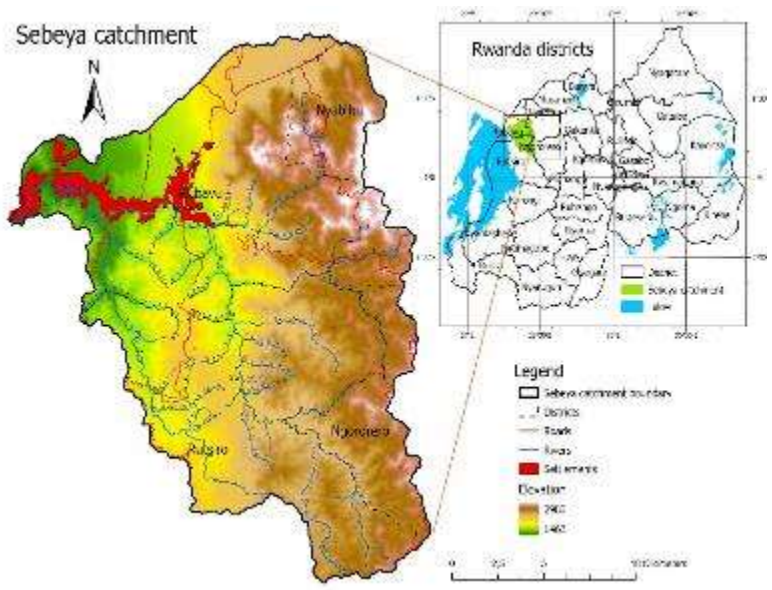
Baseline Biophysical and Socio-economic Assessment for Landscape Restoration and Integrated Water Resources Management in Sebeya Catchment, Rwanda

Background and Context

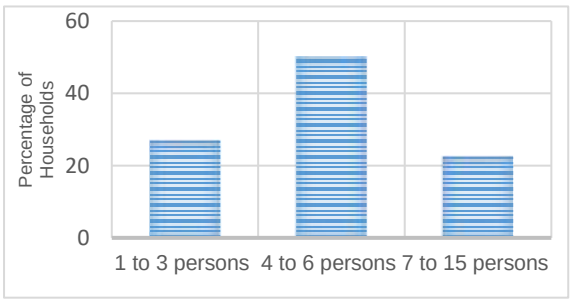
The EWMR Project, implementing IWRM and landscape restoration measures in Sebeya Catchment, Rwanda, is carried out by Rwanda Water Resources Board (RWB) in collaboration with International Union for Conservation of Nature (IUCN) and its consortium partners, Netherlands Development Organization (SNV) and Rwanda Rural Rehabilitation Initiative (RWARRI) with funding from the Embassy of the Kingdom of the Netherlands (EKN). The overall goal of the EWMR project is "Improved catchment management, contributing to increased resilience of communities & landscapes to the impacts of climate change and other drivers". The focus of the EWMR project is community engagement that is founded in development of Village Land Use Action Plans (VLUAPs). A baseline assessment has been carried out to document baseline indicators for measuring socio-economic and biophysical parameters that will be monitored throughout the implementation of the EWMR project. Monitoring these indicators is key to determining progress towards the accomplishment of established goals.



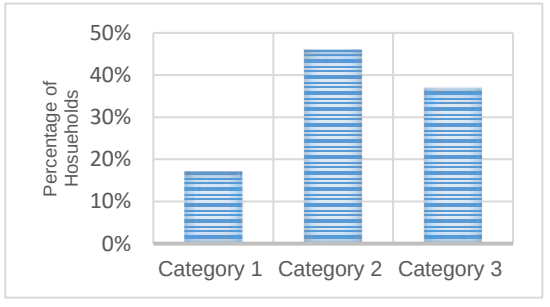
Baseline biophysical data including water and land cover characteristics (quantitative and qualitative) was obtained from surveys, Key Informant Interviews and focus group discussions. In situ observation of water physical-chemical parameters was obtained at various locations and supplementary data from WASAC water treatment plant of Gihira. A Household Economic Approach was used to collect socio-economic data. Demarcating livelihood zones based on land use, actions on the ground, climate, rainfall, mining, restoration activities, markets, and other economic information was done. Socioeconomic data collection targeted three main agro-ecological zones: upstream, middle stream, and downstream. 15 Villages (428 households) were sampled in the Sebeya catchments.

Summary Findings

Demographic and Socio Economic Profile



Household size



Wealth Category

Category 1: Very poor and vulnerable families, who are unable to cover basic needs without assistance.
Category 2: Citizens who can afford some form of rented or low class owned accommodation, but who are not gainfully employed.
Category 3: Citizens who are gainfully employed, or are employers of labor including smallholder farmers.

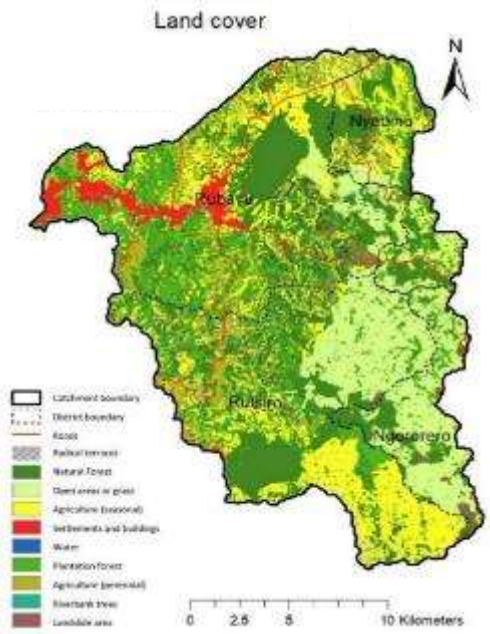
- At least 50% of households in Sebeya have family size of 4-6 persons.
- 17.1% of households are in wealth category 1 (very poor), 46% in category 2 (poor), and 36.9% in category 3 (better off). The average household size is 4.5, 4.8, and 5.4 persons per household for wealth category 1, category 2, and category 3 respectively. Better-off families mainly own larger land and more livestock than the poor and very poor families and mainly make income from livestock and crop sale.
- The poor and very poor households' main source of income is labour either on their small farms or working in the farms of the better-off families, and also depending on government programs covering basic needs such as education and health care.
- Agriculture and livestock husbandry are the most common income-generating activities across the three agro-ecological zones.

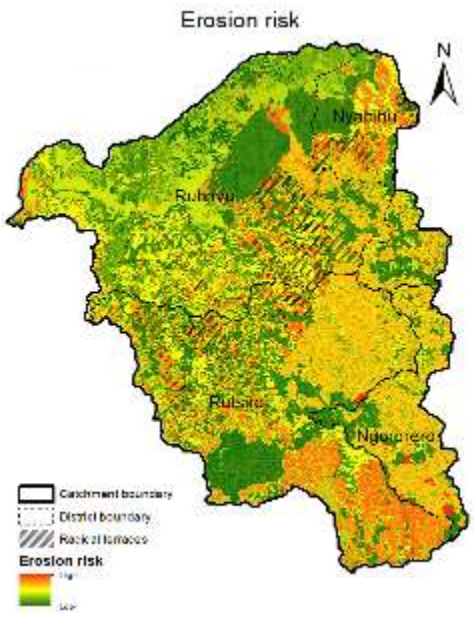
Land Ownership and Land Holding Size			
Description	Agro-ecological zones		
	Downstream	Midstream	Upstream
Percentage of households that own land	31.1%	68.5%	60.5%
Average farm land per household	0.25 ha	0.47 ha	0.44 ha

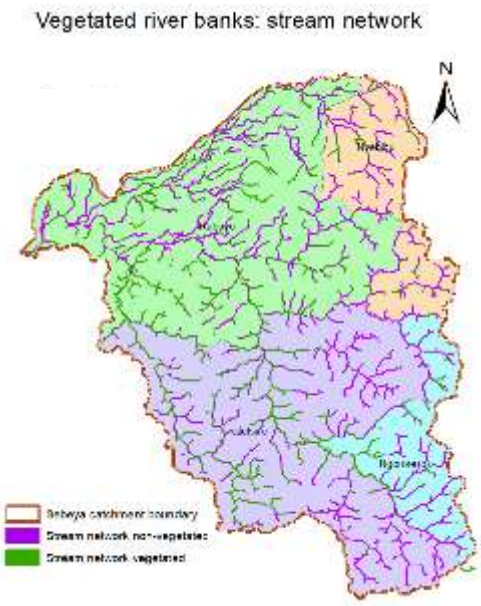
Water Use	
Description	**Water Use (L/d)**
Daily water consumption for domestic use per capita	9
Average livestock daily water useper household	52
Average irrigation daily water use per household	76

- Land ownership is concentrated in the better-off households (wealth category 3) as 47.9% of households that own land belong to this category. The land is mainly used for small-scale farming activities with Irish potatoes and maize as the maize crops.
- Average crop yield- Irish Potatoes: 11882 kgs/ha (Nyabihu) and 11350 ha/kgs (Rubavu); Maize: 1277 kgs/ha (Ngororero) and 1501 kgs/ha (Rutsiro).
- At least 46% of households belong to a village savings and loan association and about 28% have some form of a water harvesting system.
- Primary sources of energy (fuel) is wood (85%) while 14% use charcoal.
- The average daily per capita water use for domestic activities is above the national average in all the agro-ecological zones.

