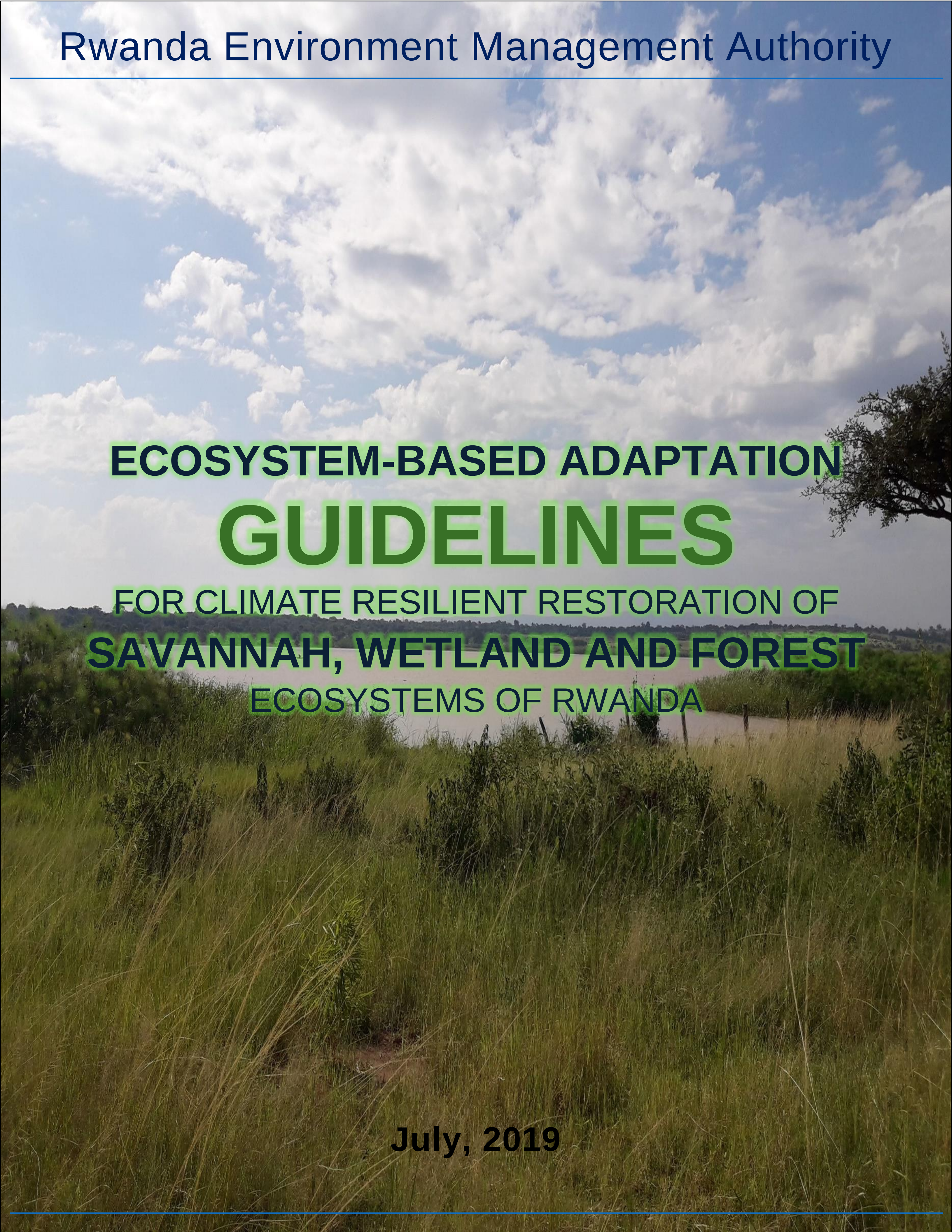

Rwanda Environment Management Authority

ECOSYSTEM-BASED ADAPTATION GUIDELINES

FOR CLIMATE RESILIENT RESTORATION OF SAVANNAH, WETLAND AND FOREST ECOSYSTEMS OF RWANDA

July, 2019

REPUBULIKA Y'U RWANDA

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Rwanda Environment Management Authority

ECOSYSTEM-BASED ADAPTATION GUIDELINES FOR CLIMATE RESILIENT RESTORATION OF SAVANNAH, WETLAND AND FOREST ECOSYSTEMS OF RWANDA

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July, 2019

"Communities that plan, own and understand ecosystem-based approaches for adaptation can benefit their livelihoods and the environment"

(UNFCC/SBSTA/2013/2)

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

The objective of this document is to describe developed Ecosystem-based Adaption guidelines and restoration plans for climate resilient restoration of savannahs, wetland and forest ecosystems, with reference to 8 case studies: Cyohoha Lake North, Kibare Lake, Rwampanga Lake, Murago Wetland, Ruhondo buffer zone wetland, Rwinkwavu Hill, Makera Forest and Sanza Forest. EbA guidelines and restoration options are a result of various consultations with key stakeholders combined with data collected from the study sites. Developed guidelines are categorised per ecosystem type: wetlands (comprising the lakes), savannahs and forests. For each ecosystem type, 4 steps of EbA intervention actions are proposed and described. They include: planning, ecosystem assessment, EbA intervention measures development, and EbA implementation monitoring/evaluation. In the developed site-specific EbA restoration action plans, various EbA intervention measures are proposed with the main goal to bring about the sustained recovery of the study sites by using an EbA approach through the enhancement of ecosystems and local communities' resilience against the effects of climate change while improving human well-being. In this regard, 8 expected outcomes of the implementation of the measures include the *improvement of adaptation capacity of key beneficiaries; efficient monitoring of EbA measures and dissemination of best practices; available and accessible of sufficient and clean water; mitigation of seasonal flooding impacts and reduction of floods vulnerability; increase the potential for maintaining aquatic biodiversity and ecosystem health; recovery of savanna biodiversity and ecosystem services; recovery of forest biodiversity and ecosystem services; and reduction of population exposure to extreme events and climate catastrophes.* For each expected outcome, detailed objectives are defined interlocking relevant actions. The develop restoration action plans will cover a period of 3 years at an estimated total cost of 1,533,500,000 Rwf[1].

[1] Equivalent to 1,693,030 USD as on 20 June 2019 (1 Rwf = 905.77USD) (https://www.bnr.rw, accessed on 20 June 2019)

1. INTRODUCTION

1.1. BACKGROUND OF THE STUDY

Ecosystem-based Approaches to Climate Change Adaptation, or Ecosystem-based Adaptation (EbA) has various but complementary definitions in international policies[2]*: the use of biodiversity and ecosystem services to help people adapt to the adverse effects of climate change* (CBD), *use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people and communities adapt to the negative effects of climate change at local, national, regional and global levels* (UNEP), or *use of the biodiversity as part of the overall adaptation strategy to help people adapt to adverse impacts of climate change* (GEF & IUCN). EbA has been documented largely in the literature and its relevance is highly recognized[3].

In Rwanda, natural ecosystems provide a wide range of services and they notably contribute to the resilience of local communities to climate change. However, these ecosystems are experiencing threats from climate change effects including floods, droughts and landslides mainly as a consequence of high pressure on and unsustainable use of natural resources. This leads to the degradation of natural ecosystems and thereby reducing their capacity to provide ecosystem services, and increasing the vulnerability of local communities to the effects of climate change. Yet, it has been demonstrated that the restoration of natural ecosystems does not only help address climate change effects or environmental degradation, but also promote products and yields that sustain the livelihoods of communities[4].

Due to unavoidable human impacts on ecosystems, the programs of restoration of degraded lands and vulnerable ecosystems have been implemented in various places, but often deemed to operate on business as usual basis. On this basis, restoration activities are ecosystem-centered and aim to assist the recovery of an ecosystem from anthropogenic impacts to sustain its biodiversity and re-establish its ecological functions, putting the emphasis on the conservation of threatened components of the ecosystem of concern.

EbA builds on traditional knowledge and practices of local communities to contribute to the improvement of their livelihoods by adopting appropriate measures to mitigate climate change

[2] Raasakka, N. (2013). Ecosystem-based Adaptation Approaches. LEG training workshop.
[3] Pramova, E., Locatelli, B., Djoudi, H., Somorin, O.A (2012). Forests and Trees for Social Adaptation to Climate Variability and Change, *In* Climatic Change, Adaptation, Non Timber Forest Products, Ecosystem Management, Watersheds, Coastal Areas, pp. 581–596. doi: 10.1002/wcc.195, ISSN: 1757-7799
[4] Bozzano, M. *et al.* (2014). Genetic Consideration a in Ecosystem Restoration Using Native Tree Species. State of the World's Forest Genetic Resources, Thematic Study. Rome: FAO and Biodiversity International, pp. 1–281.

impacts, thus contributing to the conservation of biodiversity and increasing the ecosystem services. This approach generates significant social and economic benefits to local communities, by protecting them from climate change and extreme weather events.

The EbA conceptualization in this study involves restoration and reforestation using climate-resilient indigenous tree species. Most likely to have the genetic basis required to adapt to climate change; indigenous species can be an efficient way for climate-resilient ecosystems and communities towards development paths across Africa [5]. Thus, the restoration practice preference is given to beneficial indigenous tree species and the diversity owing to their intrinsic relationships with local biodiversity, as well as associated local and/or traditional knowledge and practices.

[5] Fandohan, A. B. *et al.* (2015). Domesticating and Conserving Indigenous Trees Species: an Ecosystem Based Approach for Adaptation to Climate Change in Sub-Sahara Africa', *Sciences de la vie, de la terre et agronomie*, 3(1), pp. 1–9.

1.2. OBJECTIVES AND TASKS

The objective of the study is to develop guidelines for climate resilient restoration of savannahs, wetland and forest ecosystems using indigenous species to promote EbA and train local people on restoration methods and develop restoration action plans of the following ecosystems: Lakes of Cyohoha North, Kibare and Rwampanga, Murago and Ruhondo buffer zone wetlands, Rwinkwavu Hill, and Makera and Sanza natural forests (Figure 1).

Site	Sector
CYOHOHA MURAGO	1-Musenyi 2-Mayange 3-Ngeruka 4-Mareba 5-Shyara
RWAMPANGA	6-Mpanga
MAKERA	7-Nasho
KIBARE	8-Ndego
RWINKWAVU	9-Rwinkwavu
RUHONDO	10-Rugengabari 11-Gitovu 12-Kinoni 13-Gacaca 14-Remera 15-Gashaki
SANZA	16-Muhororo

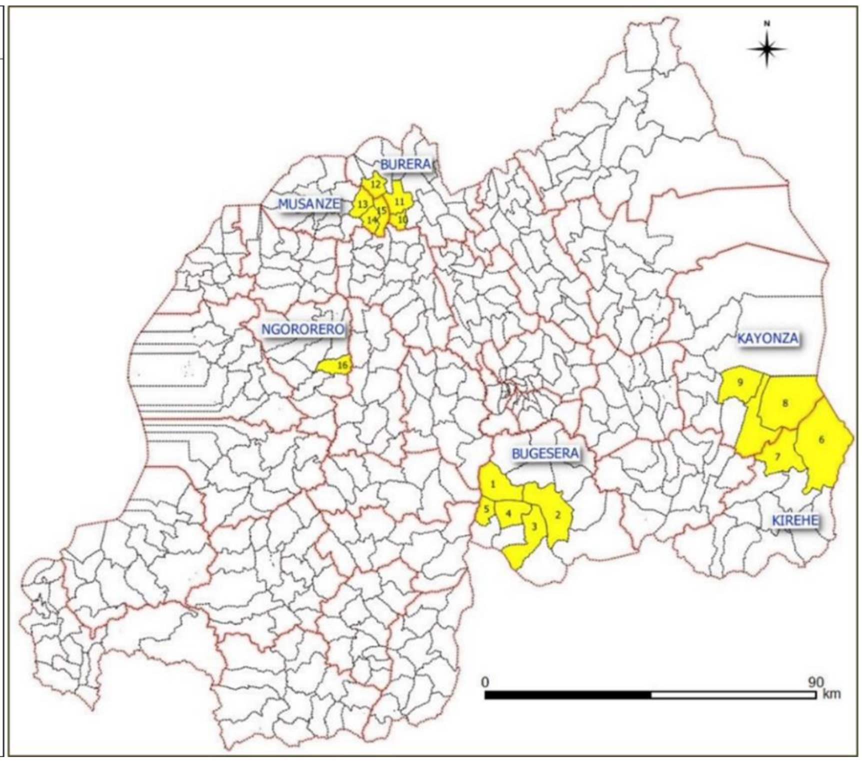

Figure 1: Study sites locations

Specifically, the study aims to undertake following tasks:

1. Review past and current landscape restoration activities which use indigenous species including existing protocols/documents for restoring ecosystems in Rwanda;
2. Review agroforestry practices in Rwanda as well as indigenous knowledge on climate resilience, planting, maintenance and use of indigenous species;
3. Identify suitable climate-resilient beneficial indigenous species for ecosystem restoration and agroforestry in project intervention areas;
4. Develop technical guidelines for climate-resilient restoration activities in wetland ecosystems in project intervention area with emphasis on EbA including best practices in planting, maintenance and use of beneficial indigenous species and develop

restoration action plan for Cyohoha, Kibare and Rwampanga lakes; Murago and Ruhondo wetlands;

5. Develop technical guidelines for climate-resilient restoration activities in Savanna ecosystems with emphasis on EbA including best practices in planting, maintenance and use of beneficial indigenous species and develop restoration action plan for Rwinkwavu hill;
6. Develop technical guidelines for climate-resilient restoration activities in forest ecosystems with emphasis on EbA including best practices in planting, maintenance and use of beneficial indigenous species and develop restoration action plan for restoration of Ibanda-Makera and Sanza natural forests;
7. Provide training to trainers from Farmers Field Schools (FFSs) on the implementation of the guidelines and action plans

2. METHODOLOGY AND SUMMARY OF THE FINDINGS

2.1. DESK-BASED RESEARCH

A review of relevant literature was done to respond to tasks 1, 2, and 3, including online documentation, relevant reports from different institutions etc. Available information about existing protocols and initiatives related to landscape restoration was collected to understand agroforestry practices and use of indigenous knowledge on climate resilience, planting, maintenance and use of indigenous species in Rwanda. This information was used to identify suitable climate-resilient beneficial indigenous species for ecosystem restoration and agroforestry in intervention areas.

2.2. STAKEHOLDER SURVEYS

Stakeholder surveys with different people mainly composed of local population neighboring the study sites were conducted. The stakeholder surveys contributed to advance the knowledge of tasks 1 to 3, and provide baseline data and background contributing to the tasks 4 to 6. At each of the 8 intervention sites (Figure 1), a sample for the survey was established at sector level surrounding the site, by considering the variety on gender, age groups, education and occupations of the informants in order to enrich the collected information, and a total of 101 respondents were interviewed using an interview questionnaire guide (Appendix 1).

2.3. CONSULTATIVE WORKSHOP

A 2-days consultative workshop was organized to collect data for tasks 3-6, by making use of the information inquired in tasks 1-3. The workshop gathered 30 key informants selected from the study sites (Appendix 2), and it was the opportunity to collect baseline data, identify the list of suitable indigenous species to be used, and share experiences and inputs towards the elaboration of the guidelines.

2.4. FIELD BASELINE DATA COLLECTION

Field visits were organized to the study sites to document and describe their current status in terms of biological composition, associated physical environment, and spatial extent. Assessments to describe the general status and major threats which affect both the natural habitats of concern as well as the livelihoods of the local communities were also conducted.

2.5. TECHNICAL GUIDELINES AND RESTORATION PLANS

Specific technical guidelines and restoration plans were developed for lakes and wetlands, savannas, and forests. The developed guidelines are effective for EbA approach for climate-resilient restoration activities of target ecosystems at the proposed intervention areas in Rwanda.

With reference to CBD (2018)[6], key stages and components which guided the analysis and selection of EbA based-restoration options for each target ecosystem are (Figure 2):

1. Asess and identify the issues related to: (i) ecosystem health conditions, (ii) climate change threats and impacts, (iii) vulnerability of local communities to climate

2. Identify appropriate intervention measures and associated context specific adaptive actions for the study site

3. Develop EbA based-restoration options to guide the implementation of intervention measures

4. Define a plan to monitor and evaluate the implementation performance

Figure 2: Guiding framework for EbA restoration options

[6] CBD. (2018). Draft Guidelines for Ecosystem-based Approaches to Climate Change Adaptation and Disaster Risk Reduction, (January). Retrieved from https://www.cbd.int/sbstta/sbstta-22-sbi-2/EbA-Eco-DRR-Guidelines-en.pdf

2.6. TRAINING OF TRAINERS

This training is planned to complete the task 7 of this study, and is planned to be offered after validation of the guidelines and restoration plans. A 3-day training session will be delivered to key respondents identified during the stakeholder's surveys and consultative workshop. These selected people from different study sites will acquire the knowledge and skills needed to practice and monitor the implementation of the guidelines and restoration action plans. The training approach will be based on principles of adult learning with a focus of peer review during all steps of planning, organizing and conducting trainings. The training methodology will use demonstration, practice, discussion, brainstorming, group works, individual works, exercises, presentations, field visit and experience sharing.

During the training session, trainees will be motivated to generate further engagement and feasibility of knowledge transfer and application. Indeed, during the training session, trainees will provide strategy of way forward. The training methodology will be participatory, active and interactive.

2.7. SUMMARY OF THE FINDINGS

These EbA guidelines advise on detailed steps and systematic protocols for the EbA approach on wetland, savanna and forest ecosystems in Rwanda. 8 study sites were used as case studies: Cyohoha Lake North, Kibare Lake, Rwampanga Lake, Murago Wetland, Ruhondo buffer zone wetland, Rwinkwavu Hill, Makera Forest and Sanza Forest.

A combination of documentation review, stakeholder surveys and consultations, and field data collections provided relevant information on existing ecological and socio-economic conditions from the study sites, which served as the baseline for the development of the EbA guidelines at the intervention areas.

For each ecosystem type, 4 steps of EbA intervention actions are proposed and described. They include: planning, ecosystem assessment, EbA intervention measures development, and EbA implementation monitoring/evaluation.

A local planning team is recommended to follow up, monitor and evaluate the implementation of all EbA interventions at site level. The team would work with technical expert (s) and in close collaboration with the national coordination committee. The ecological and socio-economic assessments help to determine detailed characterization of each site's situation. The findings from the 8 study sites revealed a high biodiversity richness potential and many ecosystem services benefiting the surrounding communities. Poverty levels of the majority of the local population are high, and livelihood conditions appalling.

The assessment of climate change impacts indicate that several key drivers exacerbate the impacts. The drivers include mainly inappropriate agriculture and grazing practices (such as encroachments to protected buffer zones, farming on steep slopes, etc), deforestation, mining, invasive species, etc.

Main EbA intervention measures to identified climate change threats include the use of suitable and beneficial indigenous species. The selection of the climate-resilient species is based on local knowledge and practices, and on existing scientific knowledge on every species' adaptability and use.

This report also contains a detailed 3-year restoration action plans for the 8 intervention areas. Various EbA intervention measures are proposed with the main goal to bring about the sustained recovery of the study sites by using an EbA approach through the enhancement of ecosystems and local communities' resilience against the effects of climate change while improving human well-being. In this regard, 8 expected outcomes of the implementation of the measures include the *improvement of adaptation capacity of key beneficiaries; efficient monitoring of EbA measures and dissemination of best practices; available and accessible of sufficient and clean water; mitigation of seasonal flooding impacts and reduction of floods vulnerability; increase the potential for maintaining aquatic biodiversity and ecosystem health; recovery of savanna biodiversity and ecosystem services; recovery of forest biodiversity and ecosystem services; and reduction of population exposure to extreme events and climate catastrophes.* For each expected outcome, detailed objectives are defined interlocking relevant actions. The develop restoration action plans will need an estimated total budget of 1,533,500,000 Rwf.

3. EBA TECHNICAL GUIDELINES FOR CLIMATE-RESILIENT RESTORATION OF WETLAND ECOSYSTEMS

The EbA guidelines for climate-resilient restoration of wetland ecosystems have been developed to provide a clear and systematic protocol for the EbA approach on wetland ecosystems in Rwanda. In these guidelines, wetland ecosystems are considered as the general term combining both lakes, swamps and marshlands (Ramsar, articles 1.1 and 2.1)[7]. The EbA technical guidelines developed in this document will apply to five pilot sites: Lake Cyohoha North, Lake Kibare, Lake Rwampanga, Murago Wetland and Ruhondo buffer zone wetland.

It has been proven that wetland ecosystem restoration provides various benefits that are reflected in the critical services offered by lakes and wetlands, as summarized in the following table (REMA 2010)[8]. The EbA guidelines for climate-resilient restoration in wetland ecosystems in Rwanda aim to adopt different wetland ecosystem management activities to reduce vulnerability in the face of climate change and thus, enhance the benefits obtained from wetland ecosystem goods and services.

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[7] "Wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres" (Article 1.1) and "may incorporate riparian and coastal zones adjacent to wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within wetlands" (Article 2.1).

[8] Rwanda Environment Management Authority (REMA) (2010). Practical Tools on Restoration and Conservation of Protected Wetlands. 27 p.

Table 1. Main benefits provided by wetland ecosystems in Rwanda

Benefits		Components	Note
Goods		Water provision	Local residents use water from those ecosystems for various purposes: domestic, agriculture, etc.
		Healthy fisheries	As their natural habitat, allowing for easy accessibility
		Weaving material and handcrafts	Typical wetland plants are source of material for weaving mats, mulching, livestock bedding, etc.
Services	Socio-economic	Flood damage reduction	Temporary store of runoff and reduction of discharge damages
		Erosion control	Wetland vegetation protects upland from erosion
		Transport facilitation	Easy transport between opposite residents by means of boats
		Education and research	Excellent places for scientific enjoyment and learning
		Aesthetics, recreation and tourism	Many recreational and tourism activities are developed around lakes and major wetlands
	Ecological	Biodiversity protection	High diversity of species with some rare or endemic species
		High biological productivity	They are rich in organic matter and nutrients
		Nutrient cycling	Different organisms and physico-chemical conditions of lakes and wetlands permit nutrient cycling
		Local climate regulation	Lakes provide fresh air and riparian wetlands determine the local climate conditions
		Support for birds and other wildlife	Waterfowl and other typical animals such as amphibians and crocodiles
		Good water quality	Though water purification and storage

3.1. GUIDING PRINCIPLES FOR THE EBA PROCESS FOR WETLANDS RESTORATION

The following principles adapted from REMA (2010a) should serve as the standards to guide, plan and implement EbA approach for wetland restoration in Rwanda, to enhance the resilience of socio-ecological wetland-associated systems in the face of climate change impacts. The EbA guidelines for climate-resilient restoration in wetland ecosystems are developed in the line with these principles (Table 2).

