to create different flow facies. The use of mechanical shovel, bulldozer is necessary. The work will have to be carried out in such a way as to limit soil compaction: use machines with good bearing capacity ("marsh" shovels), avoid driving with machines on the talweg, decompact the soil at the end of the work.... The period of execution of the work is largely conditioned by the hydraulic constraints (low water). It is important to underline the importance of the quality of the company and the project management in this type of work. It is advisable to choose companies that have already carried out this type of work, and to provide for very regular monitoring of the site by an ecologist.

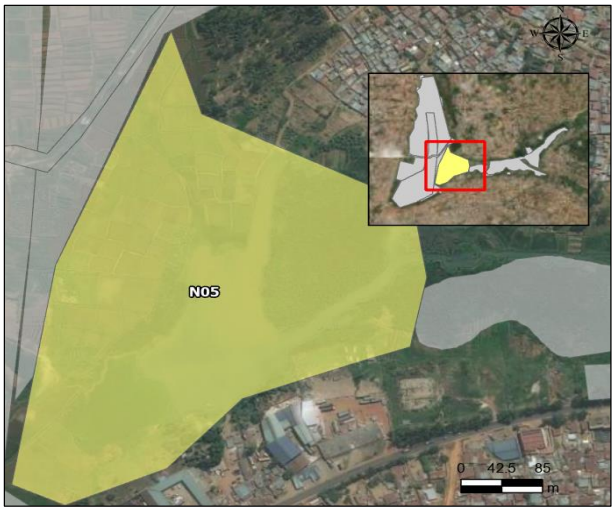
Comments	
Maintenance need	Annual management by mowing in August, before the rainy season The management of the new minor bed must be vigilant on the following hydraulic phenomena: - Creation of hydraulic plugs at the level of the flows; - Departure of boulders positioned in the minor bed; - Presence of erosion of the banks and the bottom of the watercourse. A management plan also aims to ensure the cutting of vegetation with export of green waste
Management monitoring	Monitoring of the evolution of vegetation and hydraulics twice a year, during dry and rainy seasons, by an expert in ecological engineering, for 30 years (n+1, n+2, n+3, n+5, n+7, n+10, n+15, n+20, n+25, n+30)

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

Action 27	Name	Management to limit the expansion of the water hyacinth and increase of the size of the existing lake
	Action target	Biodiversity
	Wetland	Nyabugogo

Location (map) N05



Photos / examples





Characteristics	Rough cost estimate	Priority	Objectives
N05 Area to be treated : 19 800 m²	513,216 USD	1 - Short-term 2025	The aim is to remove the water hyacinth, increase the depth of the lake to limit the colonization of this invasive plant and improve navigability in the lake. Removed water hyacinth would need to be burnt in a designated area to avoid spreading the plant in other habitats. Excavating the contour of the lake would help to limit future colonization of the plant and improve recreational activities. Currently, the lake has a size of about 3 ha. With the removal of water hyacinth and excavation, the lake would have a size of about 7.5 ha. The depth of excavation would be about 1 meter in the additional area (4.5 ha). A significant recovery would also be achieved by solving current water quality issues. The vegetative multiplication of the water hyacinth is very fast when the conditions are met (temperature higher than 18°C) : it is done by the production of stolons at the base of the leaves. The biomass of the herbariums can reach 300 tons per hectare. In order to fight against the expansion of the water jascinth, the chosen solution is the mechanical pulling up. This technique consists in pulling out the feet of the water jascinth, and to bring them back to the banks on zones of deposits, where cloths of jutes were beforehand laid out. This technique requires heavy equipment: - boats with digging forks or cutting bars, dredging machines in order to detach and pull out the water jascinth plants. - push boats or conveyor belts to collect the plants and transport them to the bank. The intervention must take place just after the end of the rainy period. The temporary storage of the uprooted plants is important because it allows a significant reduction in the volume of plant debris that will then have to be incinerated or transported to appropriate channels (landfill). It must be done in an area sheltered from strong winds to avoid any risk of dissemination, where access to animals is reduced and a flat area to avoid any risk of runoff in case of heavy rain. The evacuation of the site will be carried out by machines adapted to the low bearing capacity of the soil. In addition, it will be advisable not to leave any pieces or cuttings of water jascinth on the treated zones (wetland and aquatic zone), any remainder of

Comments	- The existing water supply pipelines implemented into the wetland will be included and considered during the further studies and works
Maintenance need	Based on the results of the monitoring, repeat the action each year to limit the expansion of the water jascinth.
Management monitoring	Annual monitoring by an expert botanist of the treated area and of the deposition zones to control the evolution of the water jascinth populations and thus adapt the actions to limit its expansion.

Feasibility study, baseline studies and detailed designs for wetland rehabilitation in the city of Kigali

Action sheet

Action 28.N	Name	Pedestrain path to connect both sides of the wetlands
	Action target	Transportation, Recreational
	Wetland	Nyabugogo

Location (map) N11



Photos / examples





Characteristics	Rough cost estimate	Priority	Objectives
N10: Creation of a pedestrain path over 660 m	769,824 USD	1 - Short-term 2025	

Comments	- The existing water supply pipelines crossing the wetland at the level of the planed pedestrian path will be included and considered during the further studies and works
Maintenance need	Ensure cleanliness on a weekly basis
Management monitoring	