Biophysical and Hydrological Characteristics

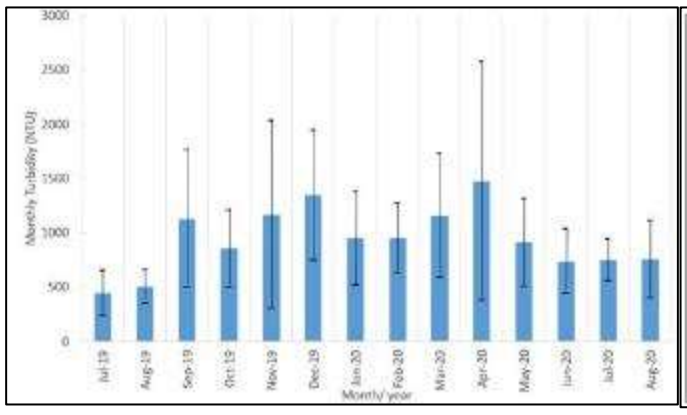




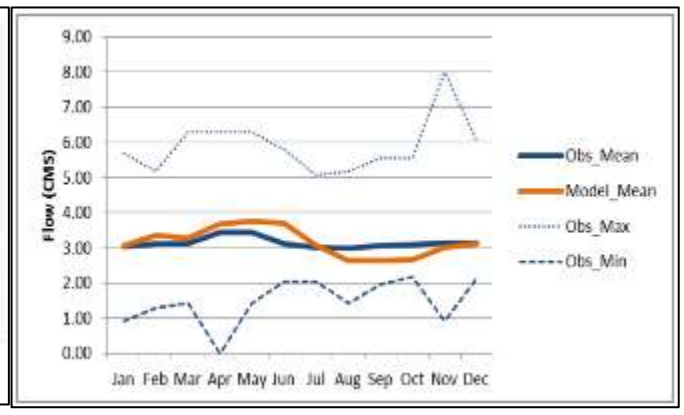


Land cover class	Area (ha)
Natural Forest	9,306 (26%)
Plantation forest	8,141 (23%)
Open areas or grass	6,512 (18%)
Agriculture (seasonal & perrenial)	10819 (30%)
Urban areas	1,037 (3%)
Total	36,252 (100%)

Major Gullies, rills and landslides					
District	Sector	Gullies (ha)	Landslide (ha)	Rill erosion (ha)	Total land affected (ha)
Ngororero	Muhanda	278		2	279
Rutsiro	Murunda	596	35	1172	1,803



Monthly averaged Turbidity (NTU) of Sebeya river water at Gihira intake



Discharge (observed (Obs) and modelled) for the period 1974 to 2014


Sebeya River at its source

- The Sebeya River average daily discharge at the outlet station ranges from 2.76 m^3/s to 5.3 m^3/s corresponding to an annual average discharge in the range of 1,4 million m^3/year and 2,8 million m^3/year
- Hydrologic simulations (using WEAP) show that water demand by 2030 will be 4 -10 times higher than in 2017.
- The high turbidity in Sebeya River, throughout the year, indicates the degraded status of the catchment.
- Vegetative cover has decreased to ca. 60% (main river) and 50% (stream network) and indicates great potential for riverbank revegetation.
- 56% of the catchment is covered by either Natural and plantation forest (50%), or Perennial agriculture (5%) - which helps reduce the landscape vulnerability to erosion, while 14% of Sebeya catchment is very sensitive to soil erosion. The total ha of land under restoration in the catchment is 5227 ha (2018). To support implementation of the Sebeya project, priority indicators listed below were identified for monitoring:

Key Indicators Identified for monitoring under the Sebeya Project		
	Indicator	**Baseline value**
1	Turbidity	Values ranged from 61-1118 NTU (in situ) and 10-3500 NTU (WASAC data)
2	River Water quality status	EC 17-1000 µS/cm, pH (5.5-7.9), DO (75-119 % sat.), Turbidity (61-1118 NTU).
3	River Water quantity status	Mean daily discharge at Sebeya outlet of 2.8 m^3/s - 5.3 m^3/s
4	Mining areas	12 licensed mining cooperation sites. 15 operational sand and gravel mining companies At least 400 small mining areas
5	Stable riverbanks	52% of streams have vegetated riverbanks with a 5 m buffer and 63% of the main riverbanks are vegetated based on a 10 m buffer zone.
6	Forest cover	26% of catchment area covered by dense forest and 23% is sparse forest
7	Catchment area under restoration	5227 ha of land under restoration


Sebeya River in built up area

Concluding Remarks

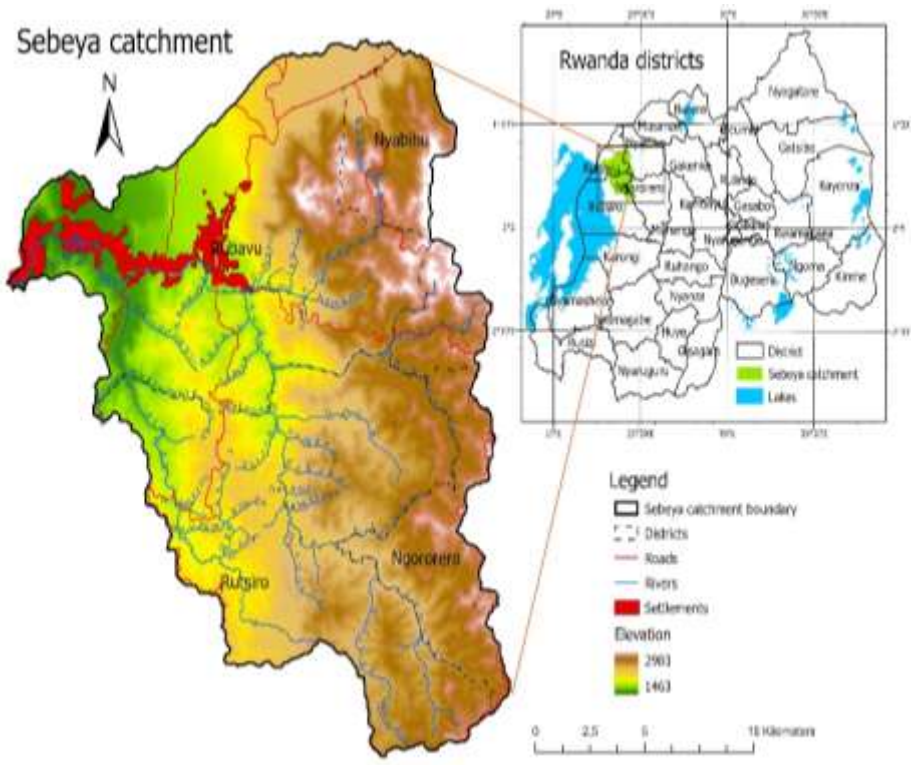
- There are multiple options for the Sebeya catchment to combine sustainable ecological conservation while increasing income and livelihood levels.
- A step-by-step and multilevel approach delivering durable proof first, followed by stimulating the required changes is recommended.
- Terracing combined with perennial agriculture is a suitable counter-erosion measure on steep slopes. Combined with reforestation in erosion prone areas, it will enhance the catchment's resilience. The financial part and knowledge development of terracing must be well established through undertaking cost benefit analyses.
- The study recommends to focus interventions on the following sectors: agroforestry, coffee and tea production, terracing and permanent agriculture, composting and irrigation, off-farm job creation and value chain improvement, new energy sources and Payment for Ecosystem Services.
- The full study report can be found on the IUCN – Rwanda website- *www.iucn.org*

IUCN SNV

Guidelines for the community participatory approach from the Embedding Integrated Water Resources Management (EWMR) in Rwanda project

BACKGROUND AND CONTEXT

The EWMR Project, implementing Integrated Water Resources Management and landscape restoration measures in the Sebeya Catchment, is carried out by Rwanda Water Resources Board (RWB) in collaboration with International Union for Conservation of Nature (IUCN) and its consortium partners Netherlands Development Organization (SNV) and Rwanda Rural Rehabilitation Initiative (RWARRI). The project is funded by the Embassy of the Kingdom of the Netherlands (EKN). The overall goal of the project is "improved catchment management, contributing to increased resilience of communities and landscapes to the impacts of climate change and other drivers".



Key to the Sebeya project approach is to empower and build capacity of local stakeholders to take the lead in landscape restoration. This grassroots approach is being achieved through the participatory development and subsequent implementation by local communications of 200 Village Land Use Action Plans (VLUAPs) that prioritize interventions that increase resilience by addressing the challenges that they are facing.

To successfully roll out, replicate, scale up, and scale out this village-based community approach, **guidelines** have been developed to support government institutions, NGOs and other stakeholders who want to use this successful approach.