Table 2: Principles for EbA-based wetland ecosystem restoration

Principle	**Relevance for EbA-based wetland ecosystem restoration**
Sustainability as a goal	Restoration outcomes should appear in a way that natural dynamics and services are maintained to serve effectively future generations
Clarity of process	The process and procedures of EbA-based wetland ecosystem restoration should be clear to all concerned stakeholders
Equity in participation and decision-making	There is need of fair allocation and endowment of interests and roles among all stakeholders with focus on local communities
Credibility of science	The scientific methods to be used should be supported by local knowledge and practices; and they should be credible and supported by the scientific community
Transparency in implementation	Implementation must be aligned with defined and agreed procedures; correct and fair monitoring should apply
Flexibility of management	As the ecosystems are affected by anthropogenic impacts and natural events, an adaptive strategy should be adopted whenever it applies
Accountability for decisions	Decision-makers should be accountable and the decision-making process should bring credible and relevant results to all stakeholders

3.2. EBA STEPS FOR WETLANDS RESTORATION

This section describes the steps of EbA intervention actions for wetlands restoration (Figure 3).

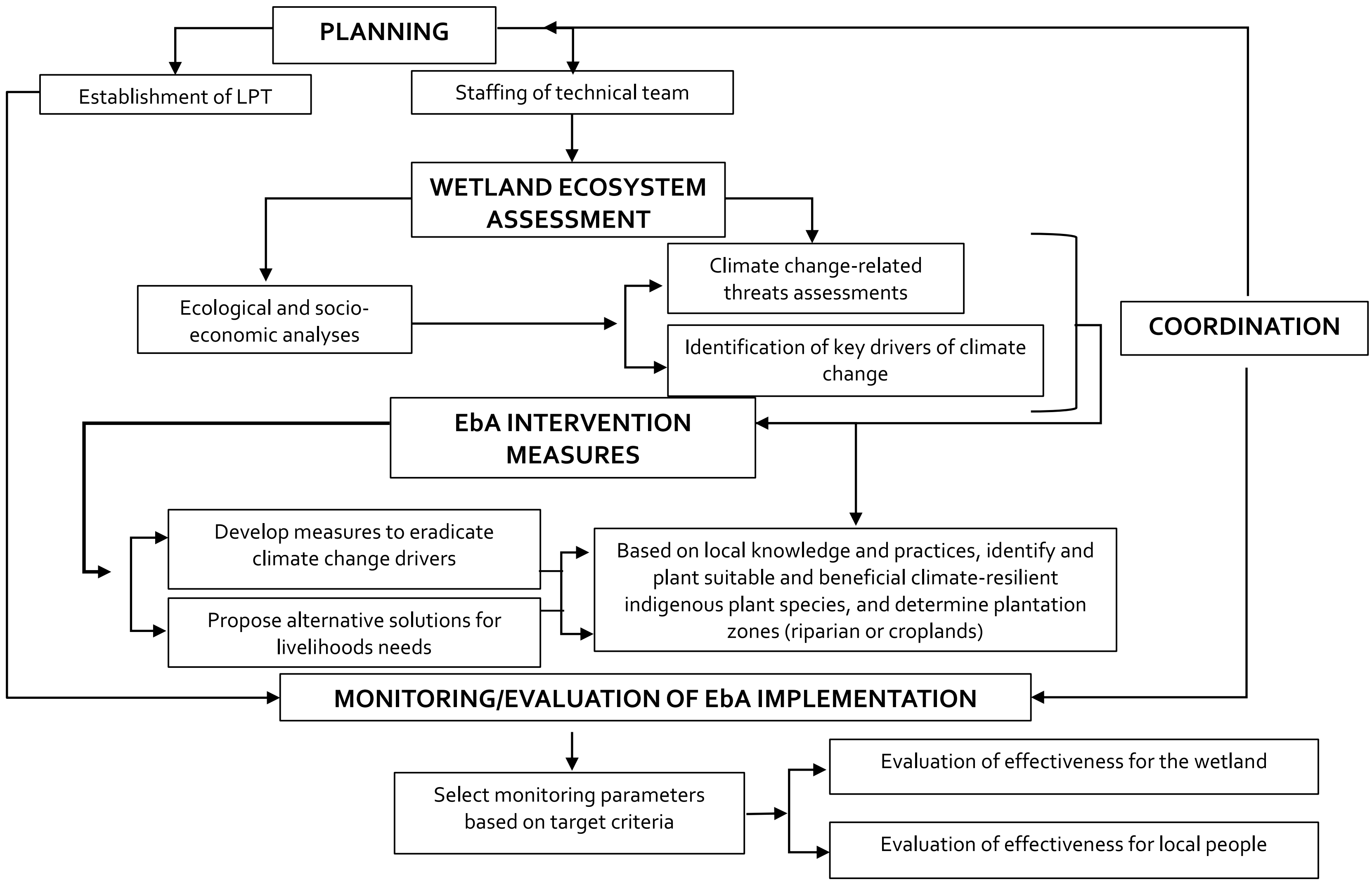

Figure 3: Proposed conceptual model for EbA process in wetland restoration

Step 1: Planning

During the planning phase, the EbA project managers and stakeholders need to turn goals into clear and measurable objectives and actions, and identify starting and ending points for restoration of specific landscape elements[9].

A. Establishing a Local Planning Team

The first step for EbA implementation is the establishment of a **Local Planning Team (LPT)** responsible of following up the implementation of EbA interventions at the site level (For each target wetland). The team would oversee the implementation of standard procedures and EbA guidelines, monitor plans for the long-term sustainability and maintenance of the project's EbA activities to generate long-term ecological and socio-economic benefits. For EbA wetlands restoration, we propose that the LPT will be composed of at least 10 people, including **(1)** REMA representative (site manager), **(1)** field technician, **(8)** local people (1 from fishing and 1 from agro-pastoral cooperatives (if existing), 2 females, 2 representing the youth), **(1)** local agronomist and the **(1)** Socio-Economic Development Officer (SEDO) of the Cell.

The LPT will be different from **Coordination Committee** which would oversee the whole process nationwide, mainly at the level of Planning and Monitoring & Evaluation. The LPT would be established by the Coordination Committee in consultation (where necessary) with any relevant stakeholders. This Committee is proposed to be composed of the project team at REMA (Project manager, Monitoring & Evaluation Officer and SPIU Coordinator).

B. Staffing of Technical Team

For effective implementation of EbA wetlands restoration, adequate knowledge and expertise of wetland ecosystems is required. Thus, the Coordination Committee will define qualification criteria and other requirements for the recruitment of needed expert(s).

[9] Stanturf, J., Mansourian, S. and Kleine, M. (2017) 'Implementing Forest Landscape Restoration, A Practitioner's Guide'. International Union of Forest Research Organizations (IUFRO), pp. 1–128

Step 2: Ecosystem Assessment

A. Ecological and Socio-Economic Assessments

Ecological and socio-economic characterizations of each target site are necessary to understand background situation of the site. Therefore, it is important to conduct a baseline data collection for key data as indicated in table 3 (adapted from Stanturf et al. (2017)).

Table 3: Key data for wetlands' baseline characterization

Data types	Examples
Ecological	Species information (fauna and flora), ecological processes, ecosystem services, climate patterns…
Socio-economic	Main economic activities, livelihood conditions, demographic variables, …

For any type of wetland ecosystem, the technical team is recommended to use the proposed methodological approach for the assessments as indicated in Table 4. The estimated time for the assessments may vary depending on each ecosystem's characteristics and the amount of required data.

Table 4: Baseline information collection guidelines-wetlands

Data types	Proposed methodology	Sources of data
Ecological	Biodiversity inventories of key species, direct observations, interviews, review of information records, mapping tools, lab tests…	Primary (mainly) and secondary
Socio-economic	Literature review, interviews (households, individuals, focus group); key informants consultations, direct observations of major land uses…	Primary (mainly) and secondary

Case studies: Ecosystem Assessments
Lake Cyohoha North, Murago Wetland, Lake Kibare, Lake Rwampanga, and Ruhondo buffer zone wetland

Climatic patterns of each site[10] indicate that all other wetland ecosystems are located (refer to Figure 1) in drought prone regions, except Ruhondo (Figure 4).

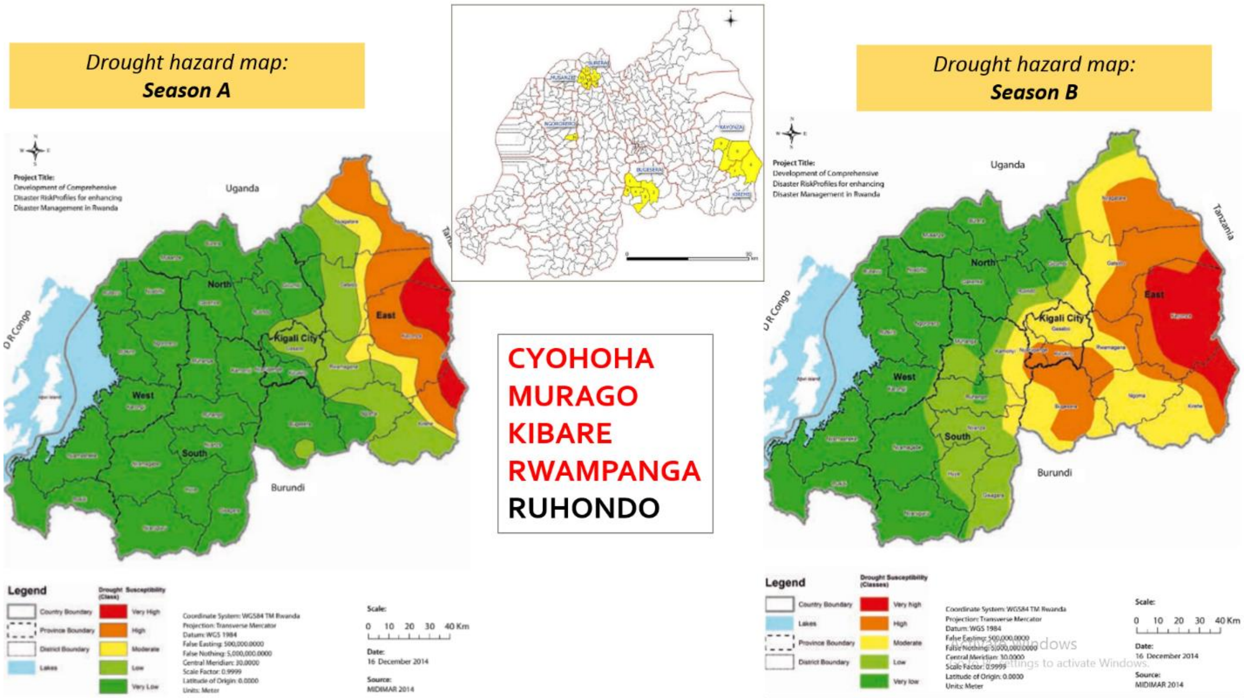

Figure 4: Drought hazard maps of Rwanda

Detailed description of ecological and socio-economic characteristics of the study sites is provided in table 5.

Table 5: Wetland ecosystems descriptions

Ecosystem[11]	Ecological features	Socio-economic characteristics
Lake Cyohoha North (Area: 901 ha)	• Medium altitude (1,346m a.s.l[12]) • Contiguous to Murago Wetland in the West, and located at 12km in the north of Lake Cyohoha South • Characteristic biodiversity: ◦ Dominant native plant species include mainly the grasses of *Cyperus papyrus*, *Typha domingensis* and *Cyperus latifolius*. Trees of *Grevillea robusta*	• Low density as a large proportion of the land is an uninhabited rangeland and forest reserve under the management of the military authority (Gako Military Domain in the East of Lake Cyohoha North) • Subsistence agriculture on small parcels (mainly beans, vegetables

[10] MINEMA (2015). The National Risk Atlas of Rwanda.
[11] The maps of sites locations are found in Appendix 3
[12] a.s.l: above sea level

	and bamboos have been planted along the lake shores for agroforestry purposes.
	• Tilapia and *Clarias sp* fish species reported to be found in the lake (in small quantities though).
	• Some birds like Papyrus Gonolek, Black-lored Babbler, Red-Chested Sunbirds, White-winged Warbler, and Carruther's Warbler…present, mainly in the papyrus-associated swamp.
	• Main ecosystem services:
	  • Water supply: Being the only major source of water in the area, the lake's water is used for all domestic uses (including drinking), and for livestock watering, etc.
	  • Fisheries
	  • Shoreline stabilization from deforested surroundings
	• Climatic patterns: Prolonged dry seasons and erratic rainfall (Figure 4) resulting in severe water shortage conditions.
		and cassava), with low production as a result of unfavorable climatic conditions, low soil fertility and inadequate agriculture practices. Livestock rearing involves cows mainly.
		• Poverty level: Moderately High: 40-49.9% (NISR, 2017[13]).

Murago Wetland
(Area: 745 ha)
	• Murago is in the East of and contiguous to Lake Cyohoha North (1,346m a.s.l).
	• Characteristic biodiversity:
	  • Dominant native plant species include mainly the grasses of *Cyperus papyrus*, *Typha domingensis*, *Cyperus latifolius*, *Pennisetum purpureum*, *Cynodon dactylon…*and different wetland herbaceous species such as *Polygonum spp.*, *Ludwigia abyssinica*, *Hydrocotyle sp.*, *Hygrophyla auriculata…*
	  • Bird species (same as above-see Lake Cyohoha North)
	• Main ecosystem services:
	  • Source of fodder for the cattle
	  • Collection of medicinal plants
	  • Water reservoir and purification (same water issue as described for Lake Cyohoha North)
	• Climatic patterns: (same as above-see Lake Cyohoha North)
		Same as above-see Lake Cyohoha North

Lake Kibare (Area: 336 ha)	• Located at 2.3km from Tanzania border with Rwanda, the lake is part of the Nasho Basin Lakes, and is found at an elevation of 1,287 m a.s.l. • The waters turn brown due to heavy siltation as Akagera River traverses the northern part of Lake Kibare. • Characteristic biodiversity: • The lake used to be part of the Akagera National Park, and many remnant savanna tree species can be found in the area, mainly in cattle	• Ndego Sector is the second less populated sector in Kayoza District. Most of its inhabitants are immigrants who occupied the lands after the degazettment of part of the Akagera National Park. • Two main activities are source of income for local people: fishing and livestock keeping.

[13] National Institute of Statistics of Rwanda (NISR) (2017). Poverty Mapping Report, 2013/2014.

	ranches at the eastern side of the lake. They comprise mainly *Vepris nobilis*, *Rhus natalensis*, *Olea europea* subsp. *cuspidata*, *Grewia* spp., *Zanthoxylum chalybeum*, *Grewia similis*, *Albizia petersiana*, *Haplocoeulum foliolosum*, *Acacia gerrardii*, *Lannea humilis*, *Afrocanthium lactescens*, *Lannea schimperi*, *Aloe sp*, etc. The lake shores comprises species of *Aeschynomene elaphroxylon*, *Cyperus papyrus*, *Acacia polyacantha*, *Phoenix reclinata*…. • Some fish are found in the lake, among which Nile Tilapia, African Catfish and *Haplochromis sp* are most dominant. Mamba is also common in the lake. • Main ecosystem services: • Water supply: Water scarcity in this region obliges people to use this lake's water for domestic purposes, including drinking, cooking…, so the lake is a critical source of water supply. Cattle farming much practiced in the region also greatly benefits from this lake for livestock watering. • The lake produces big quantity of fish, mainly Tilapia. A local fishing cooperative (COVIPE [14] Ndego) manages fishing activities in this lake. • Climatic patterns: Kibare is located in very dry area, where rainfall is very low, and temperature very hot compared to other parts of the country (Figure 4).	• Various crops are also grown for agriculture, including maize, sorghum, beans, banana, potatoes, etc. • Poverty level: Low: 20-29.9% (NISR, 2017).
Lake Rwampanga (Area: 986 ha)	• The Akagera River also traverses the northern part of Lake Rwampanga, and the lake is located at 4km in the west of Tanzania border with Rwanda, at an elevation of 1,290 m a.s.l. Located in the west of Lake Rwampanga is Lake Cyambwe (in less than 1.5 Km). • As in the case of Lake Kibare, the waters of this are also brown due to siltation by the Akagera River. • Characteristic biodiversity: • The lake is mainly surrounded by crop fields of banana plantations, vegetables, etc. The shores are dominated by *Cyperus papyrus*, and a few trees of *Acacia polyacantha.* • Commonly found fish include Tilapia and Catfish. • Main ecosystem services: • Water supply: As in the case of other lakes found in the Eastern Province, this lake constitutes an important of water used for various activities. People use it for drinking, household activities…and also for irrigation of crops (mainly banana and vegetables planted close to the lake).	• Mpanga Sector is at the border with Tanzania, and local. Due to severe drought, water scarcity constitute a major challenge to local population. • Agriculture in wetlands associated with lakes constitutes the main source of revenue. Banana plantations are very common, and other crops such as maize, beans, as well fruits like pineapple, etc. • Poverty level: Moderately High: 40-49.9% (NISR, 2017).

[14] COVIPE: Cooperative Icyerekezo de Pêche de Ndego

	• Fish produced from the lake is an important source of food and revenue from surrounding population. • Climatic patterns: Same situation as above (see Lake Kibare)	

Lake Ruhondo
(Area: 2,687 ha)
	• Lake Ruhondo borders two Districts, Musanze and Burera, where a small river of Gihugu separates the portion of Musanze from the one of Burera District. The lake is surrounded by high mountains and is located at an altitude of 1,760 m a.s.l.
	• Lake Ruhondo is connected to Lake Burera in the East and the two are usually referred to as twin lakes. Ruhondo receives its waters from lake Burera and from four other streams, of which Gasura is the most important[15]
	• Characteristic biodiversity:
	  • The aquatic flora and fauna are poor because of the physical-chemical composition of the lake[16].
	  • About ten fish species are known to be present in the Lake. A few birds have also been recorded in the area.
	  • On the buffer zone of the lake, *Sesbania sesban* shrubs and grasses of *Pennisetum purpureum* and *Bambusa vulgaris* have been planted by the cooperative HIMO to protect the lake shores. Several other species are available including indigenous species such as *Phragmites mauritianus*, *Hallea rubrostipulata, Erythrina abyssinica, Alnus acuminata, Acanthus pubescens, Clerodendron johnstonii, Rumex spp…*
	• Main ecosystem services:
	  • Lake Ruhondo and Lake Burera as well as Rugezi Wetland constitue a complex which plays an important role in the production of hydropower used countrywide[17].
	  • Water availability increases crop production.
	  • Various adapted species growing on the lake shores used for different purposes
	  • Although fish production is not high, some fish are found in the lake (Tilapia, African catfish, and *Rastrineobola argentea*)
		• About 62 families who used to live in some islands of Lake Ruhondo are being removed and installed in a village upland (16 families have been installed to date).
		• The relocated population are grouped in a cooperative named Ubumwe-Birwa-Gacaca, which aims to restore the lake.
		• People mainly live of subsistence agriculture, where main crops include beans, sorghum and Irish potatoes.
		• Poverty level: Moderately High: 40-49.9% (NISR, 2017).

[15] MINAGRI (2011). Master Plan for Fisheries and Fish Farming in Rwanda.
[16] RoR (2003). National Strategy and Action Plan for the Conservation of Biodiversity in Rwanda.
[17] Willetts, E (2008). Watershed Payments for Ecosystem Services and Climate Change Adaptation. Case Study: Rugezi Wetlands, Rwanda. Masters Project for Master's Degree in Environmental Management. Duke University.

B. Assessment of Climate Change-Related Threats and Identification of human-induced drivers of Climate Change

The technical team will conduct an assessment of the impacts of climate change (CC) at two levels: CC impacts on the wetland ecosystem under study (natural system) and CC impacts on the livelihoods of local communities (social system).

The information/data from the vulnerability analysis will serve as a starting point to the assessment of CC impacts. As defined in the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), vulnerability to climate change is "a function of the character, magnitude and rate of climate change and variation to which a system is exposed, its sensitivity and its adaptive capacity [18] ".Thus, not all wetland ecosystems would need EbA process, depending on the information from vulnerability analysis. The expert(s) will therefore determine the vulnerability of the communities to adverse impacts of climate change and assess the vulnerability of ecosystems through known vulnerability maps for the intervention site or other possible field assessments.

Due to lack of sufficient climate-related data in most cases, it is advised to carry out qualitative ranking of the impacts (through stakeholders' involvement, meetings, interviews, questionnaires, field observations…), and combine the information on the likelihood of the hazard and the consequence of the hazard[19] (Table 6):

Table 6: Qualitative ranking of the impacts-wetlands

		Consequence of impact		
		Insignificant	***Moderate***	***Extreme***
Likelihood of impact	***Certain***	Medium	High	High
	Possible	Low	Medium	High
	Unlikely	Low	Low	Medium

The proposed approach to determine the spectrum of impacts is to consider the temporal and spatial scales:

- *Temporal scale:* Assess whether the CC causes short, medium or long term impacts

[18] McCarthy, J.J., Canziani, O.F., Leary, N.A., Dokken, D.J., White, K.S. (2001). Climate Change 2001. Impacts, Adaptation, and Vulnerability. Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.
[19] Adapted from Bhat, C. (2017). Climate Change Impacts and Adaptation for Coastal Transport Infrastructure in Caribbean SIDS. UNCTAD National Workshop Saint Lucia 24 – 26 May 2017, Rodney Bay, Saint Lucia

- *Spatial scale:* The technical expert(s) can determine the limits of the spatial scale. The extent of the impacts will be defined as being either place-based (i.e. at the ecosystem level - within the limits of the lake or wetland…), or locally limited (catchment area, village level…), or extended to national level…

Collected information can be supplemented by quantitative assessments (such as indicators, indices and maps…[20]).

Case studies: Climate Change Impacts Assessments
Lake Cyohoha North, Murago Wetland, Lake Kibare, Lake Rwampanga, and Ruhondo buffer zone wetland

Two systems are taken into consideration: natural systems (=ecological systems: the sites themselves and surrounding agro-ecosystems) and social systems (=socio-economic systems: surrounding local communities). For each extreme weather feature, root causes have been determined (drivers), and their impacts identified (Table 7).

[20] Two available resources are of great interest: MINEMA (2015). The National Risk Atlas of Rwanda; and an online interactive map which contains useful climatic-related datasets (http://maproom.meteorwanda.gov.rw/maproom/Climatology/Climate_Analysis/)

Table 7: Assessment of climate change impacts on wetland ecosystems

Extreme weather	**Prolonged drought**				**Heavy rainfall**			
Impacts	***Hot temperatures***		***Decrease in water levels***		***Soil erosion***		***Floods***	
Site	**Impact/System**[21]							
	NS	**SS**	**NS**	**SS**	**NS**	**SS**	**NS**	**SS**
Lake Cyohoha North ***Key drivers:*** • Agriculture and grazing encroachments on the lake's shores • Waste dumping in the lake (linked to cattle grazing and drinking) • Deforestation on the watershed • Drainage of Murago Wetland • Cutting of *Cyperus papyrus* and *Typha domingensis* • Invasive species		- Water scarcity **(HIGH)** - Decrease of crop production **(HIGH)** - Food shortage (famine) **(HIGH)**	- Invasive species[22] due to water decrease in Murago Wetland **(HIGH)** - Local extinction of some species (e.g. Grey crowned cranes, water birds…) **(HIGH)** - Lake's siltation **(HIGH)**	- Lack of clean water **(HIGH)** - Polluted water **(HIGH)** - Diseases outbreaks **(MEDIUM)** - Decrease of fish production **(HIGH).**	- Loss of lake shores **(HIGH)** - Depletion of soil fertility **(HIGH)**	- Crops damage **(HIGH)** - Diseases outbreaks **(MEDIUM)**		
Murago Wetland ***Key drivers:*** • Agriculture encroachment leading to wetland drainage • Burning for cultivation land preparation	Lack of fodder **(MEDIUM)**		- Reduction of wetland's ground-water flow **(HIGH)** - Reduction of wetland's stretch **(HIGH)**	Decrease of crop production **(MEDIUM)**				
Lake Kibare ***Key drivers:*** • Grazing encroachment on lake shores	- Crops damage **(HIGH)**	- Water scarcity **(HIGH)** - Decrease of crop production **(HIGH)**	Water hyacinth (invasive) from Akagera River **(HIGH)**	- Lack of clean water **(HIGH)** - Polluted water **(HIGH)**				Decrease of fish production **(MEDIUM).**

[21] NS: Natural System (including agro-ecosystem); SS: Social System

[22] Invasive species found in Lake Cyohoha North: *Nymphaea lotus, Ceratophyllum demersum* and *Potamogeton schweinfurthii*

• Water hyacinth • Intensive fishing	- Lack of fodder **(HIGH)** - Depletion of soil fertility **(MEDIUM)**	- Food shortage (famine) **(HIGH)** - Cattle deaths due to heat stress **(LOW)** - Decrease of milk production **(HIGH)**		- Diseases outbreaks **(MEDIUM)** - Decrease of fish production **(MEDIUM).**				
Lake Rwampanga ***Key drivers:*** • Agriculture encroachments on the lake's shores • Deforestation on the watershed	- Crops damages **(HIGH)** - Lack of fodder **(MEDIUM)**	- Water scarcity **(HIGH)** - Decrease of crop production **(HIGH)** - Food shortage **(MEDIUM)**	Local extinction of some species (e.g. Grey crowned cranes, water birds…) **(HIGH)**	- Lack of clean water **(HIGH)** - Polluted water (**HIGH)** - Decrease of fish production **(HIGH).** - Diseases outbreaks **(MEDIUM)**	- Loss of lake shores **(MEDIUM)** - Depletion of soil fertility **(MEDIUM)**	Decrease of crop production **(MEDIUM)**	Crops damage **(MEDIUM)**	- Diseases outbreaks **(MEDIUM)** - Decrease of crop production **(MEDIUM)** - Decrease of fish production **(MEDIUM)**
Lake Ruhondo ***Key drivers:*** • Agriculture on the steep slopes • Lack/insufficient soil stabilization practices				Significant decrease of some species such as *Allophylus africanus* (important habitat for fish spawning), *Phragmites mauritianus* (for shores stabilization) and *Atilax paludinosus* (an aquatic mammal) **(HIGH)**	- Loss of lake shores **(HIGH)** - Depletion of soil fertility **(HIGH)**	Crops damage **(HIGH)**	Crops damage **(HIGH)**	Human losses **(LOW)**

Step 3: Developing EbA Intervention Measures

A. Stressors control and eradication

The best practice for preventing further loss and degradation of wetlands is to remove non-climatic stressors or pressures on the ecological character of wetlands and avoid further disturbance. The possibility to restore a wetland does not justify the trade-off for the continued degradation; thus decision-makers and managers will not take restoration as a substitute for protecting and ensuring the wise use of wetlands.

Enabling conditions must be ensured for immediate and appropriate measures to recognize the full suite of environmental, cultural and socio-economic benefits from wetland restoration. In this regard, alternative sources of livelihoods needs must be developed, accompanied with steady awareness raising and education on the importance of the protection and conservation of wetlands & lakes. Technical support would also be needed for appropriate practices (e.g. conservation agriculture, protection of watersheds, waste management…). In drought prone areas, more water sources should be availed for health conditions improvement.

A wetland might not restore to the original state but could recover most of the ecological functions through ecological dynamics. Another complementary strategy is to control and avoid the negative influence of factors that are external to the natural systems such as erosion and pollution, etc. It is important also to focus on the management of invasive plants that proliferate further degrade the natural ecosystems.

B. Restoration of riparian and buffer zones with suitable and beneficial climate-resilient indigenous plant species

For the restoration of degraded wetland ecosystems using indigenous trees, the following table describes recommended protocol for each aspect.

Table 8: Recommended protocol for EbA restoration of degraded wetland ecosystems

No	Aspect	Description
1	Scope	Aim to cover the whole degraded sections, starting with the highly degraded zones or the most vulnerable to the current climatic and non-climatic stressors
2	Ecological adaptability	- Each plant should be chosen according to its ecological requirements, and only ecologically adapted indigenous tree species should be planted.

		- Anatomical and physiological characteristics of identified plant species should be considered during the plantation (waterlogged areas, riparian zone, buffer zone...) - No exotic plant should be used, except in rare cases after careful judgment of the inevitability.
3	Climate change adaptation/mitigation	Species should be identified based on their potential contribution to climate change adaptation/mitigation
4	Benefits to local communities	Identify suitable climate-resilient but also beneficial indigenous species to local community's needs.
5	Local knowledge and practices	- Take into consideration local knowledge and traditional practices in terms of preferred plant species and planting/maintenance practices - Technical/scientific methods for planting/maintenance should supplement local knowledge/practices
6	Care and maintenance	- It is advised to avoid the use of fertilizers in wet places to prevent them from leaching - Take appropriate measures for the management to remove invasive species and prevent further propagation. - Protect the plants from damages (e.g. encroachment, uprooting...) - Regularly monitor the health status of the plants and take appropriate action

Case studies: Identified Climate-Resilient Indigenous species Lake Cyohoha North, Murago Wetland, Lake Kibare, Lake Rwampanga, and Ruhondo buffer zone wetland

Identified climate-resilient indigenous species for the restoration of the wetlands/lakes in the study sites are described in table 9. All the names of wetland ecosystems will be symbolized by their two first initials (Cyohoha = CY, Murago = MU, Kibare = KI, Rwampanga = RW, Ruhondo = RU). Any critical information for their role in the implementation of EbA interventions is described. The roles are defined as:

1) For climate resilience: FH = Fish spawning habitat, LF = Live fence, I&D = Insect and disease resistant, SF = Soil fertility (litter production, nitrogen fixation...), SH = Shading, SP = Shore's protection, SS = Soil stabilization, WB = Wind breaking

2) For livelihood impact: BF = Bee forage, CM = Construction material, HC = Handicraft, FD = Fodder/Mulch, FR = Edible fruits, FW = Fuel wood, O = Ornamental, TB = Timber, TM = Traditional medicine

For the case of wetlands/lakes, two zones/areas are considered for the plantations, namely riparian zone (RZ) and cropland (CL).

Table 9: Description of suitable indigenous tree species for wetland ecosystem restoration

No	Scientific name	Local name	Site					Climate resilience role	Livelihood impact role	Zone	
			CY	MU	KI	RW	RU			RZ	CL
1	*Acacia gerrardii*	Umugunga			x			SF, SH, SS	BF, HC, FD, TM		x
2	*Acacia polyacantha*	Umunyinya/Umugu	x	x	x	x		SF, SP, SS, WB	BF, CM, FD, FW, TB	x	
3	*Aeschynomene elaphroxylon*	Ikizira			x	x		FH, LF, SF, SP	HC, FW, TM	x	
4	*Albizia petersiana*	Umumeyu			x			SF, SH, SS	CM, HC, FW, TB, TM		x
5	*Allophylus africanus*	Umutete					x	FH, SP, SS	BF, HC, FD,	x	
6	*Bambusa vulgaris*	Umugano	x	x		x	x	LF, I&D, SP, SS, WB	CM, HC	x	
7	*Cyperus latifolius*	Urukangaga		x				SS	HC, FD	x	
8	*Cyperus papyrus*	Urufunzo	x	x		x		FH, SP	HC, FD, O, TM	x	
9	*Erythrina abyssinica*	Umuko	x	x				LF, I&D, SF,SH, SS	BF, HC, FW, O, TB, TM		x
10	*Ficus thonningii*	Umuvumu	x	x		X		I&D, SF, SH, WB	HC, FD, FW, TB		x
11	*Ficus vallis-choudae*	Umudobori			x	x		I&D, SP, SS	BF, CM, HC, FR	x	
12	*Grewia similis*	Umukomagore			x			I&D, SF, SH, SS	BF, HC, FD, FW, TM		x
13	*Lannea schimperi*	Umumuna			x			I&D, SH, SS	BF, CM, HC, FD, FW, FR, TB, TM		x
14	*Marhamia lutea*	Umusave	x	x		X		I&D, SF, SH, SS	CM, HC, FW		x

15	*Olea europea* subsp. *cuspidata*	Umunzenze			x			I&D, SF, SH, SS, WB	BF, CM, HC, FW, FR, TB		x
16	*Pennisetum purpureum*	Urubingo		x		x	x	SP, SS	FD	x	x
17	*Phoenix reclinata*	Umukindo	x	x	x	x		SP, SS	HC, O	x	
18	*Phragmites mauritianus*	Imiseke/Amaseke	x			x	x	FH, LV, SP	HC, O	X	
19	*Sesbania sesban*	Umunyegenyege					x	SF, SH	BF, HC, FD, FW, TM	x	x
20	*Typha domingensis*	Umuberanya	x	x				FH, SP	HC, FD, O, TM	x	

Step 4: Monitoring and Evaluation of EbA Implementation

The coordination of implementation of activities, and mostly also the other activities from planning until monitoring and review, has on top the Rwanda Environment Management Authority (REMA). REMA will have a site manager at the pilot sites who will coordinate activities. However, as coordination and follow-up reach better performance when they are participatory and systematically organized, two other major options will be considered: 1) involving one person either REMA staff or consultant in a team of coordination, 2) include one member of the LPT in the coordination. Thus, up to four people will make the ***coordination committee*** at each intervention site.

A. Monitoring

Monitoring activities are to be conducted each 3 months in the two first years and each 6 months after first two years of implementation of EbA interventions. Annual workshops are to take place at the intervention sites to present monitoring progress and findings in the presence of all key stakeholders of the EbA program, including a high representation of local communities.

It is recommended to set a monitoring plan along the project management cycle. Below are key elements adapted from REMA (2010) [23] with conceptualization into EbA interventions in restoration programs.

[23] *Idem* as in REMA (2010).

Proposed steps to be defined for the monitoring planning include:

- Select the parameters to will monitor based on the target criteria established
- Develop procedures for qualitative and quantitative monitoring
- Collect data at intervals that will ensure maximum monitoring performance
- Use an adaptive process to identify corrective measures where appropriate
- Set long-term monitoring and maintenance plan to ensure maximum ecological value
- Disseminate monitoring data and results to local communities and publish in newsletters

B. Evaluation

The process of EbA evaluation has been elucidated in different interventions, such as in Nepal[24], in Kenya[25] and in Bangladesh[26]. Effective EbA can be defined as "an intervention that has restored, maintained or enhanced the capacity of ecosystems to produce services; these services in turn enhance the wellbeing, adaptive capacity or resilience of humans, and reduce their vulnerability; the intervention also helps the ecosystem to withstand climate change impacts and other pressures". The coordination committee will therefore make an evaluation of the EbA interventions to ensure that they are financially and/or economically viable, and for benefits to materialize it needs support from local, regional and national governments and to be embedded in an enabling policy, institutional and legislative environment.

The evaluation must assess the different key attributes of ecosystem-based approaches to adaptation (EbA):

1) Human-centric
2) Harnesses the capacity of nature to support long-term human adaptation
3) Draws on and validates traditional and local knowledge
4) Based on best available science
5) Can benefit the world's poorest
6) Community-based and incorporates human rights-based principles
7) Involves cross-sectoral and intergovernmental collaboration
8) Operates at multiple geographical, social, planning and ecological scales
9) Integrates decentralized flexible management structures
10) Minimizes trade-offs and maximizes benefits with development and conservation goals

[24] *Idem* as in Reid, H. and Ali, L. (2018).
[25] Reid, H. and Orindi, V. (2018). Ecosystem-based approaches to adaptation: strengthening the evidence and informing policy. Research results from the Supporting Counties in Kenya to Mainstream Climate Change in Development and Access Climate Finance project, Kenya. International Institute for Environment and Development, 38 p.
[26] Reid, H. and Adhikari, A. (2018). Ecosystem-based approaches to adaptation: strengthening the evidence and informing policy. Research results from the Mountain EbA Project, Nepal. International Institute for Environment and Development, 40 p.

11) Provides opportunities for scaling up and mainstreaming
12) Involves longer-term 'transformational' change

According to those authors again, more generally, the evaluation of EbA should follow the steps in the framework of assessing EbA effectiveness, as summarized in the following table.

Table 10: Steps for EbA evaluation-wetlands

No	Area of evaluation	Question for evaluation
1	Effectiveness for human societies	Did the initiative allow human communities to maintain or improve their adaptive capacity or resilience, and reduce their vulnerability, in the face of climate change, while enhancing co-benefits that promote long-term wellbeing?
2	Effectiveness for the ecosystem	Did the initiative restore, maintain or enhance the capacity of ecosystems to continue to produce adaptation services for local communities, and allow ecosystems to withstand climate change impacts and other stressors?
3	Financial and economic effectiveness	Is EbA cost-effective and economically viable over the long-term?
4	Policy and institutional issues	What social, institutional and political issues influence the implementation of effective EbA initiatives and how might challenges best be overcome?

Proposed timeline or schedule for evaluation of the EbA program of restoration of degraded wetland ecosystems is as summarized in the following table.

Table 11: Schedule for evaluation of the EbA restoration of wetland ecosystems

No	Level of evaluation	Period or specific time in the program
1	First evaluation	1 year after tree plantation to assess the success rate
2	Follow-up evaluation	4 years after tree plantation
3	Follow-up evaluation	8 years after tree plantation
4	End-project evaluation	10 years after the beginning of project

We also recommend that evaluation will be part of aspects to be included in the Rwanda State of Environment Outlook Report (SEOR) which is produced every four years.

4. EBA TECHNICAL GUIDELINES FOR CLIMATE-RESILIENT RESTORATION OF SAVANNA ECOSYSTEMS

In Rwanda, savanna ecosystems are commonly found in the Eastern part of the country, mostly around the largest savannah Akagera National Park. The EbA technical guidelines developed in this document will apply to one pilot site (Rwinkwavu Hill), to guide on appropriate approach on how to help people leaving in the surroundings of savanna ecosystems to adapt to negative impacts of climate change.

The impacts of climate change on savanna ecosystems due to prolonged and severe drought have a dangerous effect on the benefits provided by these ecosystems. The degradation from human activities such as deforestation, bad farming practices, overgrazing…combined with climate change impacts exacerbates the negative effects. As consequence, various ecological and socio-economic benefits provided by savanna ecosystems are threatened. Major threatened ecosystem services include typical floral and wildlife biodiversity useful for different purposes such as source of tourism, medicine, food, wood…, their role in protecting associated water bodies, their aesthetic beauty, their role in maintaining soil processes and hydrological balance and their contribution to climate regulation by carbon sequestration (Kaur, 2006[27]; Egoh *et al.*, 2011[28]; FAO 2014[29]; Mansourian & Vallauri 2014[30] and Stanturf et al. 2017[31])

[27] Kaur, K. (2006). The role of ecosystem services from tropical savannas in the well-being of Aboriginal people: A scoping study. A report for the Tropical Savannas Cooperative Research Centre, Darwin, NT.
[28] Egoh, B.N., Reyers, B., Rouget, M., Richardson, D.M (2011). Identifying priority areas for ecosystem service management in South African grasslands. Journal of Environmental Management. Volume 92, Issue 6, pages 1642-1650
[29] Food and Agriculture Organizationof the United Nations (2014). Restoration of grasslands and forests for climate change mitigation and adaptation, and the promotion of ecosystem services. FAO Regional Conference for Asia and the Pacific (APRC). 12 p.
[30] Mansourian, S. and Vallauri, D., 2014. Restoring forest landscapes: important lessons learnt. Environmental Management 53, 241-251
[31] *Idem* as in Stanturf *et al (*2017).

4.1. GUIDING PRINCIPLES FOR THE EBA PROCESS FOR SAVANNAS RESTORATION

Seven principles are applicable for the EbA restoration of savanna ecosystems in order to enhance the resilience of socio-ecological savanna-associated systems in the face of climate change impacts. The principles indicated in the following table will be followed to ensure the best desired situation of restoration.

Table 12: Principles for EbA-based savanna ecosystem restoration

Principle	**Relevance for EbA-based savanna ecosystem restoration**
Sustainability as a goal	Restoration outcomes should appear in a way that natural dynamics and services are maintained to serve future generations
Clarity of process	The process and procedures of EbA-based savanna ecosystem restoration should be clear to all concerned stakeholders
Equity in participation and decision-making	There is need of fair allocation and endowment of interests and roles among all stakeholders with focus on local communities
Credibility of science	The scientific methods to be used should be supported by local knowledge and practices; and they should be credible and supported by the scientific community
Transparency in implementation	Implementation must be aligned with defined and agreed procedures; correct and fair monitoring should apply
Flexibility of management	As the ecosystems are affected by anthropogenic impacts and natural events, an adaptive strategy should be adopted whenever it applies
Accountability for decisions	Decision-makers should be accountable and the decision-making process should bring credible and relevant results to all stakeholders

4.2. EBA STEPS FOR SAVANNAS RESTORATION

This section describes the steps of EbA intervention actions for savanna ecosytem restoration (Figure 5).

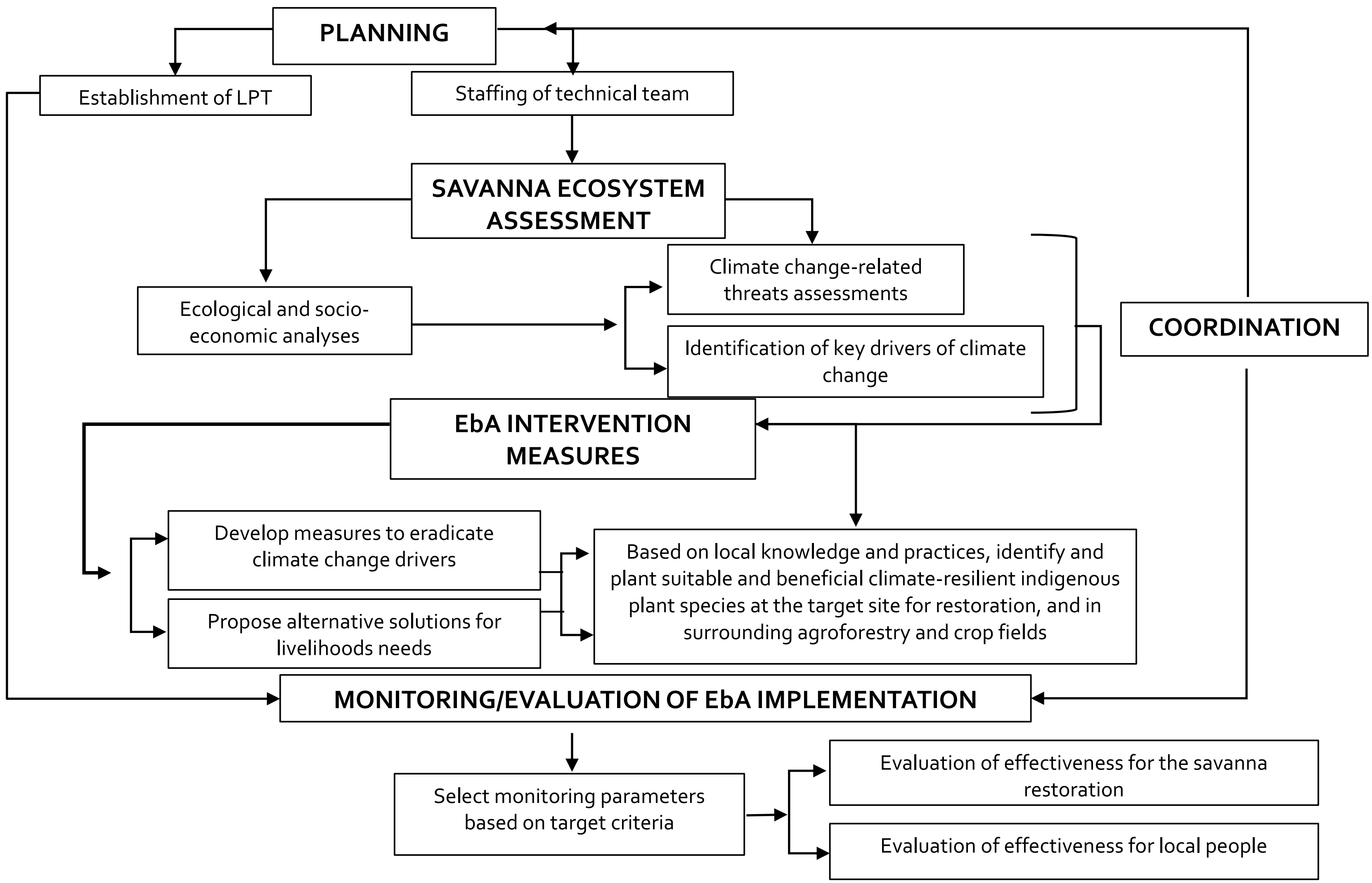

Figure 5: Proposed conceptual model for EbA process in savanna restoration

Step 1: Planning

During the planning phase, the EbA project managers and stakeholders need to turn goals into clear and measurable objectives and actions, and identify starting and ending points for restoration of specific landscape elements[32].

A. Establishing a Local Planning Team

The first step for EbA implementation is the establishment of a **Local Planning Team (LPT)** responsible of following up the implementation of EbA interventions at the site level. The team would oversee the implementation of standard procedures and EbA guidelines, monitor plans for the long-term sustainability and maintenance of the project's EbA activities to generate long-term ecological and socio-economic benefits. For EbA savanna restoration, we propose that the LPT will be composed of at least 10 people, including **(1)** REMA representative (site manager), **(1)** field technician, **(6)** local people (1 from agro-pastoral cooperative (if existing), 1 from mining cooperative (if existing), 2 females and 2 youth representatives), **(1)** local agronomist and the **(1)** Socio-Economic Development Officer (SEDO) of the Cell.