The Community Participatory Approach consists of the following steps:

PLANNING PHASE

1. ***Identification of priority areas***: Since the landscape restoration requires huge investments, before to initiating any project, Districts need to prioritise areas that are highly exposed to degradation.
2. ***Stakeholders mapping***: Landscape restoration involves the engagement of all stakeholders who have interests in the catchment resources, to determine choices and set interventions together.
3. ***Awareness campaign***: Public awareness consists of informing the community and stakeholders within the landscape, about the current problem by drawing attention to it in such a way the information and education provided can solicit action to make changes.
4. ***Preparation of base maps***: For field VLUAP process, communities use GIS maps, which are produced with high-resolution satellite images overlaid with hydrological features and contours. The images allow communities to visualize the geography of their villages.
5. ***Training of facilitators***: A group of key personnel, including District, Sector and Cell technical staffs are trained to facilitate the VLUAP process. Each Cell within the intervention area should have representative to lead the community during the planning meetings.
6. ***Understanding the landscape characteristics***: Before conducting the community meetings for VLUAP process, facilitators need to visit the concerned villages for a quick assessment on land use, the level of degradation along with the physical and socio-economic impacts.
7. ***Community meetings***: Community meeting is the core part of VLUAP process. Such meetings involve all lays of community members within the landscape and should consider all aspects such as gender, age, social, professional occupation, public & private sector, etc.
8. ***Final report of VLUAPs and costing***: VLUAP process delivers agreed (by village, Cell, Sector, District and partner institutions) actions. It is composed of a narrative part, a list of proposed measures, implementation plan, technical specifications, budget, etc.
9. ***VLUAPs Validation:*** During community meetings, collected data help to draft VLUAPs. Additional data collection will lead to elaborate the final VLUAPs, which are validated jointly by Districts and all concerned stakeholders.
10. ***Building linkages between VLUAPs and Catchments:*** Water resources are managed on hydrological boundary basis. The linkage consists of aggregating VLUAPs with their interventions, quantities and costs within a given micro-catchment in order to catch-up the principle of catchment-based water resources management.

IMPLEMENTATION PHASE

1. ***Implementation plan***: VLUAPs implementation is integrated in the District annual work plan and budget of each District (District Imihigo).
2. ***Human Resources Mobilisation***: The staffs to be employed in the community participation method are in two categories: Employees on daily basis (manpower & capita), technical staffs on short term contracts (site technicians and Surveyors).
3. ***Procurement of goods and services***: The success of the community approach depends on the ability to procure timely the necessary inputs and make payments. Procurement of goods and services will be based on law governing public procurement.
4. ***Community mobilisation and capacity building:*** The community mobilisation is an important aspect of community participatory approach for landscape restoration. It creates VLUAP process awareness in order to gain community interests and ownership.
5. ***VLUAPs Implementation:*** Based on the annual work plan agreed at district level, concerned villages mobilise the community to implement actions planned through VLUAPs.
6. ***Payment modalities:*** The payment rates for various restoration measures (number, meters, ha) are established and agreed by the districts. Site technicians are conducting daily-based performance verification. Manpower are paid through their bank accounts in SACCOs every fortnight based on payroll lists made from site and approved by the District.
7. ***Maintenance and Sustainability:*** To sustain restored landscapes, it is essential to sensitise all service users on the costs to preserve those services and the role they can play. Community approach in LSR is a way of increasing the landscape restoration sustainability as it creates local ownership and equips people the need to keep restoring their lands even after the project ends.

MONITORING, EVALUATION AND LEARNING PHASE

1. ***Monitoring, evaluation and reporting***: Monitoring VLUAPs implementation will be done by the community through "comite de suivi" at village level under the guidance of District. Whilst village action plans are aligned with district Imihigo, their monitoring has also to be in line with Imihigo monitoring supported by the communities. It is likely villagers will become confident in planning and monitoring which is important for sustainability.
2. ***Establishment of comite de suivi***: Comite de suivi or community monitoring committee is the eyes and the ears of villagers. It helps to increase accountability and quality of implemented VLUAPs.
3. ***Learning from actions***: The community led monitoring will not only help in accurate monitoring but prior to this, villagers will learn from their own implementation. This supports local ownership and sets the scene for further implementation. It involves local communities in learning from the action they plan and implement. This is crucial in supporting sustainability beyond project cycles.

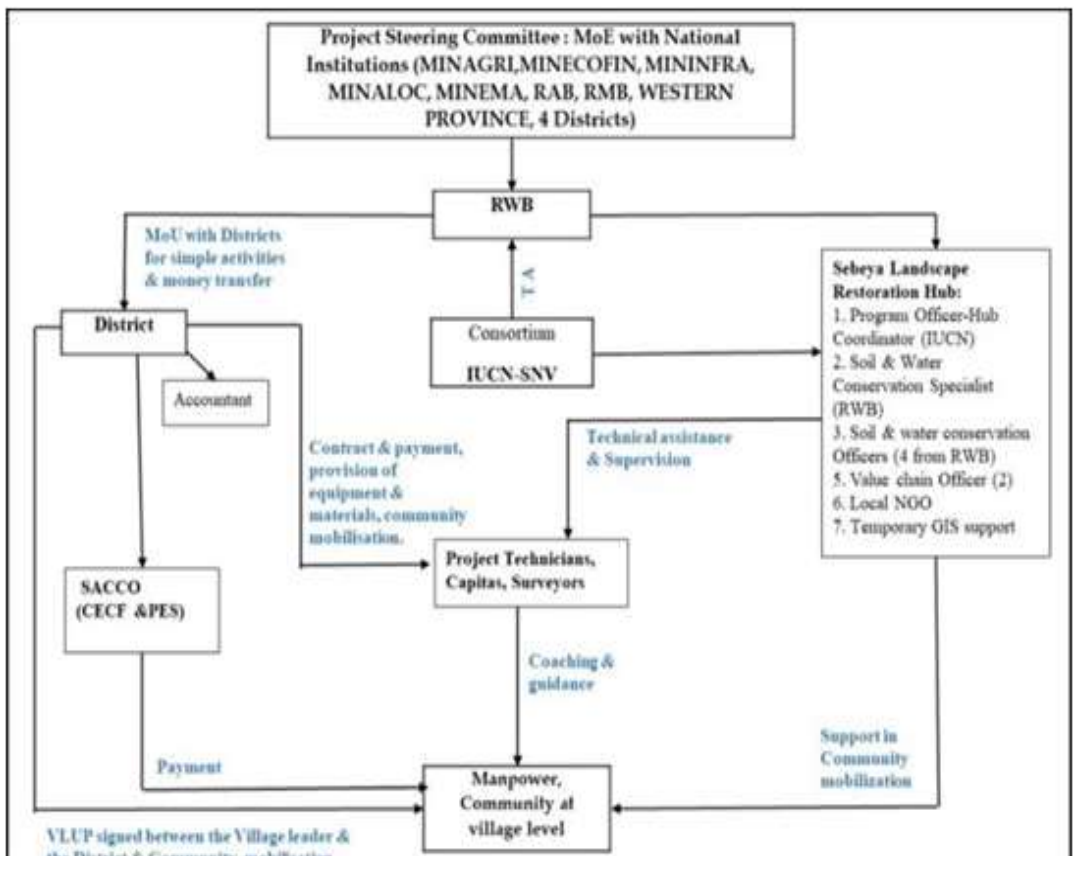
CONCLUSION

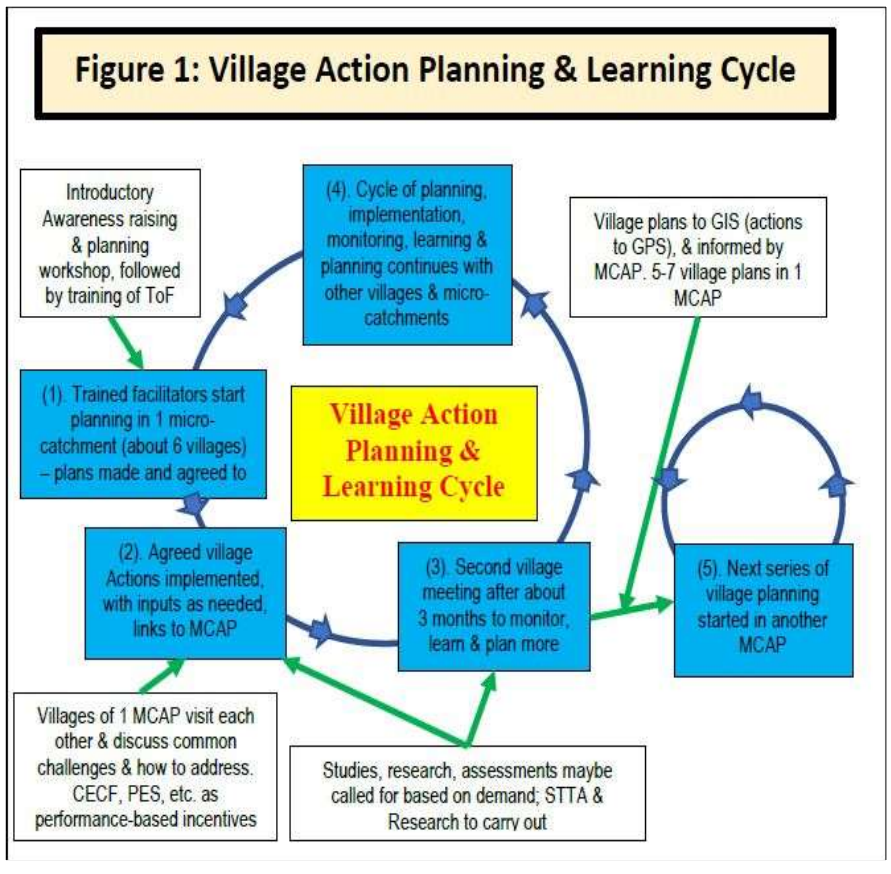
The Community Participatory Approach creates and re-enforces the importance of farmers and village ownership regarding plans they have developed and the actions they have agreed to. Farmer and village monitoring and learning strengthens community empowerment and ability, which in turn contributes to longer-term sustainability and reduced dependence on external support.