The LPT will be different from **Coordination Committee** which would oversee the whole process nationwide, mainly at the level of Planning and Monitoring & Evaluation. The LPT would be established by the Coordination Committee in consultation (where necessary) with any relevant stakeholders. This Committee is proposed to be composed of the project team at REMA (Project manager, Monitoring & Evaluation Officer and SPIU Coordinator).

B. Staffing of Technical Team

For effective implementation of EbA for savannas restoration, adequate knowledge and expertise of savanna ecosystems is required. Thus, the Coordination Committee will define qualification criteria and other requirements for the recruitment of needed expert(s).

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[32] *Idem* as in Stanturf *et al (*2017).

Step 2: Ecosystem Assessment

A. Ecological and Socio-Economic Assessments

EbA interventions for savanna ecosystem restoration must ensure the collection of ecological and socio-economic baseline data of each target savanna ecosystem which are key to understand background situation of the ecosystem (Table 13).

Table 13: Key data for savannas' baseline characterization

Data types	Examples
Ecological	Species information (fauna and flora), landscape structure, ecological processes, ecosystem services, climate patterns…
Socio-economic	Main economic activities, livelihood conditions, demographic variables, …

For Rwinkwavu Hill as pilot site for savanna restoration, the technical team is recommended to use the proposed methodological approach for the assessments as indicated in Table 14. The estimated time for the assessments will depend on technical teams scoping, which should range from one to two weeks.

Table 14: Baseline information collection guidelines-savannas

Data types	Proposed methodology	Sources of data
Ecological	Biodiversity inventories of key species, direct observations, interviews, review of information records, mapping tools, lab tests…	Primary (mainly) and secondary
Socio-economic	Literature review, interviews (households, individuals, focus group); key informants consultations, direct observations of major land uses…	Primary (mainly) and secondary

Case study: Ecosystem Assessment
Rwinkwavu Hill Savanna

Climatic patterns of Rinkwavu Hill[33] indicate that it is located (refer to Figure 1) in drought prone region (Figure 6).

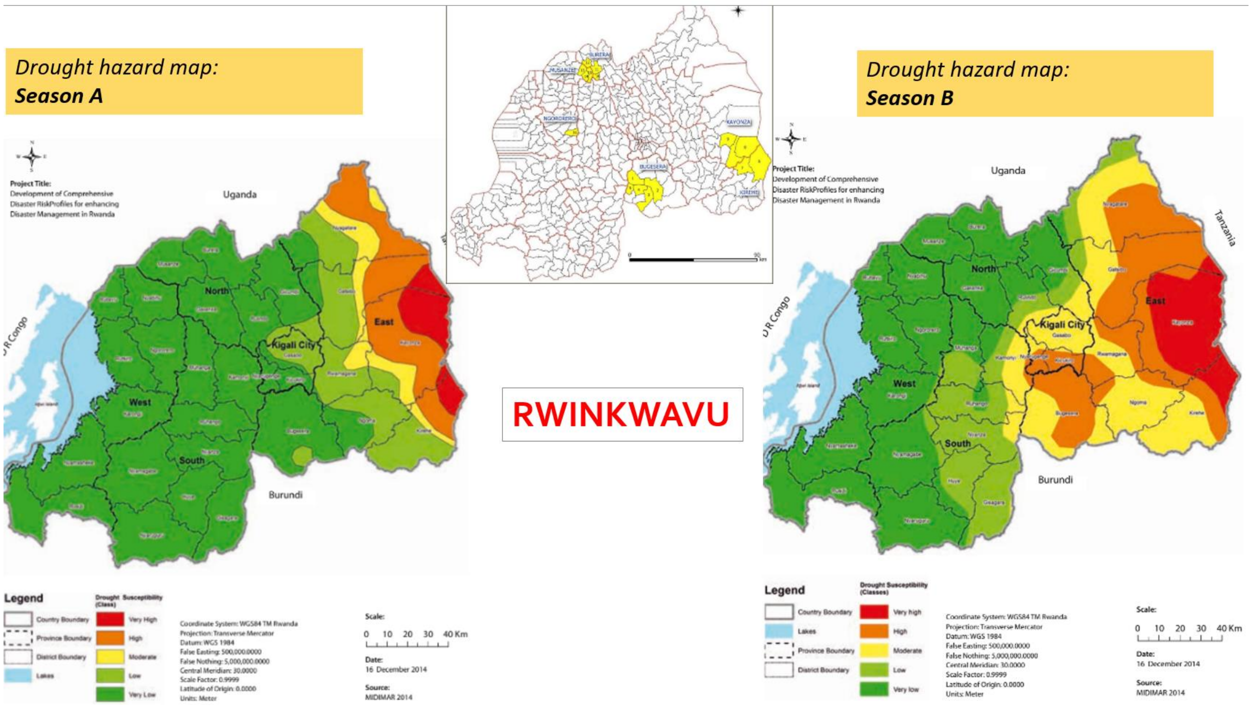


Figure 6: Drought hazard maps of Rwanda

Detailed description of ecological and socio-economic characteristics of the study site is provided in table 15.

Table 15: Savanna ecosystem descriptions

Ecosystem[34]	Ecological features	Socio-economic characteristics
Rwinkwavu hill (Area: 117 ha)	• Medium altitude (1,430-1,630m a.s.l) • Rwinkwavu Hill is located in the vicinity of Kadiridimba River • Characteristic biodiversity: • Although severely degraded, some relicts of native plant species can still be found. They include *Combretum collinum*, *Combretum molle*, *Grewia bicolor*, *Searsia pyroides*, *Gymnosporia*	• The site is located not far from commercial centers of Kabarondo and Rwinkwavu • Various crops are grown in the Kadiridimba-associated wetland (mainly vegetables…) • Mining activities are common in this area which is rich in wolfram, cassiterite…

33 *Idem as* in MINEMA (2015).
34 The map of Rwinkwavu location is found in Appendix 3

	senegalensis, Vernonia amygdalina, Euclea racemosa, Euphorbia candelabrum… • Eucalyptus plantations dominate the biggest part of Rwinkwavu Hill • There was no wildlife recorded • Main ecosystem services: • The forest contributes to soil stabilization and erosion control • It is the source of firewood, timber for construction, medicinal plants, and it is used for bee keeping • The site is rich in wolfram minerals • Climatic patterns: Prolonged dry seasons and erratic rainfall (Figure 5) resulting in severe water shortage conditions.	• Poverty level: Low: 20-29.9% (NISR, 2017[35]).

B. Assessment of Climate Change-Related Threats and Identification of human-induced drivers of Climate Change

It is recommended that a technical team conducts an assessment of the impacts of climate change (CC) at two levels: CC impacts on the savanna ecosystem under study (natural system) and CC impacts on the livelihoods of local communities (social system).

The information/data from the vulnerability analysis will serve as a starting point to the assessment of CC impacts. As defined in the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), vulnerability to climate change is "a function of the character, magnitude and rate of climate change and variation to which a system is exposed, its sensitivity and its adaptive capacity[36]". To determine the relevance and scope of EbA process, the expert(s) will therefore determine the vulnerability of the communities to adverse impacts of climate change and assess the vulnerability of ecosystems through known vulnerability maps for the intervention site or other possible field assessments.

Due to lack of sufficient climate-related data in most cases, it is advised to carry out qualitative ranking of the impacts (through stakeholders' involvement, meetings, interviews, questionnaires, field observations…), and combine the information on the likelihood of the hazard and the consequence of the hazard[37] (Table 16):

[35] *Idem* as in NISR (2017).
[36] *Idem* as in McCarthy *et al* (2001).
[37] *Idem* as in Bhat, C. (2017).

Table 16: Qualitative ranking of the impacts-savannas

		Consequence of impact		
		Insignificant	***Moderate***	***Extreme***
Likelihood of impact	***Certain***	Medium	High	High
	Possible	Low	Medium	High
	Unlikely	Low	Low	Medium

The proposed approach to determine the spectrum of impacts is to consider the temporal and spatial scales:

- *Temporal scale:* Assess whether the CC causes short, medium or long-term impacts
- *Spatial scale:* The technical expert(s) can determine the limits of the spatial scale. The extent of the impacts will be defined as being either place-based (i.e. at the ecosystem level - within the limits of the savanna…), or locally limited (village level…), or extended to national level…

Collected information can be supplemented by quantitative assessments (such as indicators, indices and maps…[38]).

[38] Two available resources are of great interest: MINEMA (2015). The National Risk Atlas of Rwanda; and an online interactive map which contains useful climatic-related datasets (http://maproom.meteorwanda.gov.rw/maproom/Climatology/Climate_Analysis/)

Case study: Climate Change Impact Assessment Rwinkwavu Hill Savanna

Two systems are taken into consideration: natural systems (=ecological systems: the sites themselves and surrounding agro-ecosystems) and social systems (=socio-economic systems: surrounding local communities). For each extreme weather feature, root causes have been determined (drivers), and their impacts identified (Table 17).

Table 17: Assessment of climate change impacts on savanna ecosystems

Extreme weather	**Prolonged drought**				**Heavy rainfall**			
Impacts	***Hot temperatures***		***Decrease in water levels***		***Soil erosion***		***Floods***	
Site	**Impact/System**[39]							
	NS	**SS**	**NS**	**SS**	**NS**	**SS**	**NS**	**SS**
Rwinkwavu Hill ***Key drivers:*** • Mining • Deforestation	- Loss of soil retention capacity **(HIGH)** - Local extinction of many native plant and animal species **(HIGH)** - Increased vulnerability to invasive species **(HIGH)**	- Water scarcity **(HIGH)** - Lack of resources (firewood, timber, medicine...) **(HIGH)** - Erosion **(MEDIUM)**						

Step 3: Developing EbA Intervention Measures

A. Stressors control and eradication

As for other human-modified ecosystems, one of the best practices for preventing further loss and degradation of savannas is to remove non-climatic stressors or pressures on the ecological character of savannas and avoid further disturbance. The possibility to restore a savanna does not justify the trade-off for the continued degradation; thus decision-makers and managers will not take restoration as a substitute for protection and wise use.

Enabling conditions must be ensured for immediate and appropriate measures to recognize the full suite of environmental and socio-economic benefits from savanna restoration. In this regard, alternative sources of livelihoods needs must be developed, accompanied with steady awareness raising and education on the importance of the protection and conservation of savannas. Technical support would also be needed for appropriate practices (e.g. mining,

[39] NS: Natural System (including agro-ecosystem); SS: Social System

conservation agriculture, rangeland management ...). In drought-prone areas, more water sources should be availed for health conditions improvement.

A savanna might not restore to the original state but could recover most of the ecological functions through ecological dynamics. Another complementary strategy is to control and avoid the negative influence of factors that affect the composition, complexity and health of savanna habitats, mainly mining, and overgrazing in some places which result into creating favorable conditions for invasive species, etc.

B. Restoration of the savanna ecosystem with suitable and beneficial climate-resilient indigenous plant species

For the restoration of degraded savanna ecosystems using indigenous trees, the following table describes recommended protocol for each aspect.

Table 18: Recommended protocol for EbA restoration of degraded savanna ecosystems

No	Aspect	Description
1	Scope	Aim to cover the whole degraded sections, starting with the highly degraded zones or the most vulnerable to the current climatic and non-climatic stressors
2	Ecological adaptability	- Each plant should be chosen according to its ecological requirements, and only ecologically adapted indigenous tree species should be planted. - Anatomical and physiological characteristics of identified plant species should be considered during the plantation (drought-resistance, growth rate, disease resistance...) - No exotic plant should be used, except in rare cases after careful judgment of the inevitability.
3	Climate change adaptation/mitigation	Species should be identified based on their potential contribution to climate change adaptation/mitigation
4	Benefits to local communities	Identify suitable climate-resilient but also beneficial indigenous species to local community's needs.
5	Local knowledge and practices	- Take into consideration local knowledge and traditional practices in terms of preferred plant species and planting/maintenance practices - Technical/scientific methods for planting/maintenance should supplement local knowledge/practices
6	Care and maintenance	- It is advised to avoid the use of chemical fertilizers in planting; if needed at all, use plant debris found in the same habitat - Take appropriate measures for the management to remove invasive species and prevent further propagation. - Protect the plants from damages (e.g. encroachment, uprooting...) - Regularly monitor the health status of the plants and take appropriate action

Case study: Identified Climate-Resilient Indigenous Species Rwinkwavu Hill Savanna

Identified climate-resilient indigenous species for the restoration of Rwinkwavu Hill are described in table 19. The roles are defined as:

1) For climate resilience: DR = Drought Resistant I&D = Insect and disease resistant, SF = Soil fertility (litter production, nitrogen fixation…), SH = Shading, SS = Soil stabilization

2) For livelihood impact: BF = Bee forage, CM = Construction material, HC = Handicraft, FD = Fodder/Mulch, FR = Edible fruits, FW = Fuel wood, O = Ornamental, TB = Timber, TM = Traditional medicine.

For the case of savannas, two zones/areas are considered for the plantations, namely the natural forest (NF) and surrounding agroforestry and crop fields (AF & CF).

Table 19: Description of suitable indigenous tree species for savanna ecosystem restoration

No	Scientific name	Local name	Climate resilience role	Livelihood impact role	Zone	
					NF	AF & CF
1	*Albizia adiantifolia*	Umusebeya	DR, SF, SH	BF, FW, TB	x	x
2	*Albizia amara*	Umunanira	DR, SF, SS	FD, FW, TM	x	x
3	*Albizia petersiana*	Umumeyu	SF, SH, SS	CM, HC, FW, TB, TM	x	x
4	*Combretum collinum*	Umukoyoyo	DR, SS	BF, FW, TM	x	
5	*Combretum collinum*	Umukoyoyo	DR, SS	BF, FW, TM	x	
6	*Erythrina abyssinica*	Umuko	DR, I&D, SF,SH, SS	BF, HC, FW, O, TB, TM	x	x
7	*Euclea racemosa* subsp. *schimperi*	Umushikiri	DR, I&D, SF, SS	FW, TM	x	
8	*Lannea schimperi*	Umumuna	DR, I&D, SH, SS	BF, CM, HC, FD, FW, FR, TB, TM	x	x
9	*Markhamia lutea*	Umusave	I&D, SF, SS	BF, CM, FW, O, TB,		x
10	*Markhamia obtusifolia*	Umukundambazo	DD, I&D, SS	BF, FW, O, TM, TB	x	x
11	*Ozoroa insignis*	Umukerenke	DD, I&D, SH	BF, FW, TB, TM	x	
12	*Pappea capensis*	Umurerampango	DR, I&D, SF, SH, SS	BF, CM, HC, FW, TB,	x	x
13	*Parinari curatellifolia*	Umunazi	DD, I&D, FW,	BF, CM, FW, FR, O, TB, TM	x	x
14	*Searsia pyroides*	Umusagara	DR	FW, TM	x	

15	*Ximenia caffra*	Umusasa	DD, I&D	HC, FR, FW, TM	x	x

Step 4: Monitoring and Evaluation of EbA Implementation

The coordination of implementation of activities, and mostly also the other activities from planning until monitoring and review, has on top the Rwanda Environment Management Authority (REMA). REMA will have a site manager at the pilot sites who will coordinate activities. However, as coordination and follow-up reach better performance when they are participatory and systematically organized, two other major options will be considered: 1) involving one person either REMA staff or consultant in a team of coordination, 2) include one member of the LPT in the coordination. Thus, up to four people will make the ***coordination committee*** at each intervention site.

A. Monitoring

Monitoring activities are to be conducted each 3 months in the two first year and each 6 months after first two years of implementation of EbA interventions. Annual workshops are to take place at the intervention sites to present monitoring progress and findings in the presence of all key stakeholders of the EbA program, including a high representation of local communities.

It is recommended to set a monitoring plan along the project management cycle. Below are key elements adapted from REMA (2010) [40] with conceptualization into EbA interventions in restoration programs.

Proposed steps to be defined for the monitoring planning include:

- Select the parameters to monitor based on the target criteria established
- Develop procedures for qualitative and quantitative monitoring
- Collect data at intervals that will ensure maximum monitoring performance
- Use an adaptive process to identify corrective measures where appropriate
- Set long-term monitoring and maintenance plan to ensure maximum ecological value
- Disseminate monitoring data and results to local communities and publish in newsletters

B. Evaluation

[40] *Idem* as in REMA (2010).

The process of EbA evaluation has been elucidated in different interventions, such as in Nepal[41], in Kenya[42] and in Bangladesh[43]. Effective EbA can be defined as "an intervention that has restored, maintained or enhanced the capacity of ecosystems to produce services; these services in turn enhance the wellbeing, adaptive capacity or resilience of humans, and reduce their vulnerability; the intervention also helps the ecosystem to withstand climate change impacts and other pressures". The coordination committee will therefore make an evaluation of the EbA interventions to ensure that they are financially and/or economically viable, and for benefits to materialize it needs support from local, regional and national governments and to be embedded in an enabling policy, institutional and legislative environment.

The evaluation must assess the different key attributes of ecosystem-based approaches to adaptation (EbA):

1) Human-centric
2) Harnesses the capacity of nature to support long-term human adaptation
3) Draws on and validates traditional and local knowledge
4) Based on best available science
5) Can benefit the world's poorest
6) Community-based and incorporates human rights-based principles
7) Involves cross-sectoral and intergovernmental collaboration
8) Operates at multiple geographical, social, planning and ecological scales
9) Integrates decentralized flexible management structures
10) Minimizes trade-offs and maximizes benefits with development and conservation goals
11) Provides opportunities for scaling up and mainstreaming
12) Involves longer-term 'transformational' change

According to those authors again, more generally, the evaluation of EbA should follow the steps in the framework of assessing EbA effectiveness, as summarized in the following table.

Table 20: Steps for EbA evaluation-savannas

No	Area of evaluation	Question for evaluation
1	Effectiveness for human societies	Did the initiative allow human communities to maintain or improve their adaptive capacity or resilience, and reduce their vulnerability, in

[41] *Idem* as in Reid, H. and Ali, L. (2018).
[42] *Idem* as in Reid, H. and Orindi, V. (2018).
[43] *Idem* as in Reid, H. and Adhikari, A. (2018).

		the face of climate change, while enhancing co-benefits that promote long-term wellbeing?
2	Effectiveness for the ecosystem	Did the initiative restore, maintain or enhance the capacity of ecosystems to continue to produce adaptation services for local communities, and allow ecosystems to withstand climate change impacts and other stressors?
3	Financial and economic effectiveness	Is EbA cost-effective and economically viable over the long-term?
4	Policy and institutional issues	What social, institutional and political issues influence the implementation of effective EbA initiatives and how might challenges best be overcome?

Proposed timeline or schedule for evaluation of the EbA program of restoration of degraded savanna ecosystems is as summarized in the following table.

Table 21: Schedule for evaluation of the EbA restoration of savanna ecosystems

No	Level of evaluation	Period or specific time in the program
1	First evaluation	1 year after tree plantation to assess the success rate
2	Follow-up evaluation	4 years after tree plantation
3	Follow-up evaluation	8 years after tree plantation
4	End-project evaluation	10 years after the beginning of project

We also recommend that evaluation will be part of aspects to be included in the Rwanda State of Environment Outlook Report (SEOR) which is produced every four years.

5. EBA TECHNICAL GUIDELINES FOR CLIMATE-RESILIENT RESTORATION OF FOREST ECOSYSTEMS

FAO (2012)[44] defines a forest as a land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use. In this document, two natural forest which meet this definition are our focus: Makera and Sanza (also known as Nyabitukuru) Forests.

Forest ecosystems of Rwanda provide a range of various services of great importance for the forest habitats and human communities from local to country level. The services include mainly food and water provisioning, watershed protection, home to and protection of floral and faunal biodiversity, carbon sequestration and storage, recreation, tourism, nutrient cycling, soil formation and stabilization, pollination services, contribute to the favourable micro-climatic conditions...(RDB, 2017[45]; RoR, 2016[46]; REMA , 2015[47]; Masozera, 2008[48]).

Nonetheless, these forest benefits are threatened due to climate change impacts combined with human activities. The losses of forest areas over the last 30 years have severely affected the capacity of these ecosystems to provide the services (Andrew & Masozera, 2010[49]).

[44] Food and Agriculture Organization of the United Nations (2012). The Forest Resources Assessment Programme (FRA) 2015. Terms and Definitions
[45] Rwanda Development Board (2017). Gishwati-Mukura National Park. Ten-Year Management Plan and Three-Year Action Plan, Kigali, Rwanda.
[46] Republic of Rwanda (2016). National Biodiversity Strategy and Action Plan. Kigali, Rwanda
[47] Rwanda Environment Management Authority (2015). Threatened Terrestrial Ecosystems and Species in Need of Protection in Rwanda. Kigali, Rwanda
[48] Masozera, M. (2008). Valuing and Capturing the Benefits of Ecosystem Services of Nyungwe Watershed, SW Rwanda. Report
[49] Andrew, G., Masozera, M. (2010). Payment for Ecosystem Services and Poverty Reduction in Rwanda. Journal of Sustainable Development in Africa (Volume, 12, No. 3, 2010). Clarion University of Pennsylvania, Clarion, Pennsylvania

5.1. GUIDING PRINCIPLES FOR THE EBA PROCESS FOR FORESTS RESTORATION

The following principles adapted from REMA (2010[50]) should serve as the standards to guide, plan and implement EbA approach for forest restoration in Rwanda, to enhance the resilience of socio-ecological forest-associated systems in the face of climate change impacts. The EbA guidelines for climate-resilient restoration in forest ecosystems are developed in the line with these principles (Table 22).

Table 22: Principles for EbA-based forest ecosystem restoration

Principle	Relevance for EbA-based forest ecosystem restoration
Sustainability as a goal	Restoration outcomes should appear in a way that natural dynamics and services are maintained to serve future generations
Clarity of process	The process and procedures of EbA-based forest ecosystem restoration should be clear to all concerned stakeholders
Equity in participation and decision-making	There is need of fair allocation and endowment of interests and roles among all stakeholders with focus on local communities
Credibility of science	The scientific methods to be used should be supported by local knowledge and practices; and they should be credible and supported by the scientific community
Transparency in implementation	Implementation must be aligned with defined and agreed procedures; correct and fair monitoring should apply
Flexibility of management	As the ecosystems are affected by anthropogenic impacts and natural events, an adaptive strategy should be adopted whenever it applies
Accountability for decisions	Decision-makers should be accountable and the decision-making process should bring credible and relevant results to all stakeholders

[50] Rwanda Environment Management Authority. Practical Tools for Sectoral Environmental Planning. Kigali, Rwanda

5.2. EBA STEPS FOR FORESTS RESTORATION

This section describes the steps of EbA intervention actions for forests restoration (Figure 7).

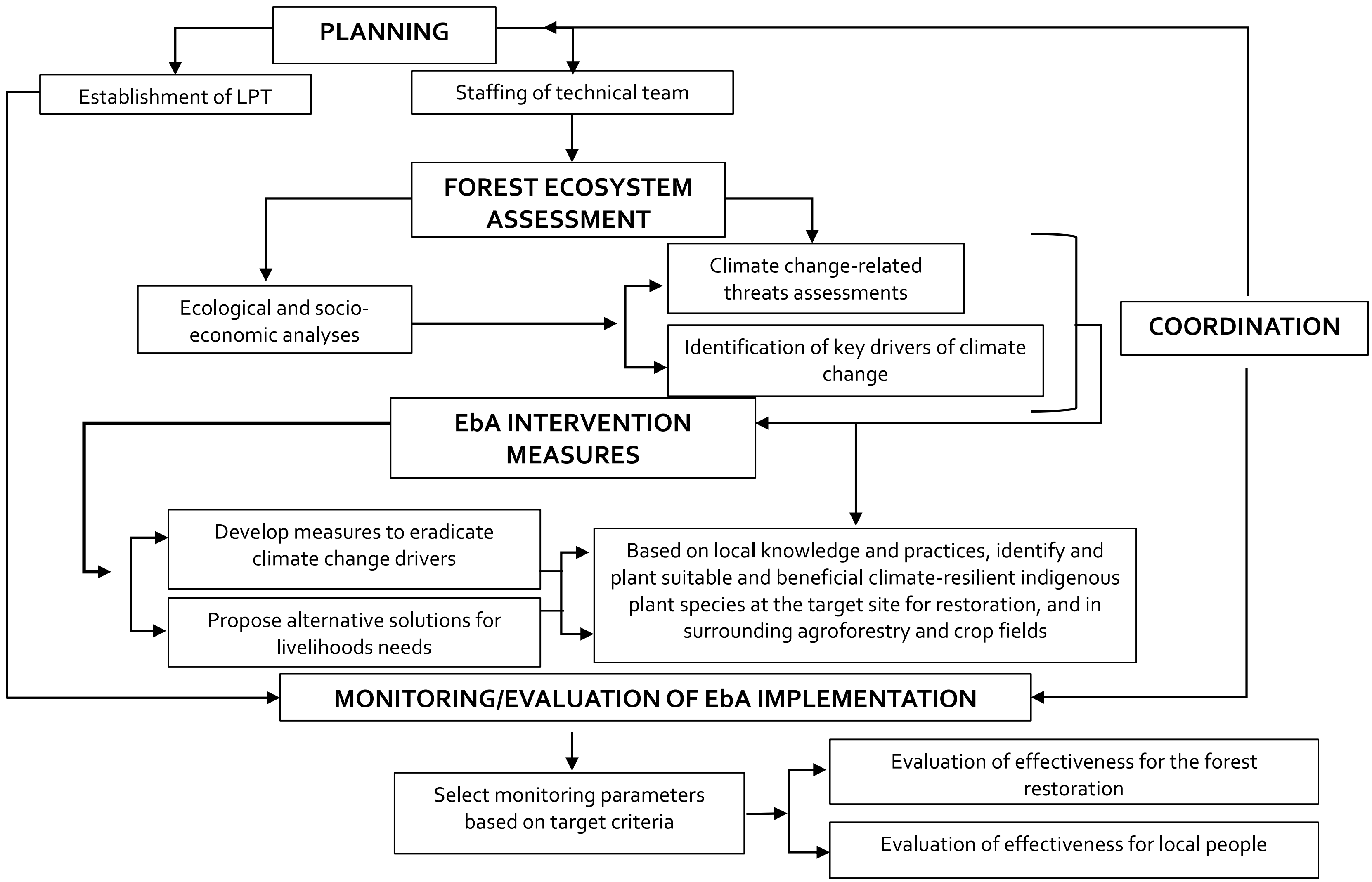


Figure 7: Proposed conceptual model for EbA process in forest restoration

Step 1: Planning

During the planning phase, the EbA project managers and stakeholders need to turn goals into clear and measurable objectives and actions, and identify starting and ending points for restoration of specific landscape elements[51].

A. Establishing a Local Planning Team

The first step for EbA implementation is the establishment of a **Local Planning Team (LPT)** responsible of following up the implementation of EbA interventions at the site level. The team would oversee the implementation of standard procedures and EbA guidelines, monitor plans for the long-term sustainability and maintenance of the project's EbA activities to generate long-term ecological and socio-economic benefits. For EbA forest restoration, we propose that the LPT will be composed of at least 10 people, including **(1)** REMA representative (site manager), **(1)** field technician, **(6)** local people (1 from agro-pastoral cooperative (if existing), 1 from mining cooperative (if existing), 2 females and 2 youth representatives), **(1)** local agronomist and the **(1)** Socio-Economic Development Officer (SEDO) of the Cell.

The LPT will be different from **Coordination Committee** which would oversee the whole process nationwide, mainly at the level of Planning and Monitoring & Evaluation. The LPT would be established by the Coordination Committee in consultation (where necessary) with any relevant stakeholders. This Committee is proposed to be composed of the project team at REMA (Project manager, Monitoring & Evaluation Officer and SPIU Coordinator).

B. Staffing of Technical Team

For effective implementation of EbA for forest restoration, adequate knowledge and expertise of forest ecosystems is required. Thus, the Coordination Committee will define qualification criteria and other requirements for the recruitment of needed expert(s).

[51] *Idem* as in Stanturf *et al (*2017).

Step 2: Ecosystem Assessment

A. Ecological and Socio-Economic Assessments

EbA interventions for forest ecosystem restoration must ensure the collection of ecological and socio-economic baseline data of each target forest ecosystem which are key to understand background situation of the ecosystem (Table 23).

Table 23: Key data for forests' baseline characterization

Data types	Examples
Ecological	Species information (fauna and flora), landscape structure, ecological processes, ecosystem services, climate patterns…
Socio-economic	Main economic activities, livelihood conditions, demographic variables…

For the two forest ecosystems (Makera and Sanza), key baseline information recommended for the technical team to collect , the proposed methodological approach as well as the sources of data are presented in Table 24. The estimated time for the assessments will depend on technical teams scoping, which should range from one to two weeks.

Table 24: Baseline information collection guidelines-forests

Data types	Proposed methodology	Sources of data
Ecological	Biodiversity inventories of key species, direct observations, interviews, review of information records, mapping tools, lab tests…	Primary (mainly) and secondary
Socio-economic	Literature review, interviews (households, individuals, focus group); key informants consultations, direct observations of major land uses…	Primary (mainly) and secondary

Case studies: Ecosystem Assessment
Makera and Sanza Forests

The drought hazard maps indicate that the two forests are located in two different climatic regions (Figure 8[52]). Makera is located in drought prone region in the East of the country, while Sanza is located in Western high mountains of the country, where the climate is cooler than it is in the East (refer to Figure 1).

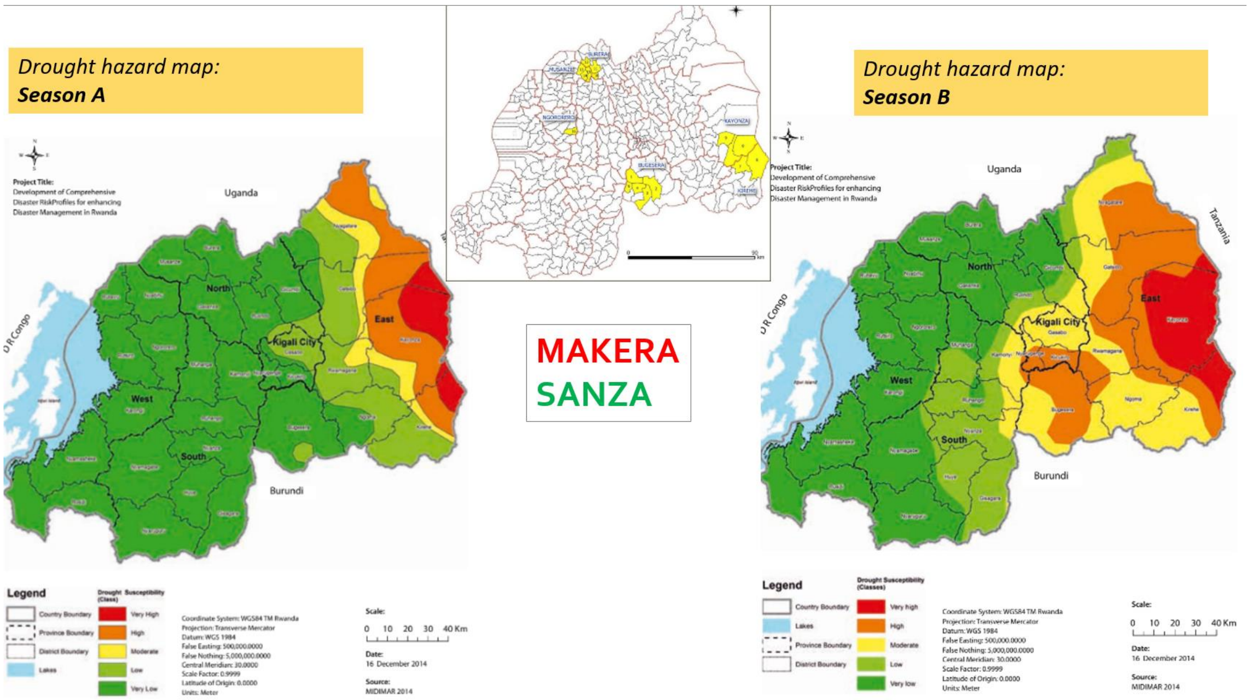


Figure 8: Drought hazard maps of Rwanda

Detailed description of ecological and socio-economic characteristics of the study site is provided in table 25.

Table 25: Forest ecosystems descriptions

Ecosystem[53]	Ecological features	Socio-economic characteristics
Makera Forest (Area: 72.5 ha)	• Middle altitude (1,313 m a.s.l) • Makera Natural Forest makes part of the complex of Ibanda-Makera made of two forests, Ibanda (a woodland savanna type located in the East) and Makera (a gallery forest located in the South-West)	• Makera regions is sparsely populated • Banana plantations are most dominant crops as source of food and income for households.

[52] *Idem as* in MINEMA (2015).
[53] The maps of Makera and Sanza locations are found in Appendix 3

	• Makera is contiguous to the Akagera wetland associated to Akagera River in the South-East on the border with Tanzania.
	• Characteristic biodiversity:
	    • The forest is host some typical gallery forest species, and dominant plant species include *Teclea nobilis, Bridellia micrantha, Rhus* divsp, *Grewia trichocarpa, Ficus thonningii, Ficus vallis-choudae, Acacia polyacantha, Dracaena afromontana, Markhamia lutea, Phoenix reclinata, Cyperus papyrus* (along the Akagera wetland), *Allophylus africanus, etc.*
	    • Different bird species have been recorded from previous studies [54][55] including migrants and forest dependent birds such as the rare Purple-bandend sunbird, Black Cuckoo-shrike, Levaillant's Cuckoo, Red-chested Cuckoo, Yellowbill…The vulnerable Grey Crowned Crane was also recorded.
	    • Baboons, bushpigs, blue monkeys and servals are known to be present in the forest, as well as several repliles including *Python sebae.*
	• Main ecosystem services:
	    • A stream called Nyampongoroma crosses the forest and is source to water used by many local people
	    • The papyrus swamp contributes to the reduction of water loss by evaporation.
	    • The forest's location in the dry region contributes to climate regulation in the region.
	    • Local people obtain different goods from the forest: firewood, medicinal plants, fodder, water…
		• Although agriculture is the main activity of the zone, pastoral and agropastoral groups are present and most households own some livestock and poultry by the poorer households[56].
		• Poverty level: Moderately High: 40-49.9% (NISR, 2017[57]).

Sanza Forest (Area: 23.9 ha)	• High altitude (1,820-1,980 m a.s.l) • The forest is on a very steep hill, and Satinsyi River borders the forest in the West. • The soil of the region of Gatumba where Sanza is located is known to be rich in mines • Characteristic biodiversity: • Sanza is an afromontane relict forest, with dominant plant species including *Syzygium parvifolium, Macaranga kilimanscharica, Neoboutonia macrocalyx, Myrianthus holstii* and *Albizia gummifera* (closest to the river). Some characteristic species of a secondary forest are	• Due to high steep relief of the area, households are scattered on the top of the hills • The soils is less fertile due to frequent erosions and landslides • Banana, beans and maize are main cultivated crops • Sources of income are very limited, and living conditions of local people are generally bad. • Poverty level: Moderately High: 40-49.9% (NISR, 2017[58]).

[54] Republic of Rwanda (2016). National Biodiversity Strategy and Action Plan. Kigali, Rwanda
[55] ACNR (2009). Eastern Gallery Forest Conservation Project. Biodiversity Survey. Rufford Small Grant Foundation.
[56] FEWSN (2012). Rwanda Livelihood Zones and Descriptions.
[57] *Idem* as in NISR (2017)
[58] *Idem* as in NISR (2017)

	also frequent. This is the case of *Maesa lanceolata, Xymalos monospora*… • Some exotic tree species including *Alnus glutinosa, Pinus patula, Grevillea robusta* and *Eucalyptus* div. sp. are also found. • Alnus and Pinus were planted as a buffer zone. • Most common birds are the Iminoga (Slender-billed Starling) which come regularly in Sanza at the beginning of the dry season in very large numbers and leaving by September each year • Main ecosystem services: • Although highly degraded, the forest hosts some remnant native species in the region • The forest is source to water sources used by local communities • Sanza Forest is a source of firewood, medicinal plants, edible fruits and honey for local communities. • The forest provides other ecological services such as water catchment, given that many water streams take source from this forest. • The forest also contributes in protecting Satinsyi River.	

B. Assessment of Climate Change-Related Threats and Identification of human-induced drivers of Climate Change

It is recommended that a technical team conducts an assessment of the impacts of climate change (CC) at two levels: CC impacts on the forest ecosystem under study (natural system) and CC impacts on the livelihoods of local communities (social system).

The information/data from the vulnerability analysis will serve as a starting point to the assessment of CC impacts. As defined in the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), vulnerability to climate change is "a function of the character, magnitude and rate of climate change and variation to which a system is exposed, its sensitivity and its adaptive capacity[59]". To determine the relevance and scope of EbA process, the expert(s) will therefore determine the vulnerability of the communities to adverse impacts of climate change and assess the vulnerability of forest ecosystems through known vulnerability maps for the intervention site or other possible field assessments.

Due to lack of sufficient climate-related data in most cases, it is advised to carry out qualitative ranking of the impacts (through stakeholders' involvement, meetings, interviews,

[59] *Idem* as in McCarthy *et al* (2001).

questionnaires, field observations…), and combine the information on the likelihood of the hazard and the consequence of the hazard[60] (Table 26):

Table 26: Qualitative ranking of the impacts-forests

		Consequence of impact		
		Insignificant	***Moderate***	***Extreme***
Likelihood of impact	***Certain***	Medium	High	High
	Possible	Low	Medium	High
	Unlikely	Low	Low	Medium

The proposed approach to determine the spectrum of impacts is to consider the temporal and spatial scales:

- *Temporal scale:* Assess whether the CC causes short, medium or long-term impacts
- *Spatial scale:* The technical expert(s) can determine the limits of the spatial scale. The extent of the impacts will be defined as being either place-based (i.e. at the ecosystem level - within the boundaries of the forest…), or locally limited (village level…), or extended to national level…

Collected information can be supplemented by quantitative assessments (such as indicators, indices and maps…[61]).

[60] *Idem* as in Bhat, C. (2017).
[61] Two available resources are of great interest: MINEMA (2015). The National Risk Atlas of Rwanda; and an online interactive map which contains useful climatic-related datasets (http://maproom.meteorwanda.gov.rw/maproom/Climatology/Climate_Analysis/)

Case studies: Climate Change Impact Assessment
Makera and Sanza Forests

Two systems are taken into consideration: natural systems (=ecological systems: the sites themselves and surrounding agro-ecosystems) and social systems (=socio-economic systems: surrounding local communities). For each extreme weather feature, root causes have been determined (drivers), and their impacts identified (Table 27).

Table 27: Assessment of climate change impacts on forest ecosystems

Extreme weather	**Prolonged drought**				**Heavy rainfall**			
Impacts	***Hot temperatures***		***Decrease in water levels***		***Soil erosion***		***Floods***	
Site	**Impact/System[62]**							
	NS	**SS**	**NS**	**SS**	**NS**	**SS**	**NS**	**SS**
Makera Forest ***Key drivers:*** • Agriculture encroachment • Tree cutting	- Local extinction of many native plant and animal species **(HIGH)** - Increased vulnerability to invasive species **(HIGH)**	- Water scarcity **(HIGH)** - Lack of resources (firewood, timber, medicine…) **(HIGH)**						
Sanza Forest ***Key drivers:*** • Mining • Inappropriate agriculture practices • Tree cutting					Local extinction of many native plant and animal species **(HIGH)**	- Landslides causing crops destruction and human & livestock causalities - Houses destructions - Diseases outbreak		Satinsyi flooding causes human casualties

[62] NS: Natural System (including agro-ecosystem); SS: Social System

Step 3: Developing EbA Intervention Measures

A. Stressors control and eradication

Regarding human-modified ecosystems, one of the best practices for preventing further loss and degradation of forests is to remove non-climatic stressors or pressures on the ecological character of forests and avoid further disturbance. The possibility to restore a forest does not justify the trade-off for the continued degradation; thus decision-makers and managers will not take restoration as a substitute for protection and wise use.

Enabling conditions must be ensured for immediate and appropriate measures to recognize the full suite of environmental and socio-economic benefits from savanna restoration. In this regard, alternative sources of livelihoods needs must be developed, accompanied with steady awareness raising and education on the importance of the protection and conservation of forests. Technical support would also be needed for appropriate practices (e.g. mining, conservation agriculture, soil stabilization on steep hills ...).

A forest might not restore to the original state but could recover most of the ecological functions through ecological dynamics. Another complementary strategy is to control and avoid the negative influence of factors that affect the composition, complexity and health of forest habitats, mainly mining, and deforestation in some places which result into creating favourable conditions for invasive species, etc.

B. Restoration of the forest ecosystem with suitable and beneficial climate-resilient indigenous plant species

For the restoration of degraded forest ecosystems using indigenous trees, the following table describes recommended protocol for each aspect.

Table 28: Recommended protocol for EbA restoration of degraded forest ecosystems

No	Aspect	Description
1	Scope	Aim to cover the whole degraded sections, starting with the highly degraded zones or the most vulnerable to the current climatic and non-climatic stressors
2	Ecological adaptability	- Each plant should be chosen according to its ecological requirements, and only ecologically adapted indigenous tree species should be planted. - Anatomical and physiological characteristics of identified plant species should be considered during the plantation (drought-resistance, growth rate, disease resistance...) - No exotic plant should be used, except in rare cases after careful judgment of the inevitability.

3	Climate change adaptation/mitigation	Species should be identified based on their potential contribution to climate change adaptation/mitigation
4	Benefits to local communities	Identify suitable climate-resilient but also beneficial indigenous species to local community's needs.
5	Local knowledge and practices	- Take into consideration local knowledge and traditional practices in terms of preferred plant species and planting/maintenance practices - Technical/scientific methods for planting/maintenance should supplement local knowledge/practices
6	Care and maintenance	- It is advised to avoid the use of chemical fertilizers in planting; if needed at all, use plant debris found in the same habitat - Take appropriate measures for the management to remove invasive species and prevent further propagation. - Protect the plants from damages (e.g. encroachment, uprooting…) - Regularly monitor the health status of the plants and take appropriate action

Case studies: Identified Climate-Resilient Indigenous Species Makera and Sanza Forests

Identified climate-resilient indigenous species for the restoration of Makera and Sanza forests are described in table 29. The roles are defined as:

1) For climate resilience: LF = Live fence, SF = Soil fertility (litter production, nitrogen fixation…), SH = Shading, SP = Slope protection, SS = Soil stabilization

2) For livelihood impact: LF = Live fencing, BF = Bee forage, CM = Construction material, HC = Handicraft, FR = Edible fruits, FW = Fuel wood, O = Ornamental, TB = Timber, TM = Traditional medicine.

For the case of forests, two zones/areas are considered for the plantations, namely the natural forest (NF) and surrounding agroforestry and crop fields (AF & CF).

Table 29: Description of suitable indigenous tree species for forest ecosystem restoration

No	Scientific name	Local name	Site[63]		Climate resilience role	Livelihood impact role	Zone	
			MAK	SAN			NF	AF & CF
1	*Acacia polyacantha*	Umugu	x		SF, SP, SS	BF, CM, FD, FW, TB	x	
2	*Albizia gummifera*	Umusebeya		x	DR, SF, SH	BF, FW, TB	x	x
3	*Allophylus africanus*	Umutete	x	x	SP, SS	BF, HC, FD	x	

[63] MAK: Makera; SAN: Sanza

4	*Bersama abyssinica* subsp. *Abyssinica*	Umukaka		x	SS	BF, FW, HC, O, TB	x	x
5	*Dombeya torrida*	Umukore		x	SP, SS	BF, FD, FW, O, TB	x	
6	*Ficus sp*	Umurehe		x	SP, SS	CM, FW, TB	x	x
7	*Ficus vallis-choudae*	Umudobori			SP, SS	BF, CM, HC, FR	x	
8	*M. kilimanscharica*	Umusekera	x	x	SP, SS	HC, FW, SH, TM	x	x
9	*Markhamia lutea*	Umusave			SF, SH, SS	CM, HC, FW		x
10	*Myrianthus holstii*	Umwufe		x	SF, SP, SS	FR, FW	x	x
11	*Phoenix reclinata*	Umukindo	x		SP, SS	HC, O	x	
12	*Polyscias fulva*	Umwungo	x	x	SP, SS	BF, HC, O	x	x
13	*Pterygota mildbraedii*	Umuguruka	x		SH, SS	BF, O, TB	x	
14	*Symphonia globulifera*	Umushishi		x	SP, SS	FW, O, TB	x	x
15	*Syzigium guineense*	Umugote						
16	*Vernonia amygdalina*	Umubirizi	x		LF, SF	BF, HC, FW, TM	x	x

Step 4: Monitoring and Evaluation of EbA Implementation

The coordination of implementation of activities, and mostly also the other activities from planning until monitoring and review, has on top the Rwanda Environment Management Authority (REMA). REMA will have a site manager at the pilot sites who will coordinate activities. However, as coordination and follow-up reach better performance when they are participatory and systematically organized, two other major options will be considered: 1) involving one person either REMA staff or consultant in a team of coordination, 2) include one member of the LPT in the coordination. Thus, up to four people will make the ***coordination committee*** at each intervention site.