Such learning can take place as a part of planning, actions, monitoring and learning, and can be organized by small committees at village level to work with farmers and document what they have learned.

The guidelines provide instructions on how the Community Participatory Approach can be implemented in practice and indicate how it can link and contribute to some selected national policies and country's long-term plans.

All guidelines developed aim at emphasizing the sustainability and ownership of the implemented catchment restoration activities through participatory and Community-based approaches



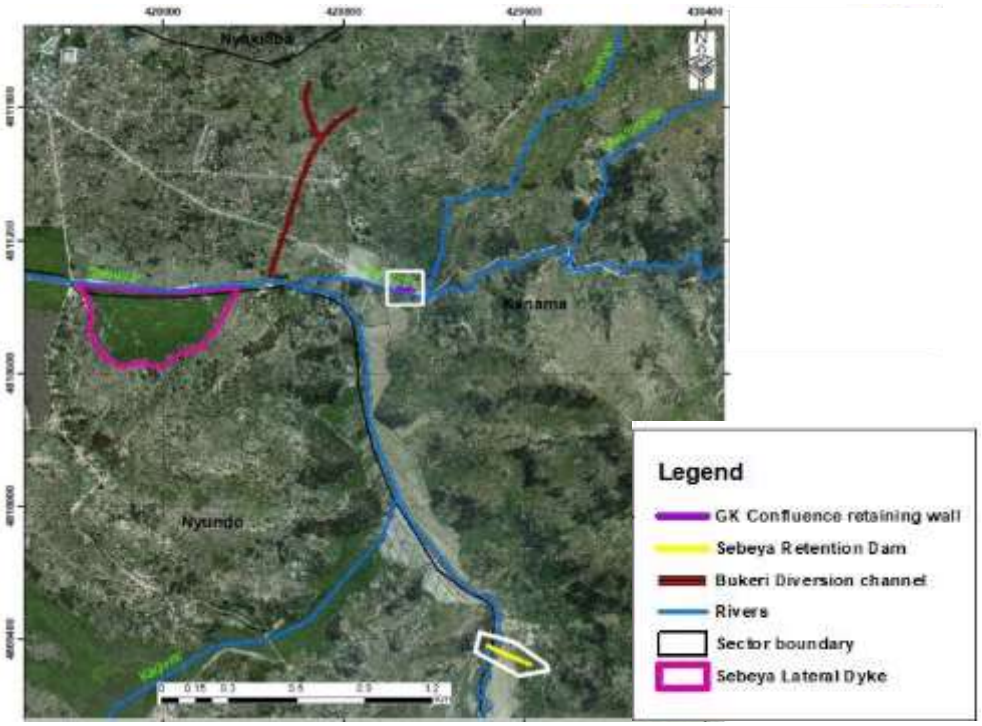


The full report for the guidelines can be accessed at: www.iucn.org

Environmental and Social Impact Assessment for Flood Mitigations and Protection Structures on Sebeya and Karambo Rivers

Background and Context

The Government of Rwanda through the Ministry of Environment, Rwanda Water Resources Board and different development partners have initiated and intensified their effort to reduce and ultimately prevent frequent flooding in catchments including the Sebeya. Intervention measures include greening the environment as part of integrated water resources management and construction of water control structures in specific areas. The Embedding Integrated Water Resources Management in Rwanda (EWMR) project funded by the Embassy of the Kingdom of Netherlands is undertaking construction of four flood control structures in Rubavu district of Sebeya catchment. The structures will contribute to the prevention of Sebeya River overflowing, and flooding of the lower Sebeya catchment floodplain and alleviate the associated flooding disasters. However, implementation of the intervention measures require comprehensive environmental and socio impact assessments to guide the sound implementation of these measures.



Flood mitigation and protection structures on Sebeya River

Project description

The major activities associated with Sebeya River Flood Mitigation and Protection Structures Project (FMPS) include the construction of Sebeya River retention dam, Sebeya lateral dike between Nyundo and Kanama sectors, the construction of a retaining wall at the confluence of Gisunyu and Karambo rivers, and the construction of the Bukeri diversion channel. The retention dam will provide for controlled release of water to downstream areas while the lateral dike will serve as a water impoundment zone. Given the nature and scope of the proposed project, the project has been assigned environmental assessment category of "category A" which means that before implementation, the preparation of an Environmental and Social Impact Assessment (ESIA) is required. In order to comply with Rwanda Law No. 48/2018, which outlines the modalities of protection, and conservation of environment and, Ministerial Orders No 001/ 2019 and No 003/MINIRENA/2015 of 24/04/2015, the ESIA has been prepared, following the applicable national ESIA procedures.

Objectives of the ESIA Study

The ESIA determined and evaluated the environmental and social impacts during construction and operation of the proposed projects.

Assessment Method

Field surveys conducted in the focus area formed the basis for the study and for the description of the baseline conditions. An inspection of the proposed sites was done with a special focus on possible social impacts mainly related to conflicting use interests and potential resettlement needs. During this survey, a qualitative and quantitative analysis of the impacts on ecology and on socio-economy caused by the project was performed.

Environmental and Socio-Economic Impacts

The positive impacts of the FMPS include:

1. Employment opportunities for local communities,
2. Skills transfer during construction and operation,
3. Enhanced economy in the project influence zone areas,
4. Increase and improvement in social and economic conditions and improved Sebeya floodplain agricultural production,
5. Health and safety of local community,
6. Private and public infrastructures safeguard.

Even though the FMPS project impacts are expected to be beneficial, such development activities may lead to some adverse impacts to existing biophysical and social environment through the potential damage to natural resources, including:

1. Land acquisition and change in land use (impacting local community),
2. Vegetation clearing and damage of biodiversity (fauna and flora),
3. Karambo and Bukeri water quality impairment,
4. Relocation of households causing disturbances to affected households,
5. Potential soil pollution due to spill of oil, grease and other chemical on construction work sites,
6. Disruption of natural drainage,
7. Water pollution due to construction activities in surface water bodies or disposal of wastes;
8. Air pollution due to dust and gases emissions and noise and vibration from the construction machinery/equipment,
9. Risk of health and safety, risks to health due to poor wastes disposal and labour influx;

Mitigation actions

It is important to identify potential impacts early in Sebeya FMPS Project planning process and to make provisions for avoiding, mitigating and compensation for these impacts/risks wherever possible and enhancement measures for the positive impacts. Among the mitigation strategies, the expropriation and compensation of the People Affected by the Project (PAPs) for their affected or lost properties is expected. The ESIA also recommends to the client and the relevant Rubavu District authorities Implementable Management Plans (IMP) to be included in tender documents and Sub-Contracts and to monitor good implementation practice. Sebeya FMPS Project will require different construction materials e.g. gravel, sand, and soil. The exploitation of identified sites for building material must be socially acceptable, economically viable and environmentally sound. It is proposed that construction materials be sourced from existing borrow pits located in the vicinity. The sourcing of materials required for the project will be undertaken in accordance with law on environment, Law N° 32/2015 of 11/06/2015 relating to expropriation in the public interest.

Monitoring actions and responsibility

A monitoring plan should be set up to ensure the identified negative impacts are avoided, mitigated, and compensated accordingly. The Contractor and Supervising Consultant will implement management, mitigation, and monitoring measures stipulated under this report and ensure compliance with National environmental and social safeguards policies under the direct supervision of Rwanda Water Resources Board, and Rubavu District. REMA will monitor and inspect the project implementation, while an independent consultant will conduct social and environmental audit during the project implementation.

Before starting construction activities, the hired Construction Contractor is expected to prepare a detailed Contractor Environmental and Social Management Plan (CESMP) and Management Strategy and Implementation Plans (MSIP) to detail required actions for the proposed mitigation measures against the identified negative impacts. To ensure that Sebeya FMPS Project is socially accepted and environmentally friendly; the implementation and monitoring of the proposed mitigation measures should be a team responsibility between the contractors, monitoring consultant, RWB and other stakeholders including Rubavu District.

Stakeholders consulted during the ESIA preparation, welcomed the project, as it will prevent the current recurrent damages and loss of human life in downstream Sebeya River floodplain. A Grievance Redress Mechanism will be prepared, and Grievance Committee established to deal with stakeholders concerns and to provide timely feedback to the complainant including any claimed damages. An environmental and social monitoring system will be established to monitor the PAPs livelihoods during and after the project activities. The expropriation and compensation payments for temporary disturbances or permanent land losses are to be supervised to ensure that all affected people are compensated adequately.

Conclusion

From the findings of this ESIA, it can be concluded that the project will bring significant benefits to the Rubavu District community and the country in general, if the proposed ESMP will be fully implemented and the implementation is monitored. The proposed Project will prevent damage and loss due to the frequent flooding in Sebeya during high rainfall events. Positive impacts of the proposed Sebeya FMPS Project outweigh potential adverse impacts/risks on the ecological and social environment.

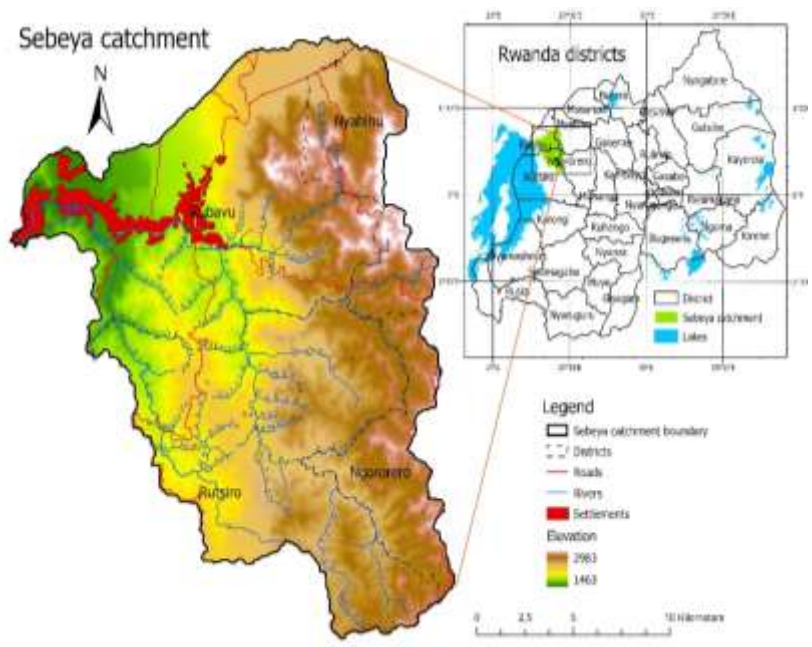
Full Report for this study can be found at www. iucn.org

IUCN SNV

Guidelines for Village Land Use Action Planning (VLUAP) and Learning to Embedding Integrated Water Resources Management (EWMR) in Rwanda project

BACKGROUND AND CONTEXT

The Sebeya Catchment in the Western Province of Rwanda has a high population density, resulting in land degradation. Thus, in turn negatively affects water resources through erosion and sedimentation.

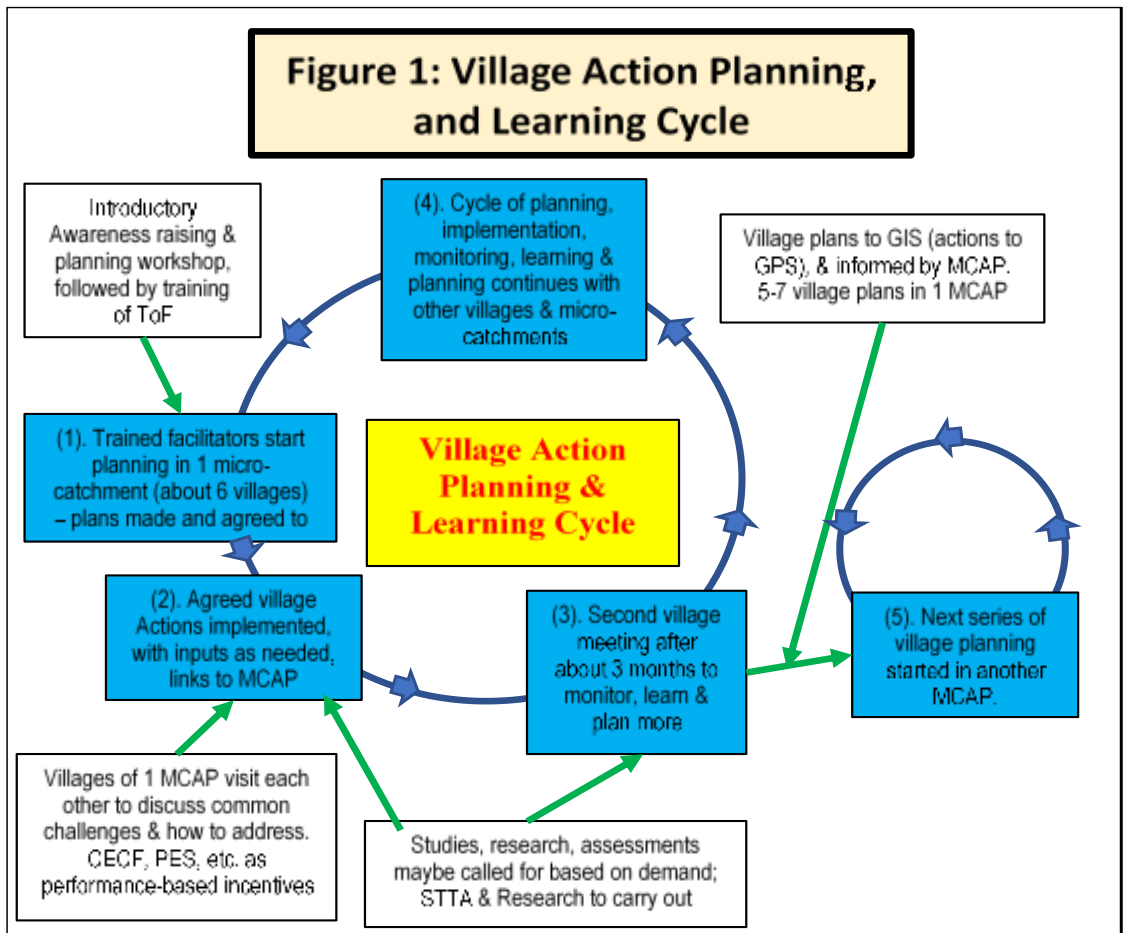


The Rwanda Water Resources Board (RWB) and consortium partners IUCN, SNV and RWARRI, are implementing the Embedding Integrated Water Resources Management in Rwanda project, funded by the Embassy of the Kingdom of the Netherlands. The overall goal of the project is "improved catchment management, contributing to increased resilience of communities and landscapes to the impacts of climate change and other drivers". Central to the Sebeya project approach is to empower and build capacity of local stakeholders to take the lead in landscape restoration through the participatory development and subsequent implementation by local communities of 200 Village Land Use Action Plans (VLUAPs).

Village Land Use Action Planning (VLUAP, Fig1) and Learning cycle (1) combines planning, action and learning; (2) learning helps promoting future planning and action to be done better; (3) learning occurs through action; (4) VLUAP is a careful reflection process around an issue or concern (e.g.: soil erosion) and (5) the village moves through a series of repeated cycles of action-observations-learning-planning.

The idea behind action-planning and learning is that a group of people (village members) with a shared concern (e.g. soil erosion) plan, implement and evaluate their actions. In this way they can implement more effectively. Action planning and learning is an overall approach and various methods and tools can be used (e.g. mapping; stakeholders analysis, transect walks)

Figure 1: Village Action Planning, and Learning Cycle



Development of VLUAP guidelines consists on the following steps:

1. ***Preparation of base maps***: For field VLUAP process, communities use GIS maps, which are produced with high-resolution satellite images overlaid with hydrological features and contours. The images allow communities to visualize the geography of their villages.
2. ***Training of facilitators***: A group of key personnel, including District, Sector and Cell technical staffs are trained to facilitate the VLUAP process. Each Cell within the intervention area should have representative to lead the community during the planning meetings.
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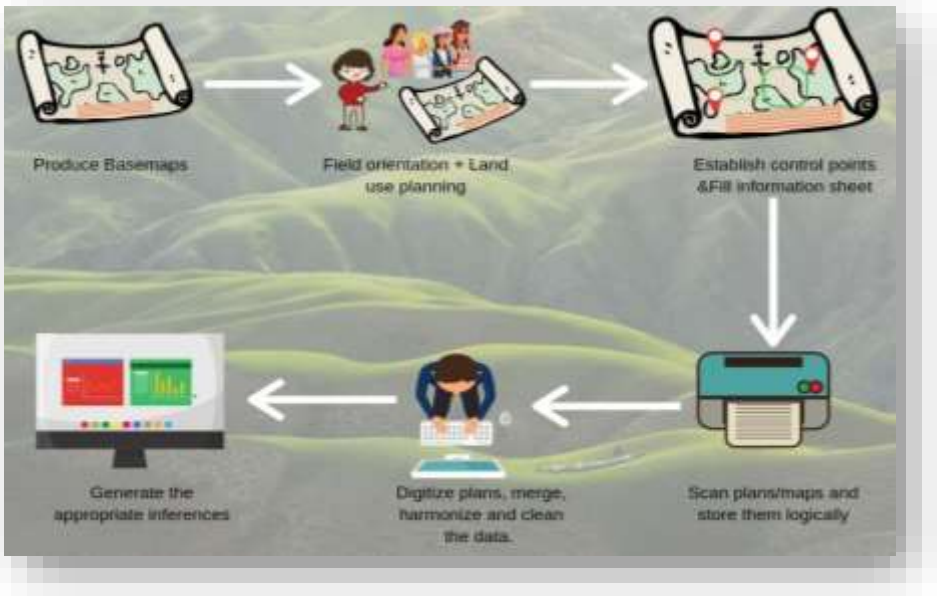
CONCLUSION

Village Land Use Action Planning (VLUAP) process creates and re-enforces the importance of farmers and village ownership regarding plans they have developed and the actions they have agreed to. Farmer and village monitoring and learning strengthens community empowerment and ability, which in turn contributes to longer-term sustainability and reduced dependence on external support.