A. Monitoring

Monitoring activities are to be conducted each 3 months in the two first year and each 6 months after first two years of implementation of EbA interventions. Annual workshops are to take place at the intervention sites to present monitoring progress and findings in the presence of all key stakeholders of the EbA program, including a high representation of local communities.

It is recommended to set a monitoring plan along the project management cycle. Below are key elements adapted from REMA (2010) [64] with conceptualization into EbA interventions in restoration programs.

[64] *Idem* as in REMA (2010).

Proposed steps to be defined for the monitoring planning include:

- Select the parameters to monitor based on the target criteria established
- Develop procedures for qualitative and quantitative monitoring
- Collect data at intervals that will ensure maximum monitoring performance
- Use an adaptive process to identify corrective measures where appropriate
- Set long-term monitoring and maintenance plan to ensure maximum ecological value
- Disseminate monitoring data and results to local communities and publish in newsletters

B. Evaluation

The process of EbA evaluation has been elucidated in different interventions, such as in Nepal[65], in Kenya[66] and in Bangladesh[67]. Effective EbA can be defined as "an intervention that has restored, maintained or enhanced the capacity of ecosystems to produce services; these services in turn enhance the wellbeing, adaptive capacity or resilience of humans, and reduce their vulnerability; the intervention also helps the ecosystem to withstand climate change impacts and other pressures". The coordination committee will therefore make an evaluation of the EbA interventions to ensure that they are financially and/or economically viable, and for benefits to materialize it needs support from local, regional and national governments and to be embedded in an enabling policy, institutional and legislative environment.

The evaluation must assess the different key attributes of ecosystem-based approaches to adaptation (EbA):

13) Human-centric
14) Harnesses the capacity of nature to support long-term human adaptation
15) Draws on and validates traditional and local knowledge
16) Based on best available science
17) Can benefit the world's poorest
18) Community-based and incorporates human rights-based principles
19) Involves cross-sectoral and intergovernmental collaboration
20) Operates at multiple geographical, social, planning and ecological scales
21) Integrates decentralized flexible management structures
22) Minimizes trade-offs and maximizes benefits with development and conservation goals

[65] *Idem* as in Reid, H. and Ali, L. (2018).
[66] *Idem* as in Reid, H. and Orindi, V. (2018).
[67] *Idem* as in Reid, H. and Adhikari, A. (2018).

23) Provides opportunities for scaling up and mainstreaming
24) Involves longer-term 'transformational' change

According to those authors again, more generally, the evaluation of EbA should follow the steps in the framework of assessing EbA effectiveness, as summarized in table 30.

Table 30: Steps for EbA evaluation-forests

No	Area of evaluation	Question for evaluation
1	Effectiveness for human societies	Did the initiative allow human communities to maintain or improve their adaptive capacity or resilience, and reduce their vulnerability, in the face of climate change, while enhancing co-benefits that promote long-term wellbeing?
2	Effectiveness for the ecosystem	Did the initiative restore, maintain or enhance the capacity of ecosystems to continue to produce adaptation services for local communities, and allow ecosystems to withstand climate change impacts and other stressors?
3	Financial and economic effectiveness	Is EbA cost-effective and economically viable over the long-term?
4	Policy and institutional issues	What social, institutional and political issues influence the implementation of effective EbA initiatives and how might challenges best be overcome?

Proposed timeline or schedule for evaluation of the EbA program of restoration of degraded forest ecosystems is as summarized in the table 31.

Table 31: Schedule for evaluation of the EbA restoration of forest ecosystems

No	Level of evaluation	Period or specific time in the program
1	First evaluation	1 year after tree plantation to assess the success rate
2	Follow-up evaluation	4 years after tree plantation
3	Follow-up evaluation	8 years after tree plantation
4	End-project evaluation	10 years after the beginning of project

We also recommend that evaluation will be part of aspects to be included in the Rwanda State of Environment Outlook Report (SEOR) which is produced every four years.

6. EBA RESTORATION ACTION PLANS

This section aims to develop EbA restoration plans for the study sites, by identifying the actions which would reduce climate risks and vulnerability, and maximise co-benefits to both ecosystems and local communities. Proposed EbA measures are aligned with different national and international tools, as described in the non-exhaustive list of key strategic frameworks and initiatives below.

6.1. ALIGNMENT OF EBA WITH KEY STRATEGIC FRAMEWORKS

6.1.1. Sustainable Development Goals (SDGs)

Proposed EbA measures contribute across the SDGs, but have specific alignment with **SDG 13** and its targets related to combating climate change and its impacts by developing appropriate measures with a focus on making the livelihoods of rural populations more resilient. EbA also contributes to fighting against poverty and hunger of people in vulnerable situations through increase of agricultural productivity **(SDG 1 and SDG 2).** Through restoration of aquatic ecosystems (wetlands, lakes…) and provision of access to safe water mainly in drought-prone regions, EbA contributes to fighting against water-borne diseases **(SDG 3 and SDG 6).** EbA measures related to protection and restoration of forests through the use of alternative sources of energy to firewood and reforestation programmes contribute to **SDG 12 and SDG 15.**

6.1.2. National Strategy on Climate Change and Low Carbon Development for Rwanda

Agriculture sector is highlighted as the most pressured and vulnerable sector to climate change. EbA contributes to recommended measures about developing appropriate adaptation and mitigation strategies to ensure Rwanda's agriculture remains productive, secure and more resilient. EbA also contributes to the sustainable management and use of forest, land and water resources mainly in extreme weather vulnerable regions.

6.1.3. Nationally Determined Contributions (NDC)

EbA measures align with the country's long-term goal for adaptation to increase the ability of people to adapt to the adverse impacts of climate change by fostering climate resilience and low greenhouse gas emissions activities without threatening food production. The country's NDC is built upon the National Strategy on Climate Change and Low Carbon Development and is aimed to support sustainable intensification of agriculture, integrated land and water management, sustainable biodiversity use and ecosystem services management, etc.

6.1.4. National Adaptation Programmes of Action to Climate Change (NAPA)

Different priority adaptation options to climate change and related projects have been selected and their profiles developed in the NAPA. Proposed EbA restoration actions respond to all 6 high priority options[68] selected and for which projects are proposed for funding.

6.1.5. National Biodiversity Strategy and Action Plan (NBSAP)

EbA restoration activities contribute to achieving Targets 13 and 14 of Rwandan NBSAP (corresponding to Aichi Target 14 and 15 respectively), related to restoration of important ecosystems for livelihoods improvement of people in vulnerable situation, and enhancement of ecosystem resilience, thereby contributing to climate change adaptation and mitigation.

6.1.6. National Strategy for Climate Change and Low Carbon Development

Two specific programmes of action of the strategy align with EbA. They include catchment management and water harvesting and conservation practices **(Programme 4)**, restoration of degraded forests **(Programme 12)**, establishment of early warning systems and intervention plans for climate-induced disasters **(Programme 13 and 14)**.

6.2. CURRENT RESTORATION ACTIVITIES

The LDCF[69] project initiated some restoration activities at all study sites (Table 32). Some activities are efficient for the restoration (e.g. removal of unfit activities from the buffer zone), but others should be carefully monitored and if necessary replaced due to inadaptability or potential negative impacts (e.g. plantation of inadaptable species…)

[68] RoR (2006). National Adaptation Programmes of Action to Climate Change. Ministry of Lands, Environment, Forestry, Water and Mines. Kigali, Rwanda
[69] LDCF: Least Developed Countries Fund

Table 32: Ongoing restoration activities at study sites

No	Site	Current Activities	Observations
1	**Lake Cyohoha North**	▪ Removal of invasive species from the lake (Photo 1 in the appendices). ▪ Removal of *Cyperus papyrus* (Papyrus) and *Typha domingensis* (Southern cattail) ▪ Preparation of seedlings of fruit trees of Mango and Avocado	▪ The approach used to remove the aquatic weeds from Cyohoha by hand-pulling them from the waters is not effective because this action stimulates the growth of the plants and they re-establish from fragments of remaining rhizomes. ▪ *Cyperus papyrus* and *Typha domingensis* are native wetland species. As C_4 photosynthetic plants, papyrus and cattail have a high yield potential of standing biomass, and papyrus represent some of the highest recorded rates of primary productivity in any natural ecosystem[70&71], and thus, are very large sinks of carbon. They also play important ecological role in hydrological flows and nutrient balances control, and as aquatic biodiversity reserve. The removal of these species will result into severely eroded ecological benefits of these species, and may lead to significantly reduced young shoots regeneration[72]. ▪ Therefore, the ongoing removal of papyrus and cattail in Cyohoha on the wrong basis that they cause water level decline (research proves the opposite[73]) should be discontinued.
2	**Murago Wetland**	▪ Excavation of a demarcation trench at 20m from the wetland ▪ Plantation of Bamboo within 20m, and Grevillea at the trench	Alternative native species to Grevillea should be adopted

[70] Jones, M.B., Kansiime, F., Saunderes, M.J. (2016). The potential use of papyrus (*Cyperus papyrus* L.) wetlands as a source of biomass energy for sub-Saharan Africa. *GCB Bioenergy,* Volume 10, Issue 1. https://doi.org/10.1111/gcbb.12392

[71] Pacini, N., Hesslerová, P., Pokorný, J., Mwinami, T., Morrison, E. H. J., Cook, A. A., Zhang, S., Harper, D. M. (2018). Papyrus as an ecohydrological tool for restoring ecosystem services in Afrotropical wetlands. *Ecohydrology & Hydrobiology*, 18(2), 142–154. doi:10.1016/j.ecohyd.2018.02.001

[72] Terer, T., Triest, L., Muasya, M. (2011). Effects of harvesting *Cyperus papyrus* in undisturbed wetland, Lake Naivasha, Kenya. *Hydrobiologia,* Volume 680, Issue 1, pp 135-148.

[73] *Idem* as in Pacini et al (2018).

3	**Lake Kibare**	▪ Relocation of the activities out of 50 m from the lake ▪ Excavation of a demarcation trench at 50 m from the lake ▪ Plantation of Mango, Avocado, Grevillea and Bamboo within 50 m from the lake	Bamboos have not been successful due to unfavourable soil conditions (Photo 3 in the Appendices). Native adapted and useful species should be adopted for replacement.
4	**Lake Rwampanga**	▪ Prohibition of farming activities out of 50 m from the lake ▪ Plantation of *Senna Spectabilis* and Grevillea within 50m from the lake.	Farming activities on the lake's shore are ongoing, more effort should be put in for their eradication.
5	**Lake Ruhondo**	People are being relocated from the islands to the main land. To date, 16 families out of 62 have been relocated.	The relocation process of families from high risk zones should be completed the sooner the better
6	**Rwinkwavu Hill**	A tree nursery of *Callitris* sp (cypress-pine) species has been established for the reforestation of Rwinkwavu Hill (Photo 6 in the Appendices)	*Callitris sp* is not the right species to reforest Rwinkwavu Hill. This exotic species competes native vegetation, and inhibits diversity of understory vegetation due to its allelopathic properties and its expansive root morphology.
7	**Makera Forest**	Reforestation with native species of *Markhamia lutea, Acacia polyacantha* and *Ficus vallis-choudae*	More native species need to be reintroduced

8	**Sanza Forest**	▪ Buffer zone of *Alnus glutinosa* around the forest ▪ Establishment of a tree nursery for reforestation of degraded mining sites and initial planting activities undertaken	Two species are questionable and their use should be discontinued: - *Pteridium aquilinum* is an aggressive invasive (although native to Rwanda) - *Callitris sp* (Ref to comments for its use in Rwinkwavu)

6.3. OVERARCHING GOAL

The all-encompassing proposed goal for the restoration of studied wetland ecosystems is "to bring about the sustained recovery of Cyohoha Lake, Murago Wetland, Kibare Lake, Rwampanga Lake and Ruhondo Lake by using an Ecosystem-based Adaptation approach through the enhancement of ecosystems and local communities' resilience against the effects of climate change while improving human well-being".

To meet the proposed goal, the restoration plans provide options for site-specific actions consistent with the provisions of the principles of the Ecosystem Approach of the Convention on Biological Diversity[74]. Proposed actions can be undertaken in the period of three (3) years, and lead to following 8 expected outcomes:

- **Outcome 1:** *Adaptation capacity of key beneficiaries improved*
- **Outcome 2:** *Implementation of EbA measures efficiently monitoring and best practices disseminated*
- **Outcome 3:** *Sufficient and clean water available and accessible*
- **Outcome 4:** *Impacts of seasonal flooding are mitigated and floods vulnerability reduced*
- **Outcome 5:** *Increased potential for maintaining aquatic biodiversity and ecosystem health*
- **Outcome 6:** *Recovery of savanna biodiversity and ecosystem services*
- **Outcome 7:** *Recovery of forest biodiversity and ecosystem services*
- **Outcome 8:** *Reduced exposure of the population to extreme events and climate catastrophes*

For the 3 types of ecosystems investigated (wetlands, savanna and forests), the first expected outcome is cross-cutting as detailed in table 33.

[74] https://www.cbd.int/ecosystem/principles.shtml

Table 33: EbA Restoration Action Plan relevant for all ecosystems

Expected outcome	Objectives	Actions	Indicators	Responsible (Lead in bold)	Timeline	Budget (Rwf)
Adaptation capacity of key beneficiaries improved	Generate public awareness, support and involvement in actions' implementation	Establish a structured and iterative knowledge production process, engaging local communities and combining traditional and contemporary scientific sources	Local good practices are scaled up to the national level	**REMA**, MINEDUC, Local Government, HLIs	3 years	20,000,000
		Enhance synergies and cooperation by lining local learning with national policy and strategies	Plans and strategies that may otherwise negatively impact on EbA initiatives are better aligned	**REMA**	6 months	1,000,000
		Undertake EbA capacity building activities (e.g. training of trainers)	Implementation of actions is facilitated	**REMA**	6 months	12,000,000
	Promotion of non-agricultural income generating activities	Reinforce the capacity of the population on project development and management	Number of follow up reports of professional training	**MINICOM**, Local Government	6 months	25,000,000
		Support and fund pilot EbA adaptation initiatives	Number of EbA projects initiated and funded	**NGOs, REMA**	1 year	100,000,000
		Support and fund income generating non-agricultural activities				
		Organize trainings in fundable mini-project development				
	Increase agriculture production	Adopt appropriate agro-ecological farming practices to	Ha of arable land protected	**RAB**, MINAGRI, REMA, HLIs	3 years	60,000,000

		boost soil and land conservation (e.g. conservation agriculture)	Area of stabilized lands at different altitudes against erosion and landslides			
			Increased agricultural yield			
		Plant adapted indigenous agroforestry trees to enhance soil fertility and moisture and shade for crops	Number and types of adapted and useful species planted	**RWAF**, RAB	1 year	30,000,000
			Increased agricultural yield			
		Promote the growth of adapted and resilient crop varieties and local landraces to reduce the risk of crop failure	Increased agricultural yield	**RAB**	1 year	12,000,000
Implementation of EbA measures efficiently monitoring and best practices disseminated	Ensure the success of actions implementation to achieve defined objectives and obtain expected outcomes	Develop monitoring and evaluation, including through long-term monitoring programs, in order to demonstrate the real benefits associated with ecosystem-based adaptation approach	Number of monitoring reports	**REMA**	3 years	15,000,000
		Involve local communities in monitoring and evaluation processes to enhance efficiency and local capacities				
		Avail sufficient resources for monitoring and supporting the implementation of the measures	Amount of funds mobilized	**Local Government**, NGOs,		
	EbA approach is applied national wide	Promote continuity to improve outcomes of future	Number of EbA projects initiated	**REMA,** NGOs	3 years	30,000,000
		Disseminate best practices at national level				

6.4. RESTORATION ACTION PLAN FOR WETLAND ECOSYSTEMS: CYOHOHA, MURAGO, KIBARE, RWAMPANGA AND RUHONDO

The proposed options of actions for wetland ecosystems are described in Table 34. For each expected outcome, related objectives are convened and SMART[75] indicators of achievement defined. Responsible institutions for the implementation of the actions are proposed, as well as the indicative timeline and budget estimations.

Table 34: Wetlands-EbA Restoration Action Plan

Ecosystem (s) of Concern	Expected outcomes	Objectives	Actions	Indicators	Responsible (Lead in bold)	Timeline	Budget
Cyohoha, Murago, Kibare and Rwampanga	***Sufficient and clean water available and accessible***	Reduce pressure on the lake for search of domestic water use	Install green rainwater harvesting systems at household level	Number of households with rainwater harvesting systems	**CBOs**, NGOs, Local Communities, Local Government	6 months	40,000,000
				Number of household accessing water for domestic use, irrigation and animal husbandry during dry seasons			
				Number of functional systems of retained rainwater			
		Prevent water-borne diseases and improve community health care	Install and/or rehabilitate clean water systems with easy access	Number of functional water points (wells and borings) satisfying	**WASAC**, Local Government	3 months	20,000,000

[75] SMART: Specific, Measurable, Achievable, Relevant, Time-bound

				safe water needs installed and protected			
		Address water needs for irrigation and cattle drinking	Construct public watering troughs for livestock	Number of functional public watering troughs	**CBOs**, Local Communities, NGOs	6 months	8,000,000
				Reduction rate of conflicts over clean water availability			
			Reforest the watershed with selected indigenous adapted and useful trees to enhance water provision and soil conservation	Number of household accessing water for domestic use, irrigation and animal husbandry during dry seasons	**RWAF**, RAB, REMA	2 years	100,000,000
				Improved soil moisture conditions			
				Amount of agricultural and livestock yield			
Cyohoha, Murago, Kibare, Rwampanga, Ruhondo	***Impacts of seasonal flooding are mitigated and floods vulnerability reduced***	Protect and restore degraded riparian zones and the catchment area	Develop spatially flood inundation maps	Number of maps	**MINEMA**	4 months	16,000,000
			Reforest the banks and the watershed with selected indigenous adapted and useful trees to reduce flooding and siltation	Surface area reforested and number of tree species planted	**RWAF**, RAB, REMA	1 year	30,000,000
Cyohoha and Kibare	***Increased potential for maintaining biodiversity and ecosystem health***	Prevent new infestations and eradicate identified invasive species from the lake	Minimize the flow of nutrients from surrounding catchments	Quantity of fish production	**CBOs**, Local Communities	6 months	10,000,000
			Combine the use of heavier duty mechanical and biological control	Changes in water level	**NGOs**, CBOs, Local	2 years	200,000,000

			(with sterile grass carp) to remove identified aquatic invasive	Changes in water quality parameters	Communities, Local Government, REMA		
			Control new infestations weekly and remove plants as soon as possible	Locally extinct species restored			
Cyohoha, Kibare, Rwampanga, Ruhondo		Protect the ecosystem against harmful agriculture and animal husbandry practices	Enforce the law to remove and prevent agriculture and grazing encroachments	Number of law infringement cases	REMA, Local Government, RNP	6 months	10,000,000
Murago			Enforce the law to prevent against wetland burning and drainage				
Cyohoha, Murago, Kibare, Rwampanga, Ruhondo			Reduce the run-off of sediments and pollutants	Changes in water quality parameters	**CBOs**, Local Communities	36months	10,000,000
			Create buffer core area to protect the habitat and biodiversity from adverse surrounding land use	Covered area	**REMA,** Local Communities	4 months	120,000,000
			Establish a riparian buffer using identified appropriate native plant species				
Cyohoha		Increase groundwater recharge	Stop harmful removal of papyrus and cattails from the lake	Reduced influx of solar radiation on the water and increased relative air humidity	**Local Government,** REMA, Local Communities	2 months	500,000
Cyohoha and Murago			Restore water flow capacity upstream at the level of Murago wetland	Changes in water level	**MININFRA**	3 years	100,000,000
Murago			Dig ditches for rewetting the wetland		**CBOs,** Local Communities, REMA	3 months	3,000,000

6.5. RESTORATION ACTION PLAN FOR SAVANNA ECOSYSTEMS: RWINKWAVU

The proposed options of actions for wetland ecosystems are described in Table 35. For each expected outcome, related objectives are convened and indicators of achievement defined. Responsible institutions for the implementation of the actions are proposed, as well as the indicative timeline and budget estimations.

Table 35: Wetlands-EbA Restoration Action Plan

Ecosystem of Concern	Expected outcomes	Objectives	Actions	Indicators	Responsible (Lead in bold)	Timeline	Budget
Rwinkwavu	***Recovery of savanna biodiversity and ecosystem services***	Eradicate destructive activities to the ecosystem	Develop appropriate restoration programs for the mining activities	Size of rehabilitated area	**RMB**, REMA	2 months	2,000,000
			Establish a living fence around Rwinkwavu Hill	Area coverd	**REMA**, NGOs, Local Communities, Local Government	1 month	2,000,000
			Develop energy sources alternative to firewood	Number of households utilizing alternative sources of energy to firewood	**NGOs**	3 months	5,000,000
			Promote incentives on the adoption of environmental friendly energy alternatives		Local Government	3 years	50,000,000
		Remove unwanted plant species and replace them with desired native species	Remove planted exotic species dominated by Eucalyptus trees	Area covered by exotic species	**Local Communities**, REMA	2 months	30,000,000
			Remove invasive species dominated by *Lantana camara*	Area covered by invasive species			

			Reforest with identified native species	Size of the reforested area	**RWAF,** Local Communities	3 months	6,000,000
				Significant changes in microclimate conditions			
	Sufficient and clean water available and accessible	Prevent water-borne diseases and improve community health care	Install green rainwater harvesting systems at household level	Number of households with rainwater harvesting systems	**CBOs,** NGOs, Local Communities, Local Government	3 months	20,000,000
				Number of household accessing water for domestic use, irrigation and animal husbandry during dry seasons			
				Number of functional systems of retained rainwater			
			Install and/or rehabilitate clean water systems with easy access	Number of functional water points (wells and borings) satisfying safe water needs installed and protected			
		Address water needs for domestic use, irrigation and cattle drinking	Construct public watering troughs for livestock	Number of functional public watering troughs	**CBOs,** Local Communities, NGOs	3 months	4,000,000
			Reforest the site with selected indigenous adapted and useful trees to enhance soil water retention capacity	Number of household accessing water for domestic use, irrigation and animal husbandry during dry seasons			
				Improved soil moisture conditions	**RWAF,** RAB, REMA	6 months	25,000,000
				Amount of agricultural yield			

6.6. RESTORATION ACTION PLAN FOR FOREST ECOSYSTEMS: MAKERA AND SANZA

The proposed options of actions for wetland ecosystems are described in Table 36. For each expected outcome, related objectives are convened and indicators of achievement defined. Responsible institutions for the implementation of the actions are proposed, as well as the indicative timeline and budget estimations.