Such learning can take place as a part of planning, actions, monitoring and learning, and can be organized by small committees at village level to work with farmers and document what they have learned.

All guidelines developed aim at emphasizing the sustainability and ownership of the implemented catchment restoration activities through participatory and Community-based approaches



The State of Soil Erosion Control in Rwanda

Background

Soil erosion is the most serious environmental problem in many landscapes' areas in Rwanda. The main factors affecting the amount of soil eroded include land use and vegetation cover, topography, soil and climate. In order to identify areas at risk to soil erosion and to develop adequate erosion prevention measures for Rwanda, a National erosion risk map (Figure 1) was generated and validated in July 2018 based on a methodology known as "Catchment Restoration Opportunity Mapping (CROM)" - a spatial model developed by the government through the former Rwanda Water and Forestry Authority (RWFA). The CROM model identified six erosion risk classes, namely: (1) No risk, (2) Low risk, (3) Moderate risk, (4) high risk zones, (5) very high risk and (6) the extremely high-risk zones of erosion.

The erosion risk map shows only the potential soil erosion risk, but fails to show areas already protected against erosion or erosive features proofing the risk. This information gap makes it hard for the government to track the progress made to fight against erosion. Moreover, the plan for the future interventions becomes difficult because the erosion risk map shows only the potential risks while districts need to know where exactly the problem lies and is the appropriate measures to combat soil loss considering different land uses. Hence, to make the soil erosion risk map more informative and useful – for multi-scale planning and the decision-making process for sustainable management of land and water resources - it was deemed essential to take the erosion risk map into a ground truthing process using most recent World View images available at National Institute of Statistics of Rwanda (NSIR). Using World View images with a spatial resolution of 30 cm to 30 cm and applying visual image interpretation techniques and onscreen digitization of erosion risk areas already affected by erosive features (gullies, landslides, rill erosion etc.) and erosion control measures in place were identified and mapped and where such measures are lacking appropriate measures were recommended.

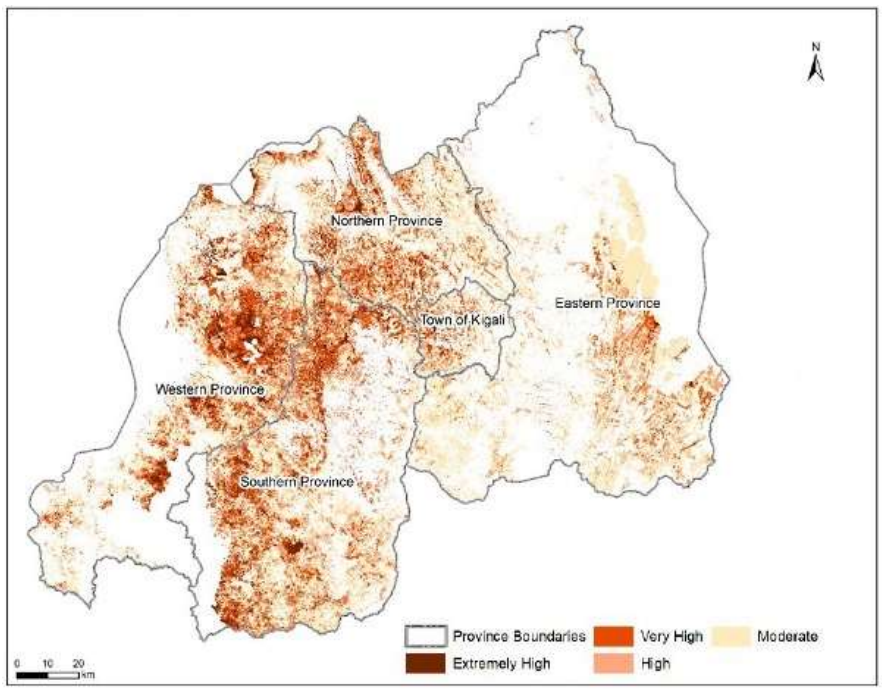


Figure 1: Erosion risk in Rwanda

In order to serve its purpose in sustainable land and water resources management, the erosion control mapping produces 5 thematic maps: 1) erosion risk distribution, 2) existing erosive features, 3) Land use and vegetation cover in high erosion risk areas, 4) existing erosion control techniques and 5) recommended erosion control practices in the view of unprotected land located at erosion risk. The data provided in this report will serve as benchmark for better monitoring of erosion control progress in Rwanda.

Erosive features in risk areas

The results of the erosion control mapping (Figure 2) shows that of the 30 districts of Rwanda, land under high erosion risk is about 1,080,168 hectares (45% of the total provinces land which is estimated to 2, 385, 830 hectares) of which 71 941 hectares (7% of the total risk areas) are at extremely high risk, 190, 433 hectares are at very high risk (18% of the total land at erosion risk), 300,805 hectares are at high risk (28% of the total risk identified), and 516,999 hectares (48% of the total land at risk) are at moderate risk. Ngororero District has the highest risk with a total of 58,003 hectares i.e. 85% of its land at high erosion risk. Muhanga district is ranked the second highest in erosion risk with 53, 352 hectares under risk (82% of the district land) while Rutsiro district comes third with 48,143 hectares prone to erosion estimated at 73% of the district land. Other districts such as Karongi, Gakenke, Huye, Nyaruguru, Rulindo and Nyamagabe districts needs considerable attention as the risk accounts for more than 60% of the district land.

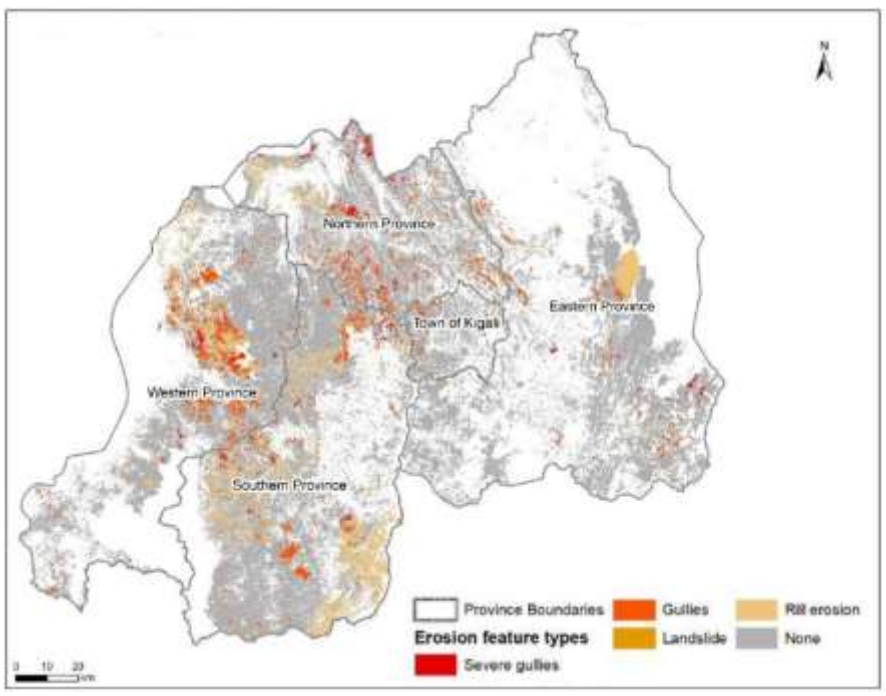


Figure 2: Erosion features in Rwanda

The observed erosive features in risk areas have shown that about 70,433 hectares (17% of the country land at risk) are affected by Gullies (39% of the affected land), severe gullies on 13,584 hectares (8% of the land-affected land), landslides on 2,823 hectares (2% of the affected land) and rill erosion (93,831 hectares, i.e. 52% of the affected land). The upper Nyabarongo is the worst affected with 45,961 hectares affected of which 28,123 hectares are affected by rill erosion, 14,337 hectares are affected by gullies, and 2,353 hectares are affected by severe gullies, while 1,148 hectares are affected by landslides. Kivu catchment area follows with 34,050 hectares affected of which 15,085 hectares are affected by rill erosion, 16,033 hectares are affected by gullies, 2,426 hectares are affected by severe gullies and 506 hectares affected by landslides.

Land Use and Vegetation Cover in area at risk

Land in the high-risk areas is mostly used for agriculture with seasonal crops accounting for 61% of the high-risk areas identified (Figure 3).