Table 36: Wetlands-EbA Restoration Action Plan

Ecosystem (s) of Concern	Expected outcomes	Objectives	Actions	Indicators	Responsible (Lead in bold)	Timeline	Budget
Makera and Sanza	***Recovery of forest biodiversity and ecosystem services***	Eradicate destructive activities to the ecosystem	Establish a living fence around Makera and Sanza forest	Area covered	**REMA**, NGOs, Local Communities, Local Government	2 month	4,000,000
			Develop energy sources alternative to firewood	Number of households utilizing alternative sources of energy to firewood	**NGOs**	3 months	5,000,000
			Promote incentives on the adoption of environmental friendly energy alternatives		Local Government	3 years	50,000,000
Sanza			Develop appropriate restoration programs for the mining activities in Sanza	Size of rehabilitated area	**RMB**, REMA	2 months	2,000,000
Makera		Remove unwanted plant species and replace them with desired native species	Remove invasive species dominated by *Caesalpinia decapetala* in Makera	Area covered by invasive species	**Local Communities,** REMA	6 months	60,000,000
Makera and Sanza			Reforest with identified native species	Size of the reforested area			

Makera	***Sufficient and clean water available and accessible***	Prevent water-borne diseases and improve community health care	Install green rainwater harvesting systems at household level	Number of households with rainwater harvesting systems Number of household accessing water for domestic use, irrigation and animal husbandry during dry seasons Number of functional systems of retained rainwater	**CBOs**, NGOs, Local Communities, Local Government	4 months	25,000,000
			Install and/or rehabilitate clean water systems with easy access	Number of functional water points (wells and borings) satisfying safe water needs installed and protected			
		Address water needs for domestic use, irrigation and cattle drinking	Construct public watering troughs for livestock	Number of functional public watering troughs	**CBOs**, Local Communities, NGOs	3 months	4,000,000
			Reforest the site with selected indigenous adapted and useful trees to enhance soil water retention capacity	Number of household accessing water for domestic use, irrigation and animal husbandry during dry seasons Changes in agricultural yield	**RWAF**, RAB, REMA	6 months	15,000,000
Sanza	***Reduced exposure of the population to extreme events and climate catastrophes***	Reduce the impacts of erosions and landslides	Establish local early warning and rapid intervention mechanisms	Reduction rate of cases of the population affected by extreme events and climate catastrophes	**MINEMA**	3 months	2,000,000
			Relocate households from high risk zones		**Local Government**	2 years	200,000,000
			Identify capacity needs and reinforce competences in risks and catastrophes management	Change in intervention time for rescue	**MINEMA**, REMA	6 months	50,000,000

APPENDICES

Appendix 1: Interview Questionnaire Guide

1. Umwirondoro				
Amazina				
Igitsina				
Imyaka				
Umurimo				
Amashuri				
2. Ese mujya mugira ibihe bihindagurika cyane:	Yego		Oya	
3. Niba ari yego ni ibiki bihinduka cyane	Izuba ryinshi		Imvura nyinshi	

4. Ni izihe ngaruka ziterwa n'iryo hindakurika? Ese mubona ibi byiyongera cg bigabanuka

Amapfa/Izuba ryinshi	Biriyongera		Biragabanuka	
Imyuzure/Inkangu	Biriyongera		Biragabanuka	
Isuri	Biriyongera		Biragabanuka	
Indwara z'ibyorezo	Biriyongera		Biragabanuka	
Gusuhuka	Biriyongera		Biragabanuka	
Gusenyuka kw'amazu	Biriyongera		Biragabanuka	
Gupfa kw'amatungo	Biriyongera		Biragabanuka	
Gupfa kw'abantu	Biriyongera		Biragabanuka	
Ubukene bukabije	Biriyongera		Biragabanuka	
Ibura ry'amazi rikabije	Biriyongera		Biragabanuka	
Ibimera bidasanzwe byangiza ibindi (invasive sp)	Biriyongera		Biragabanuka	
Ibindi (sobanura)	Biriyongera		Biragabanuka	

5. Vuga akamaro kuri buri hantu (ecosystem), n'ingaruka za z'ihindagurika ry'ikirere (CC (H: High Impact, M=Medium Impact, L= Low Impact. N=No Impact)

Ibishanga (Wetlands)	**Amapfa**	**Ibura ry'amazi rikabije**	**Imyuzure/Inkangu/Isuri**	**Gusenyuka kw'amazu**	**Gupfa kw'amatungo**	**Ibimera byangiza ibindi (invasive sp)**	**Ibindi (sobanura)**
	H/M/L/N	**H/M/L/N**	**H/M/L/N**	**H/M/L/N**	**H/M/L/N**	**H/M/L/N**	**H/M/L/N**
Amazi							
Amafi/Uburobyi							
Ubwatsi bw'amatungo							
Ibikoresho by'ubukorikori (ibiseke, ibirago...)							
Ubuhinzi							
Ubworozi							
Ubwiza (aesthetic)							
Ibumba/umucanga...							

Umwuka mwiza							
Kurinda imyuzure							
Kuyungurura amazi							
Ubukerarugendo							
Imiti gakondo							
Nyiramugengeri							
Imihango ya kinyarwanda							
Kwiga/ubumenyi							
Ubuhigi							
Ubworozi bw'inzuki							

Ibindi (sobanura)							

Ibiyaga (Lakes)	**Amapfa**	**Ibura ry'amazi rikabije**	**Imyuzure/Inkangu**	**Gusenyuka kw'amazu**	**Gupfa kw'amatungo**	**Ibimera byangiza ibindi (invasive sp)**	**Ibindi (sobanura)**
	H/M/L/N	**H/M/L/N**	**H/M/L/N**	**H/M/L/N**	**H/M/L/N**	**H/M/L/N**	**H/M/L/N**
Amazi							
Amafi/Uburobyi							
Ubuhahirane							
Ubwiza (aesthetic)							
Umwuka mwiza							
Ubukerarugendo							

Imihango ya kinyarwanda							
Kwiga/ubumenyi							
Ibindi (sobanura)							

Amashyamba (Forests)	**Amapfa**	**Ibura ry'amazi rikabije**	**Imyuzure/Inkangu**	**Gusenyuka kw'amazu**	**Gupfa kw'amatungo**	**Ibimera byangiza ibindi (invasive sp)**	**Ibindi (sobanura)**
	H/M/L/N	**H/M/L/N**	**H/M/L/N**	**H/M/L/N**	**H/M/L/N**	**H/M/L/N**	**H/M/L/N**
Ibiti byo kubaka							
Ibikoresho by'ububaji							
Inkwi/Amakara							
Imiti gakondo							
Ubwatsi bw'amatungo							

Ubworozi bw'inzuki							
Ingemwe z'ibiti							
Umwuka mwiza							
Ubukerarugendo							
Ubwiza (aesthetic)							
Gukurura imvura							
Kuyungurura amazi							
Ibikoresho by'ubukorikori (ibiseke...)							
Gufata ubutaka							
Imihango ya kinyarwanda							

Kwiga/ubumenyi							
Ubuhigi							
Ibindi (sobanura)							

6. Ni bande bagerwaho n'ingaruka z'ihindagurika ry'ibihe kurusha abandi kandi gute?

	Abana	Urubyiruko	Abagore	Abagabo	Abasaza/Abakecuru
Amapfa/Izuba ryinshi					
Imyuzure/Inkangu					
Isuri					
Indwara z'ibyorezo					
Gusuhuka					
Gusenyuka kw'amazu					
Gupfa kw'abantu					
Ubukene bukabije					
Ibura ry'amazi rikabije					
Ibindi (sobanura)					

7. Tubwire ubwoko bw'ibiti/ibimera bya kimeza byafasha guhangana n'ingaruka z'imihindagurikire

Izina	Akamaro muguhangana n'ihindagurika	Akandi kamaro igiti/ikimera gisanzwe gifite	Mukibungabunga gute kuva gitewe kugeza gikuze *(Planting material, maintainance, …)*
1.			
2.			
3.			
4.			
5.			

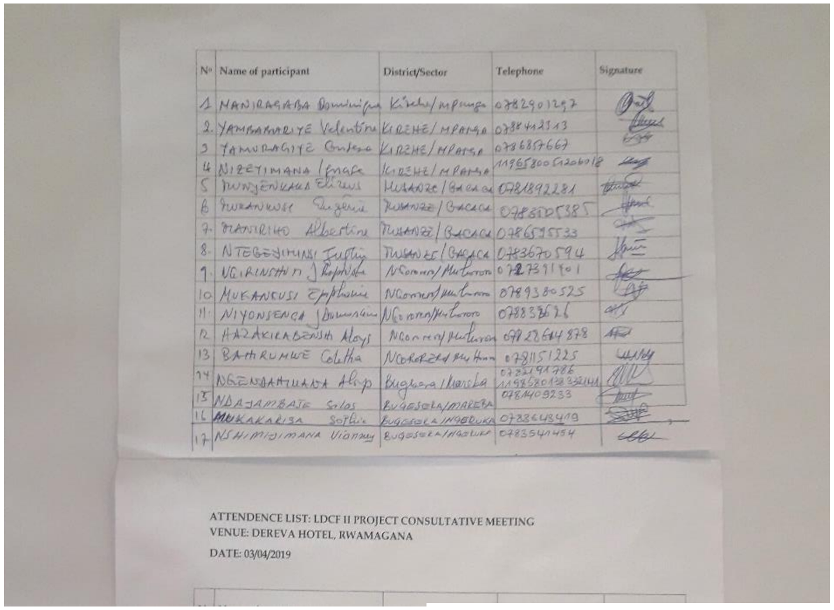
8. Mubona ari iki cyakorwa kugirango hano hantu hasubire uko hari hameze?

1.
2.
3.

9. Ni iki mukora kugirango hano hantu hasubire uko hari hameze?

1.
2.
3.

Appendix 2: Participants to the consultative workshop



Nº	Name of participant	District/Sector	Telephone	Signature
1	MANIRAGABA Dominique	Kirehe/mpanga	0782901297	
2.	YAMBABARIYE Valentine	KIREHE/MPANGA	0788412313	
3	YAMURAGIYE Gudesa	KIREHE/MPANGA	0786857667	
4	NIZEYIMANA Ignace	KIREHE/MPANGA	11965800 51206018	
5	MUNYENKAKA Elizeus	RUSANZE/BACACA	0781892281	
6	MUKANKUSI Eugenie	RUSANZE/BACACA	0788502385	
7.	MANIRIHO Albertine	RUSANZE/BACACA	0786595533	
8.	NTEGEYIMANA Justin	RUSANZE/BACACA	0783670594	
9.	NGIRINSHUTI J Bapt	NGoma/Mutenderi	0727391901	
10	MUKANKUSI Epiphanie	NGoma/Mutenderi	0789380525	
11.	NIYONSENGA J Damascene	NGoma/Mutenderi	0788338626	
12	HAZAKIRABENSHI Aloys	NGoma/Mutenderi	0722864878	
13	BAHIRUMWE Colitha	NGoma/Mutenderi	0781151225	
14	NGENDAHIMANA Alip	Bugesera/Mareba	0722191786 1198580138332144	
15	NDAJAMBAJE Silas	BUGESERA/MAREBA	0781409233	
16	MUKAKARISA Sophie	BUGESERA/NGERUKA	0783643419	
17	NSHIMIYIMANA Vianney	BUGESERA/NGERUKA	0783541454	

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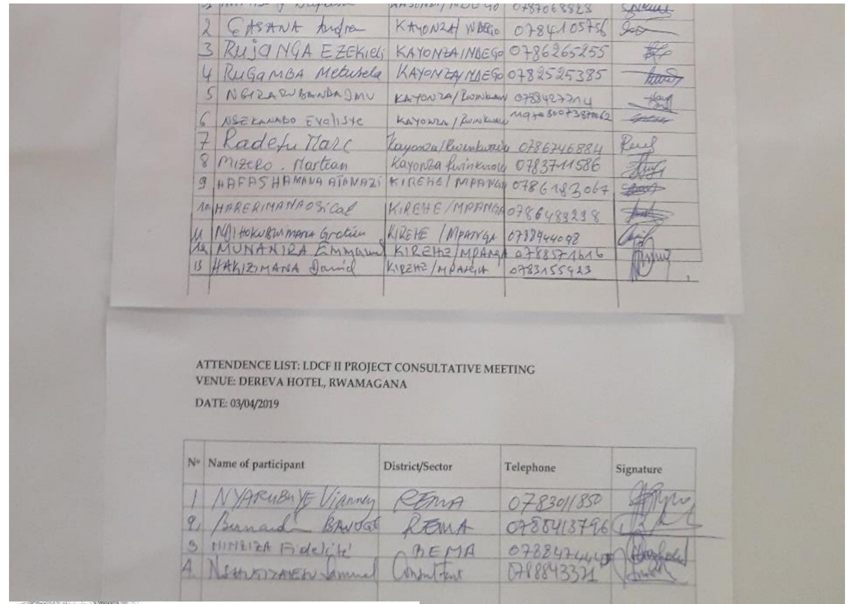
DATE: 03/04/2019



Nº	Name of participant	District/Sector	Telephone	Signature
1	[illegible]	KAYONZA/NDEGO	0787068828	
2	GASANA Andrea	KAYONZA/NDEGO	0784105756	
3	RUJANGA EZEKIEL	KAYONZA/NDEGO	0786265255	
4	RUGAMBA Methusela	KAYONZA/NDEGO	0782525385	
5	NGIRABWENDA JMV	KAYONZA/RWINKWAVU	0788427714	
6	NSEKANABO Evaliste	KAYONZA/RWINKWAVU	1197480073870062	
7	Radefu Marc	Kayonza/Rwinkwavu	0786746884	
8	MIZERO . Martean	Kayonza Rwinkwavu	0783711586	
9	HAFASHIMANA ATANAZI	KIREHE/MPANGA	0786183067	
10	HARERIMANA Oscar	KIREHE/MPANGA	0786483298	
11	NSHOKURIMANA Gratien	KIREHE/MPANGA	0788944098	
12	MUNANIRA Emmanuel	KIREHE/MPANGA	0788571616	
13	HAKIZIMANA David	KIREHE/MPANGA	0783155923	

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Nº	Name of participant	District/Sector	Telephone	Signature
1	NYARUBUYE Vianney	REMA	078301850	
2.	Bernard BAVUGE	REMA	0788413796	
3	NIMBIZA Fidelite	REMA	0788474440	
4.	NSHIMIYIMANA Samuel	Consultant	0788843321	