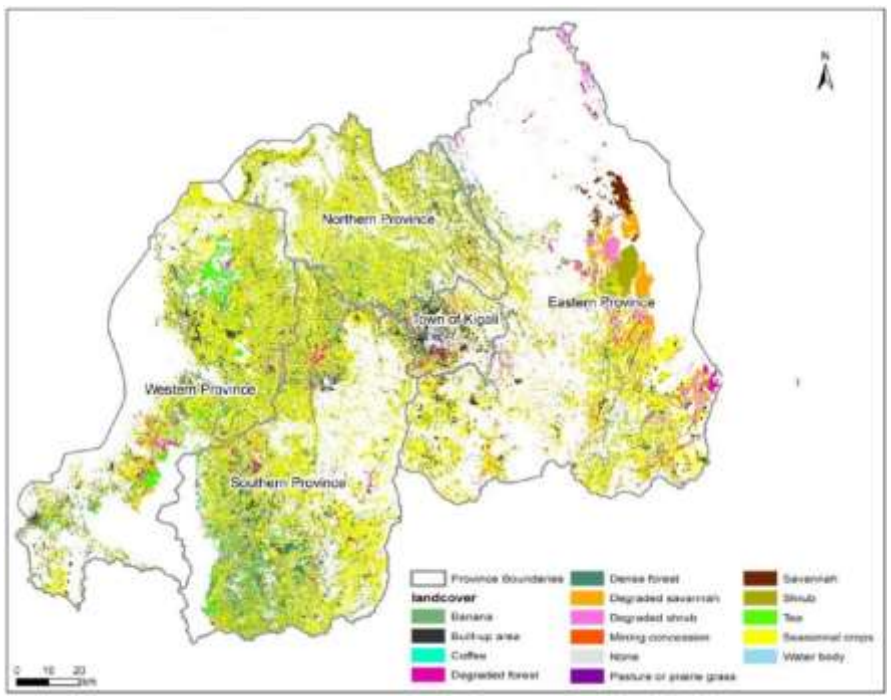


Figure 3: Land cover in areas at risk

Seasonal agriculture exposes soil to splash erosion and further detachment as land is not permanently covered. In fact, the crop management and cover factor (C) is very high for seasonal crops with conventional (regular) tillage. Forests with high canopy density occupy only 188,904 hectares (17% of the risky areas) while seasonal crops occupy 656,304 hectares (61%) and built-

up areas occupy 89,595 (8% of the land at risk). Others like banana, coffee, mining and quarry sites, and tea cover less than 2% each. This means that land will continue to be eroded if measures are not implemented.
Mining areas in high-risk zones account for 0.3%. Built-up area, although relatively small (8%), accelerates water velocity, runoff, and flow accumulation which creates severe gullies downstream. In such areas, storm-water management facilities, as well as the rainwater harvesting infrastructure, should be established to collect storm water from houses in agglomerated zones, while best practices in mining are also reinforced to stop dumping soil sediments from mining in rivers and streams as they fill the river beds or streambeds which in turn expose the river bank to erosion and flooding.

Efforts in controlling erosion in Rwanda

The proportion of land at erosion risk, which is currently protected, is very low (Figure 4). In fact, of 1,080,168 hectares of land at risk in all provinces, only 282,352 hectares are protected against erosion (26% of the country land at risk). Of this amount, 28,870 hectares are protected by contour bank terraces (progressive terraces) covering 10% of the land protected while forests protect about 190,011 hectares at risk (67 % of land protected). There are other practices like bench terraces (42,379 ha: 15%), hedgerows and shrubs (318 hectares), etc. About 797,816 hectares are not protected yet, which is about 74 % of the total country land at risk.

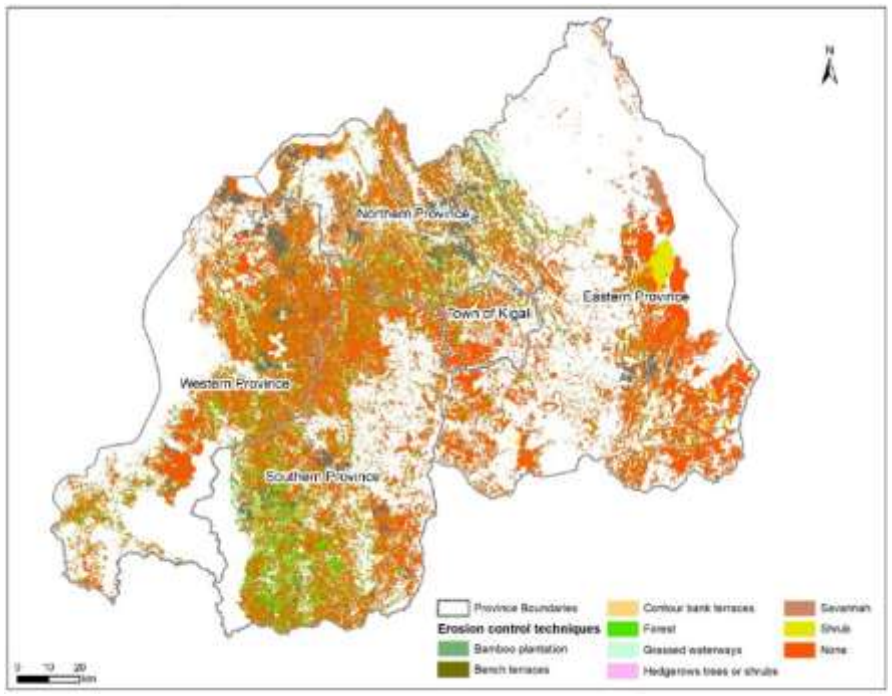


Figure 4: Erosion control measures in Rwanda

Recommended erosion control practices

Based on analysis and impacts from previous implementation of erosion control measures, the following recommendations were made:

- The contour bank terraces are recommended in high-risk agricultural lands while ditches in the forested area.
- Bench terraces are recommended in areas at high to extremely high risk where there has been started the bench terracing but which did not complete the entire area which is suitable for that recommendation.
- Grassed waterways are recommended for existing terraces, which was made without waterways or with, but no grasses can cause severe gullies and destruction of bench terraces created.
- No-till agriculture (zero tillage) is recommended for perennial crops on the extremely high-risk area while Storm-water management facilities (SWMF) or water harvesting facilities is recommended in built-up areas.
- Bamboo establishment is recommended to close gullies or to protect rivers. Forests (Afforestation or reforestation) are recommended in extremely high-risk areas.

Based on the erosion risk status for the country, contour banks terraces are required on 510,096 hectares (47% of the total country land at risk), while afforestation and reforestation are required on 39,901 hectares (4% of the country land at risk), Agroforestry and Hedgerows are required on 101,232 hectares (9% of the total country land at risk). Bamboo planting is required on about 14,915 hectares of land affected by gullies and on riverside. No-tillage agriculture is required on 43,552 hectares for perennial crops established on land at very high risk. Storm-water management facilities or water harvesting facilities are required in urbanized and settlement areas on about 89,679 hectares (8 % of the total land at risk).

Macroeconomic cost of soil erosion

- More than 745 thousand hectares of agricultural land in Rwanda are potentially eroded every year. Using a reference year of 2021A, above 3 million tons crop produces are estimated to be lost seasonally (6 million tons annually), of which 22 thousand tons of maize and 15 thousand tons of beans are estimated to be lost every season due to severe erosion. The total economic loss in agricultural productivity due to severe erosion in Rwanda is around 37.9 billion Rwandan francs (RWF) every season. In term of GDP, in the first quarter of 2021, GDP at current market prices was estimated to be 2,579 billion RWF; agriculture sector contributed 27%, which is about 690 billion RWF. The crop productivity loss therefore translates into a loss of about 37.9 billion RWF (5.5%) of the agricultural sector contribution to Rwanda's GDP in the first quarter 2021.

- The national average for topsoil loss is approximately 25t/ha/year (27 million tons of top soil lost annually).

- Considering the market value of topsoil in Rwanda, a proxy for soil productive capability, which is between US$34/ton (RwF30,000) and US$57/ton (RwF50,000); the annual loss is therefore estimated to be RWf 810 billion on average, which is about one and half fold of what landscape restoration of the entire country would cost (RWf 513billion).

- Soil erosion removes the upper fertile part of soils that contains nutrients. considering that a ratio of soil carbon/nitrogen (C/N) ranges between 8 and 10 (an average ratio of 9) in arable land, one hectare (1ha) of agricultural field contains on average 2t C/ha/yr., and an amount of organic nitrogen is in the order of 0.2t N/ha/year. Considering 641,280 hectares affected by soil erosion and an average soil loss of 25t/ha/yr., it is estimated about 16Mt/yr. of soil displaced carrying about 1,282,560t C and 128,256t N loss per year.

- In order to compensate soil nutrient loss and improve land productivity, urea and di-ammonium phosphate (DAP) is applied. In the substitution of Nitrogen loss with urea, with an average price of RWf 564,000/t, it would cost a total RWf 72 billion per year to Rwandan farmers.

Cost and benefits of erosion control actions

- The total cost of erosion control actions is estimated to 514 billion Rwandan francs of which 323 billion are for protection of agricultural land against soil erosion (about 60% of the total risk areas) using bench terraces, contour bank terraces known as progressive terraces and agroforestry and hey plantation on contour banks. This requires about 8 years from 2022 to 2030 to complete the activity by investing at least 42 billion RWf every year to protect agricultural land against excessive erosion using community approach.

- In doing so, we would cut the productivity losses and therefore raise additional agriculture contribution to about 5.5% GDP that are lost every season as a consequence of inaction.