Appendix 3: Sites locations

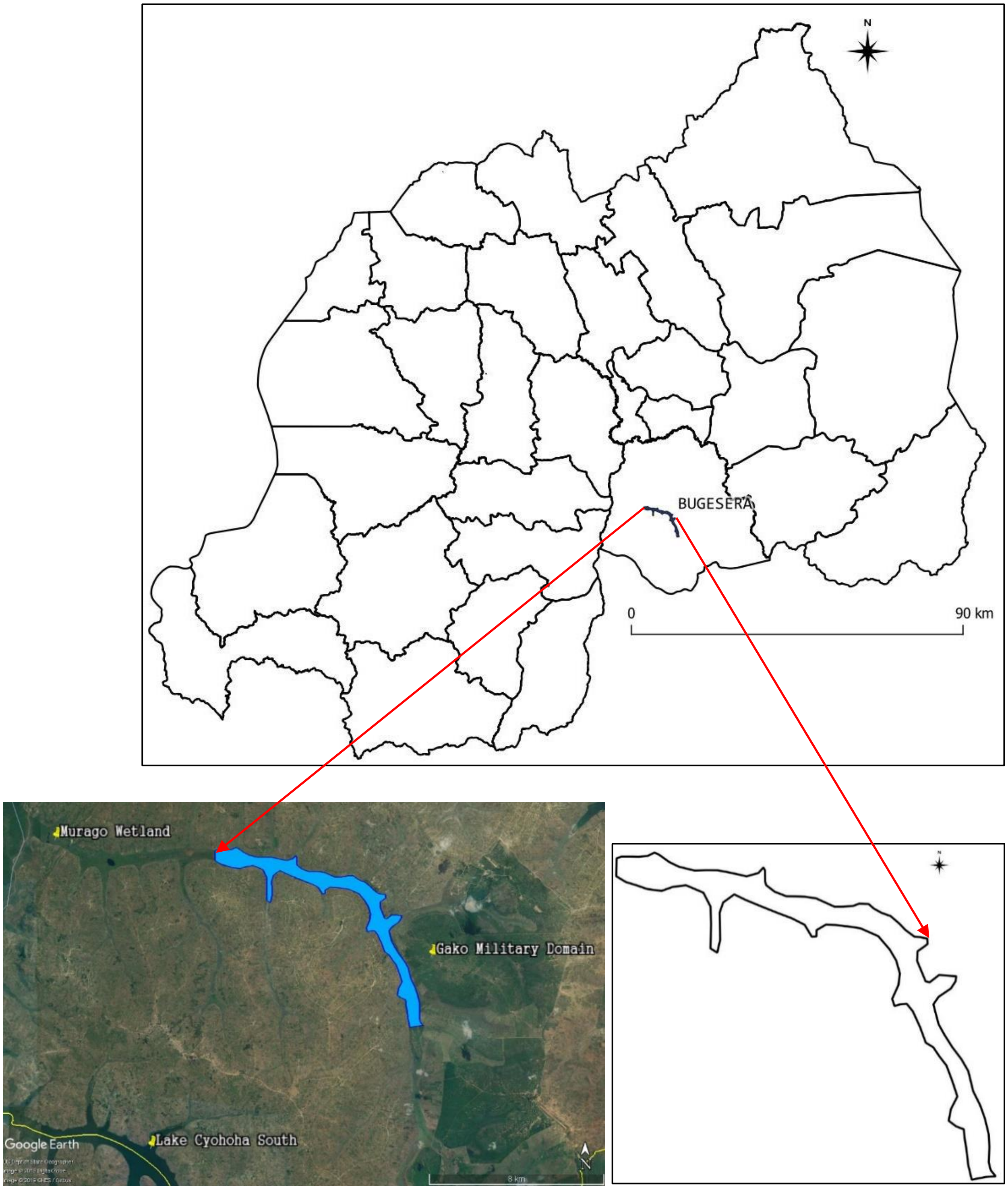

Figure 9: Lake Cyohoha North location

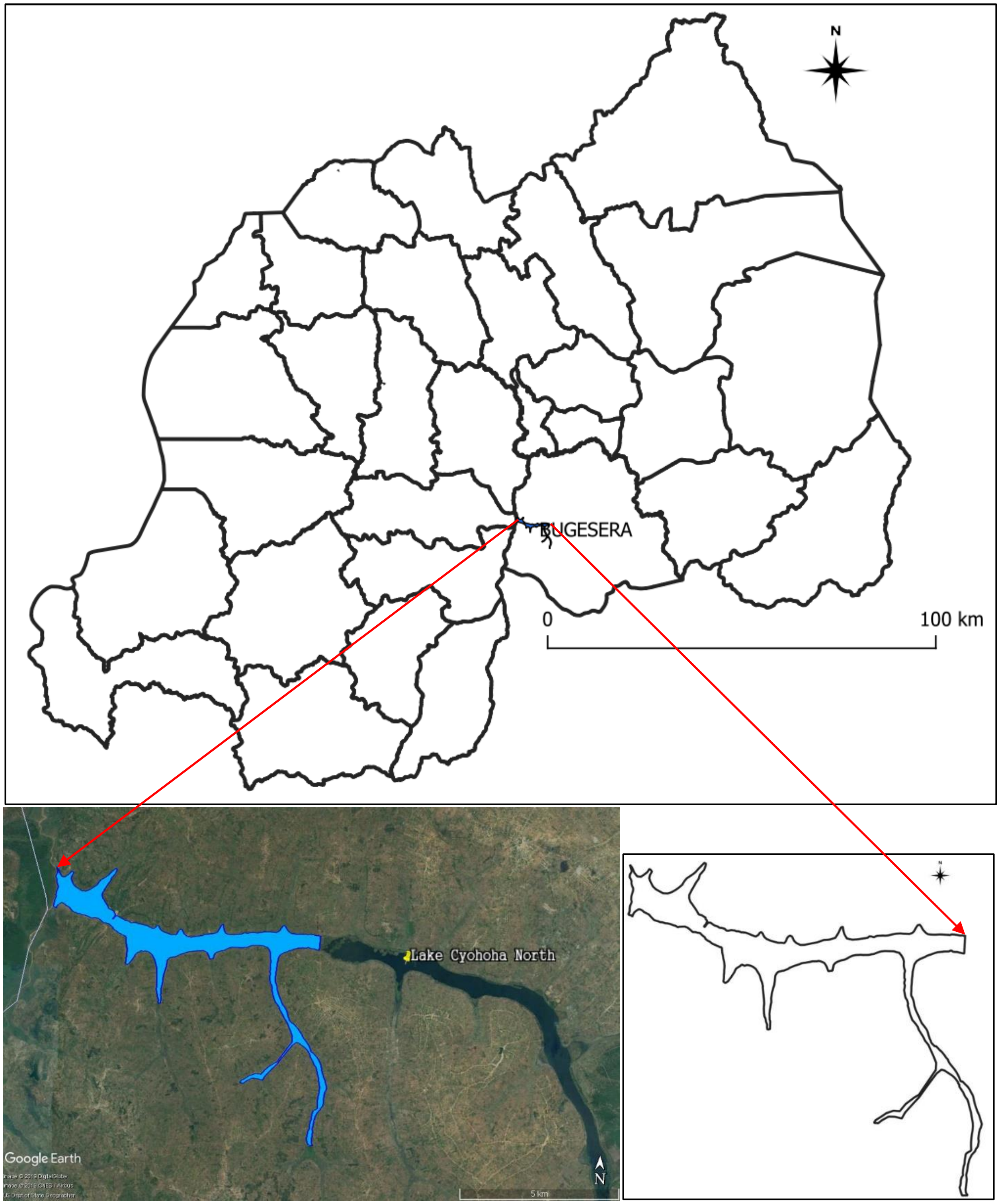

Figure 10: Murago Wetland location

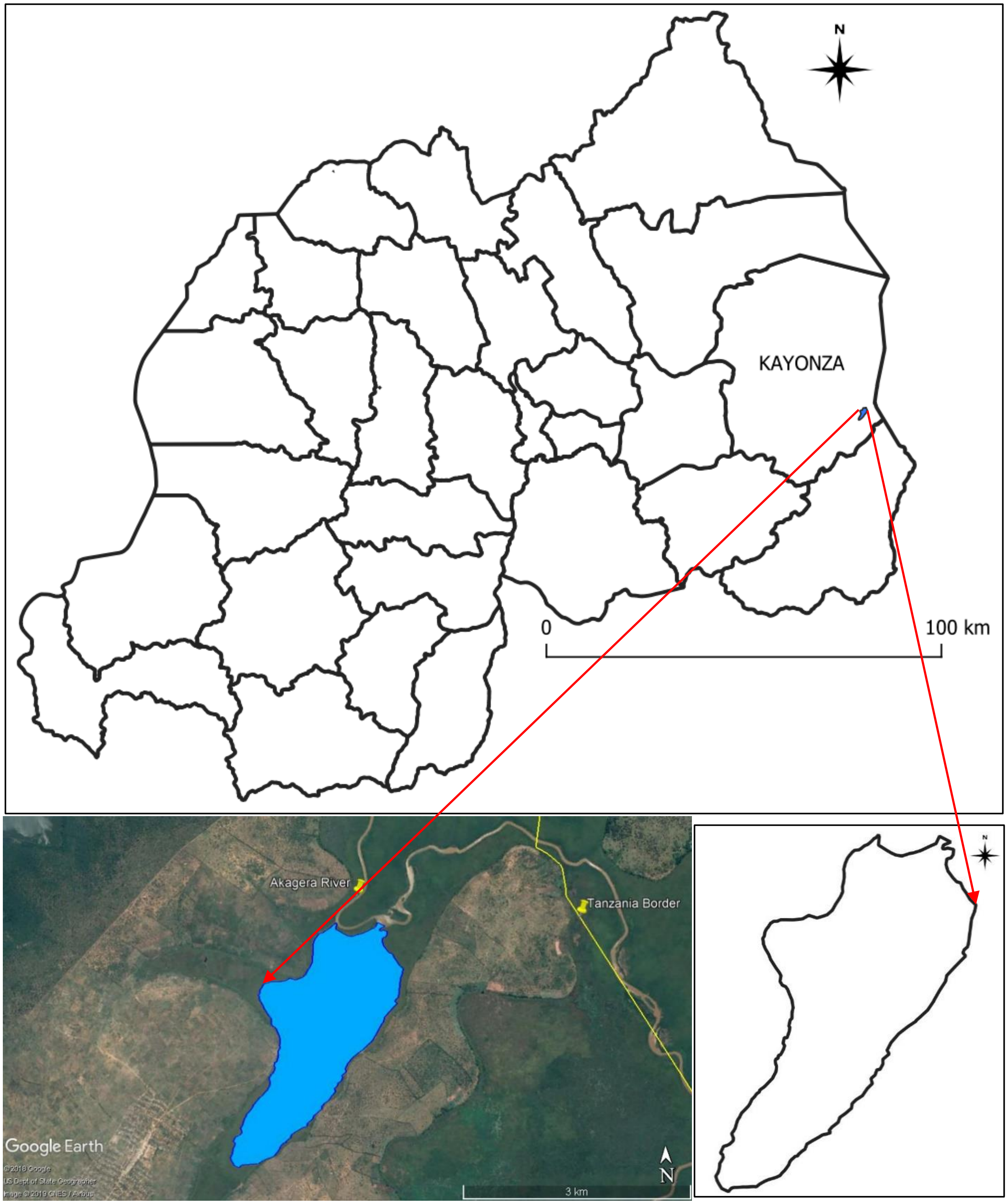

Figure 11: Lake Kibare location

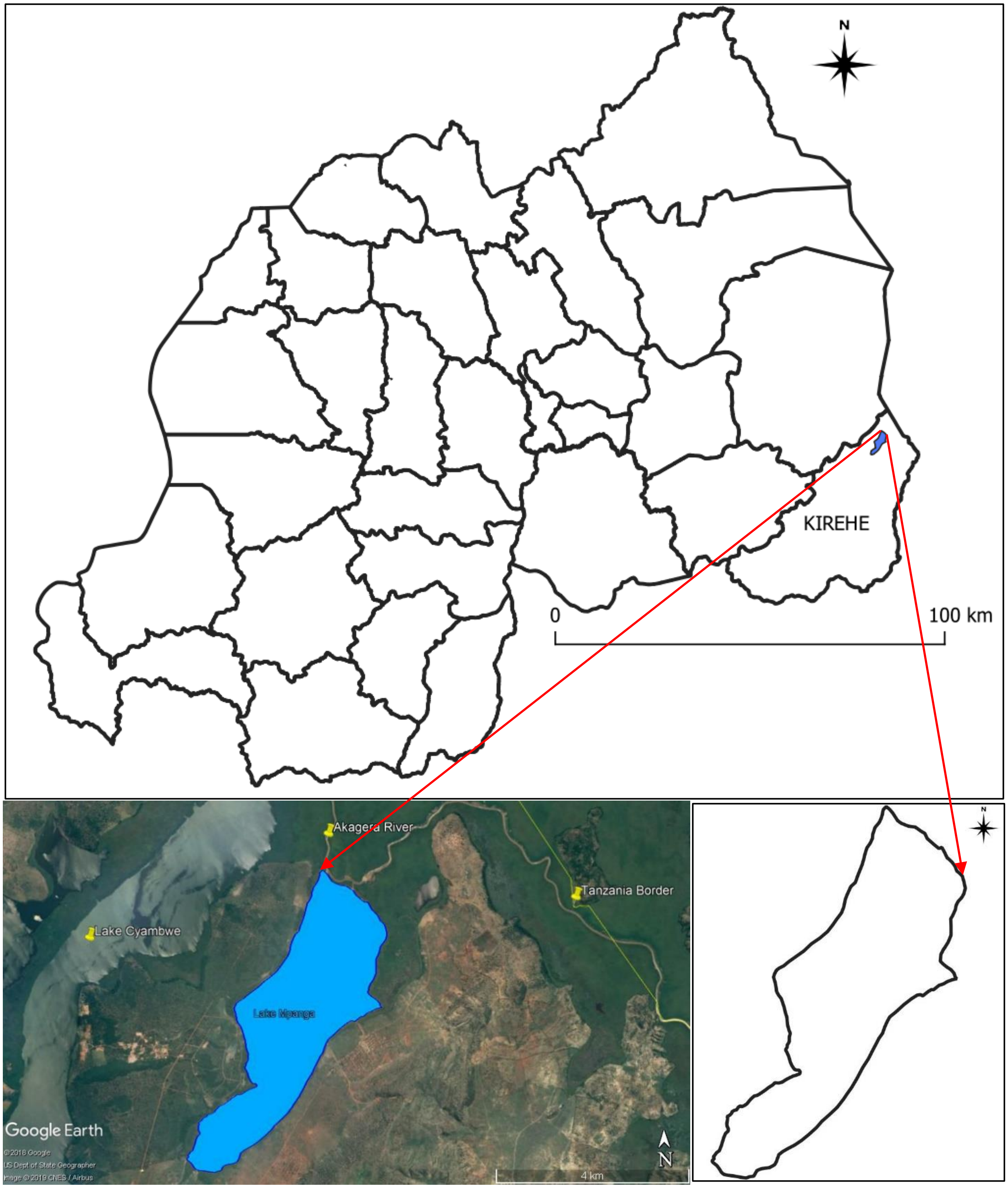

Figure 12: Lake Rwampanga location

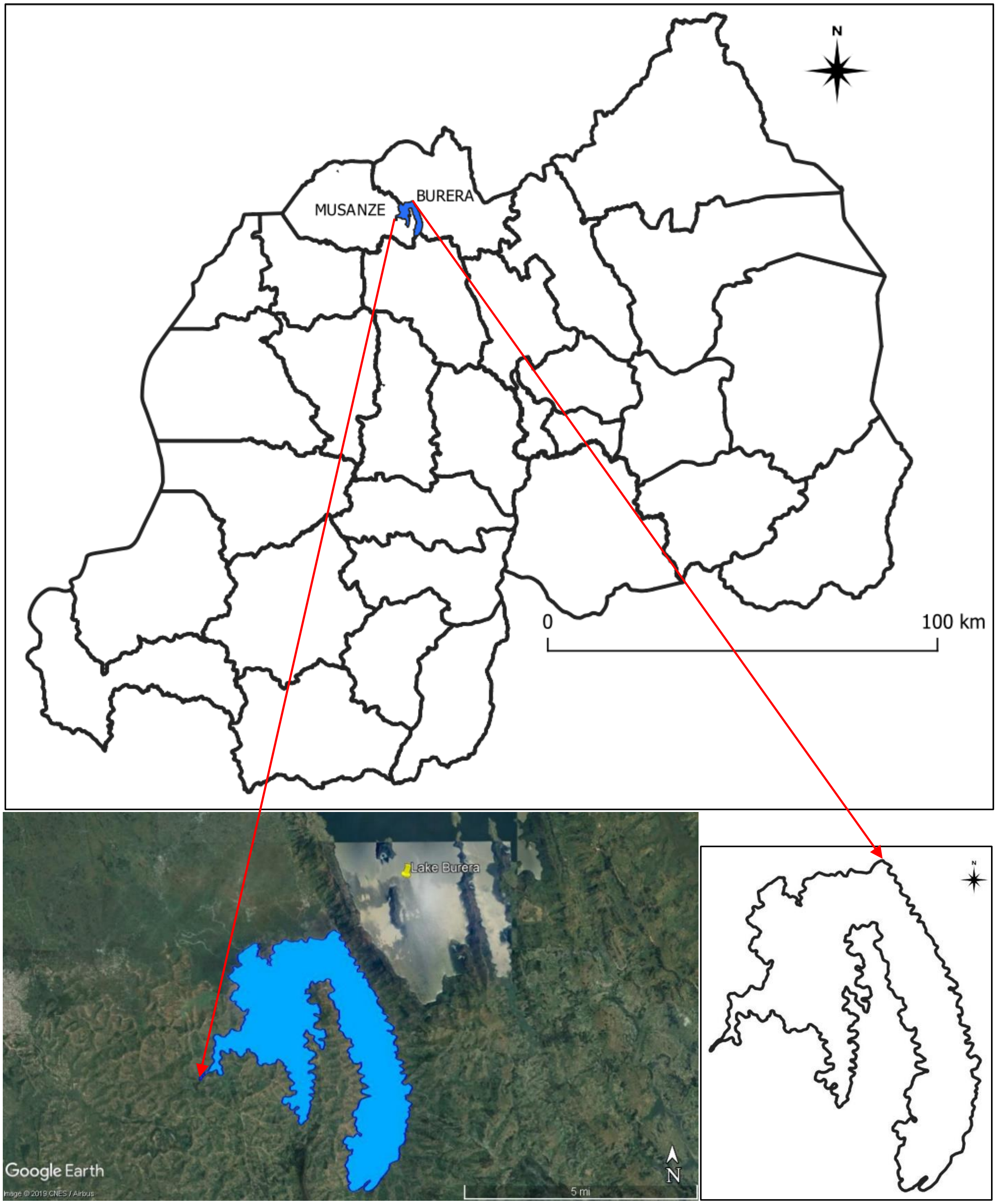

Figure 13: Lake Ruhondo location

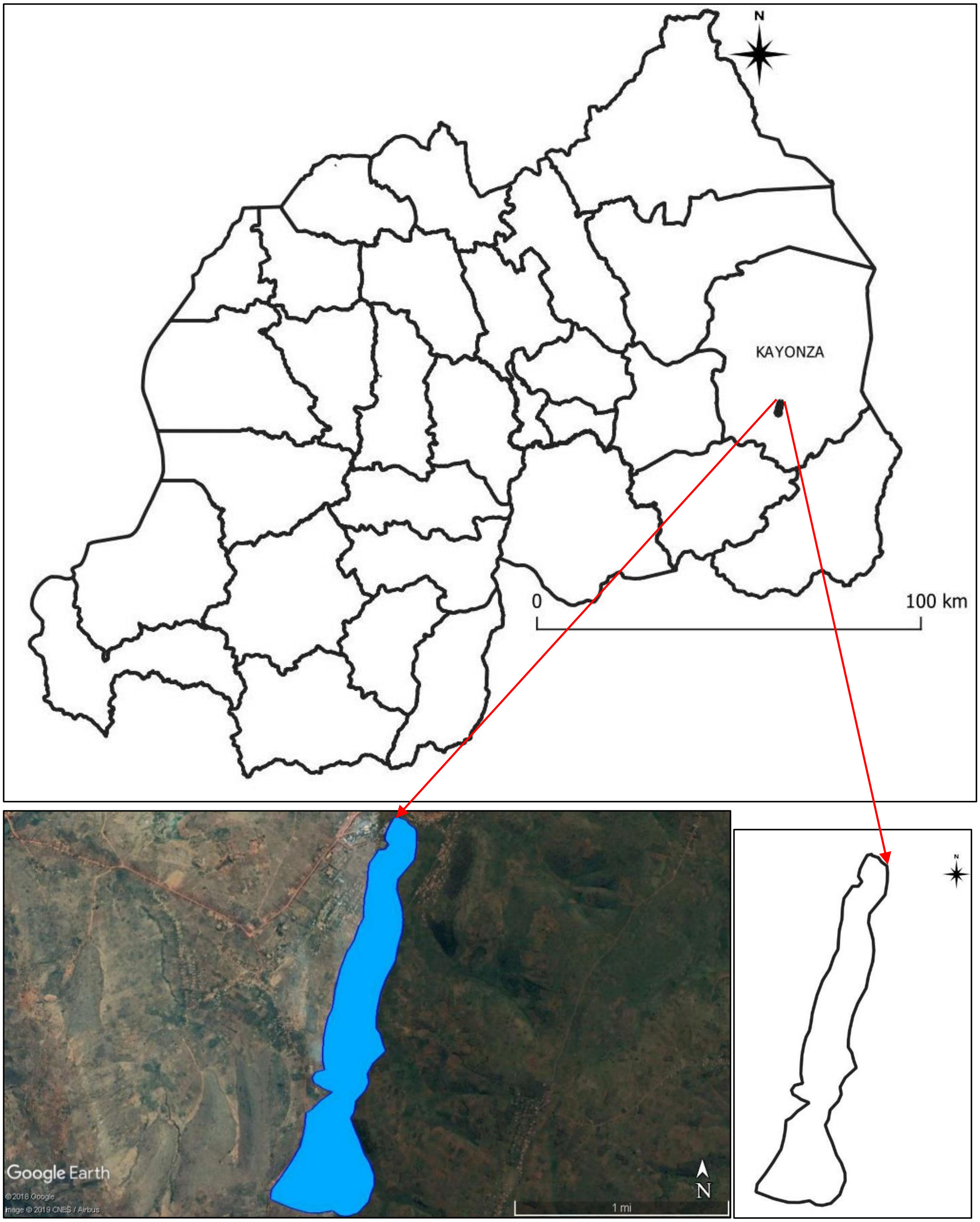

Figure 14: Rwinkwavu Hill location

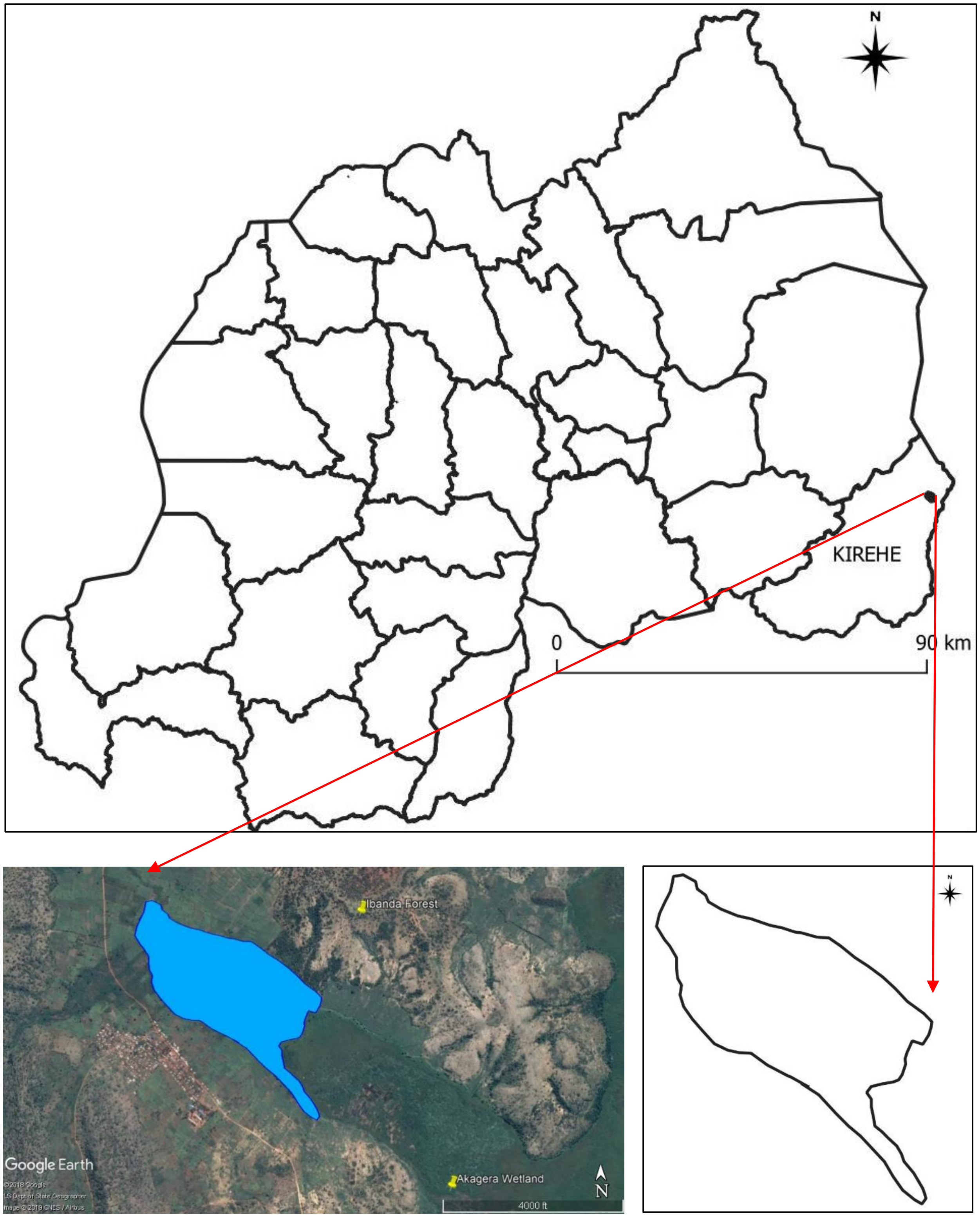

Figure 15: Makera Forest location

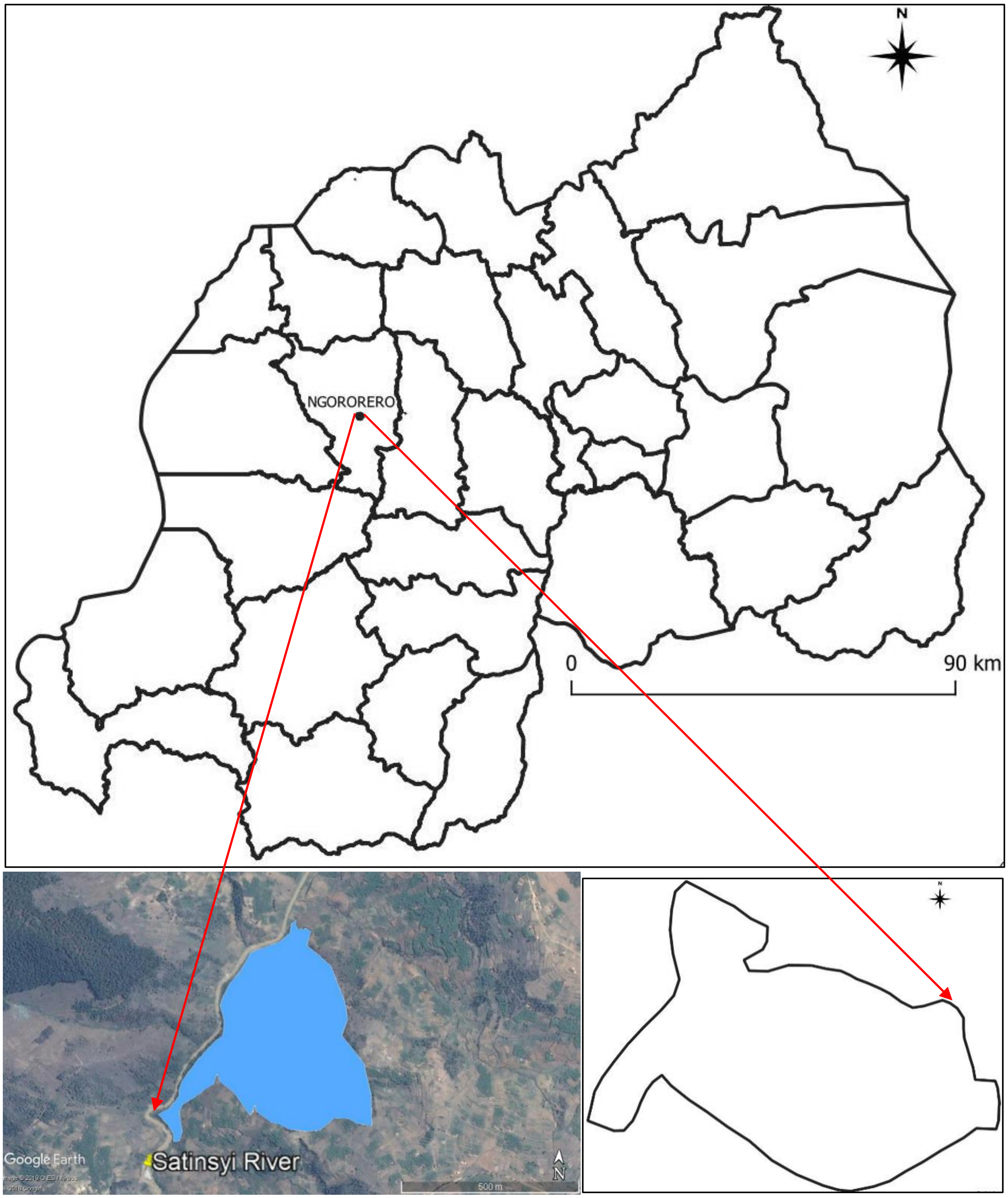

Figure 16: Sanza Forest location

Appendix 4: Photolog

Photo 1: Some threats to the Cyohoha Lake-above (left: *Nymphaea lotus*, right: *Ceratophyllum demersum*); middle: removal of papyrus in Cyohoha; below: agriculture encroachment to the Cyohoha Lake


Photo 2: Agriculture in Murago Wetland


Photo 3: Water hyacinth in Kibare Lake (left) and salty soil at the lake shores

Photo 4: Farming activities on the shores of Rwampanga Lake

Photo 5: Agriculture and grazing encroachment to Ruhondo Lake

Photo 6: Mining at Rwinkwavu Hill (left), Cypres-pine nursery bed (right)

Photo 7: Agriculture encroachment to Makera Forest

Photo 8: Mining sites in Sanza Forest (above), Steep slopes and Satinsyi River (below)