- However, because soil erosion itself is a symptom of poor land management, erosion control measures alone will remain insufficient to improve the management of land and water resources given the current agricultural land uses and related management. There should be a switch of emphasis to focus on the promotion of a high-quality integrated land management system rather than stand-alone erosion control measures in agricultural land.

- High quality land management could be achieved through an integrated conservation agriculture approach that provides profitable agricultural yields, while minimizing environmental damage. Rainwater harvesting in settlements and storm-water infrastructure in urban areas also has the potential to address accelerated erosion and other problems resulting from rainfall run-off across the country.

Conclusion

- Erosion and sedimentation problems remain a critical challenge for socio economic development in Rwanda

- Implementing erosion and Sediment control measures needs to be upscaled and prioritized at all levels from the local community level to national scales

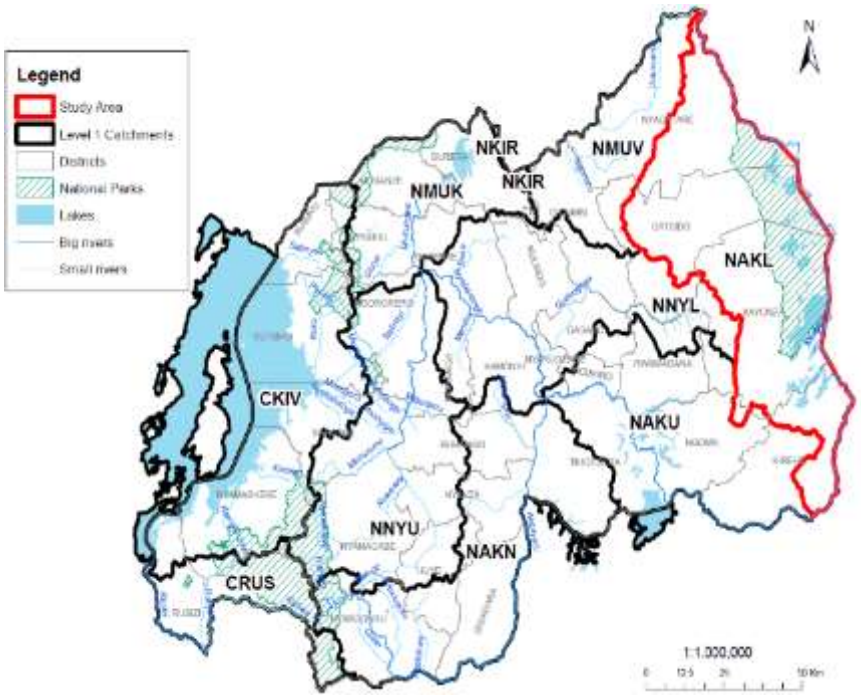
- Developing national awareness and enhancing capacity of local communities to implement erosion control measures must be prioritized. Developing erosion control guide for local government and community participation

The full report for this assessment can be found at www.iucn.org

Bio-Physical Assessment and Hydrological Analysis for Akagera Lower catchment, Rwanda

Overview

The catchment is located in the low eastern plateau of Rwanda. It includes the internationally important Akagera National Park, which includes a savannah ecosystem as well as a system of lakes and wetlands. The catchment is a transboundary catchment sharing borders with Tanzania and relying on water from Burundi. It has a surface area in Rwanda of 4294 km², while the total basin area is 30,632 km². In Rwanda, the catchment touches parts of the Nyagatare, Gatsibo, Kayonza, Kirehe, and Ngoma districts of the Eastern Province.



Akagera Lower catchment (red boundary) in Rwanda

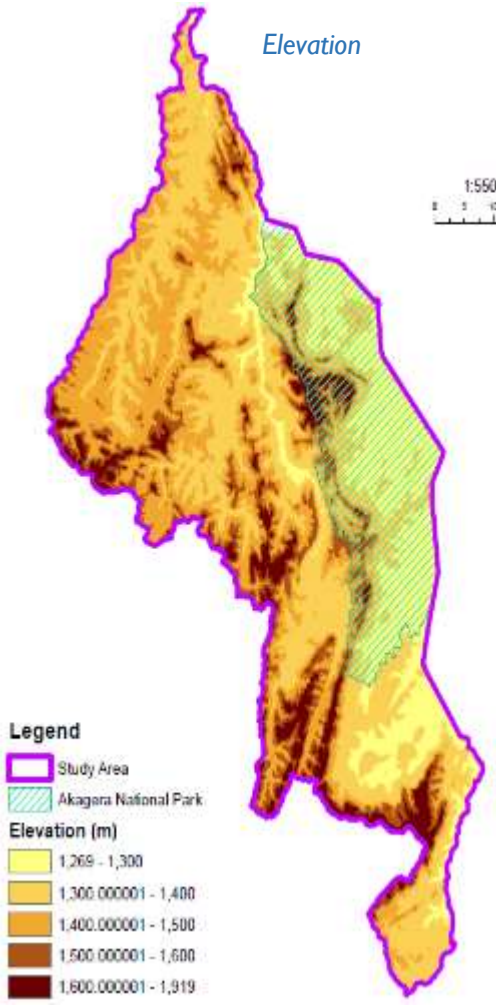
The upstream national dependencies are the Upper Akagera catchment, as well as the Ruvubu River from Burundi. The population living in the catchment is approx. 0.5 million but expected to double by 2040.The catchment receives major inflow from the upper Akagera and Ruvubu rivers. The later river almost doubles the upstream catchment area. The two main tributaries in Rwanda (Kamiramugezi and Karangazi rivers) have low and ephemeral flows at the end of the dry season when demand is the highest.

Climate change impacts is an important consideration for assessing hydrological characteristics of the Akagera Lower catchment. Results from simulation models show that, in terms of temperature, in the fnar future horizon (2015-2045), there is a likelihood of an increase of 0.1-1.8°C while in the far future (2045-2075) there is an expected increase of approximately 1.0-3.5°C, with a larger spread in model prediction. In terms of precipitation, short-term horizon (2015-2045) is expected to result in 7.5% decrease to 20% increase for 2030, while in the longer-term horizon (2045-2075), approximately 7.5% decrease to 45% increase are predicted.

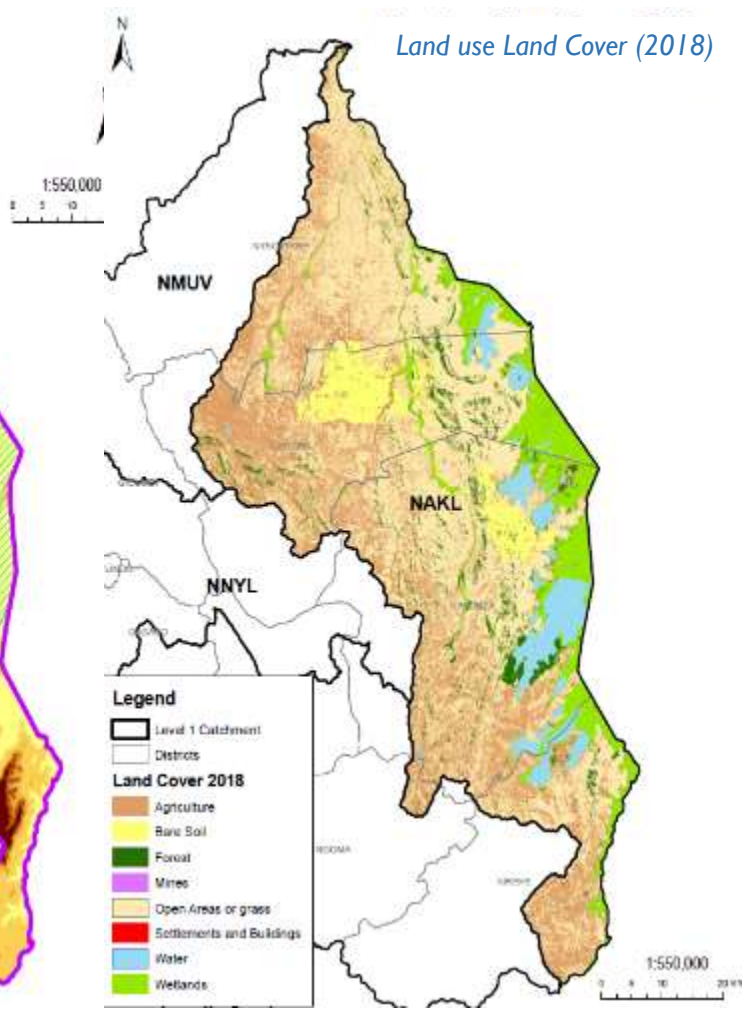
Biophysical Characteristics

The land use in the study area is mainly made of grassland (approximately 50% of total), agriculture (approximately 30% of total) and others (approximately 20% of total). The wetlands and lakes mostly cover the most eastern part of the catchment. The catchment Restoration Opportunity Mapping (CROM) model has identified the majority (66%) of the catchment as moderately prone to soil erosion while 9.6% has a very high soil erosion risk. Only 1% is extremely prone to erosion. According to the Natural Capital accounts for Rwanda Report (*Rwanda Natural Capital Accounts report, 2019*) , the Akagera Lower catchment has one of the lowest soil erosion potential (20 t.ha.yr) compared to the other eight level 1 catchments.

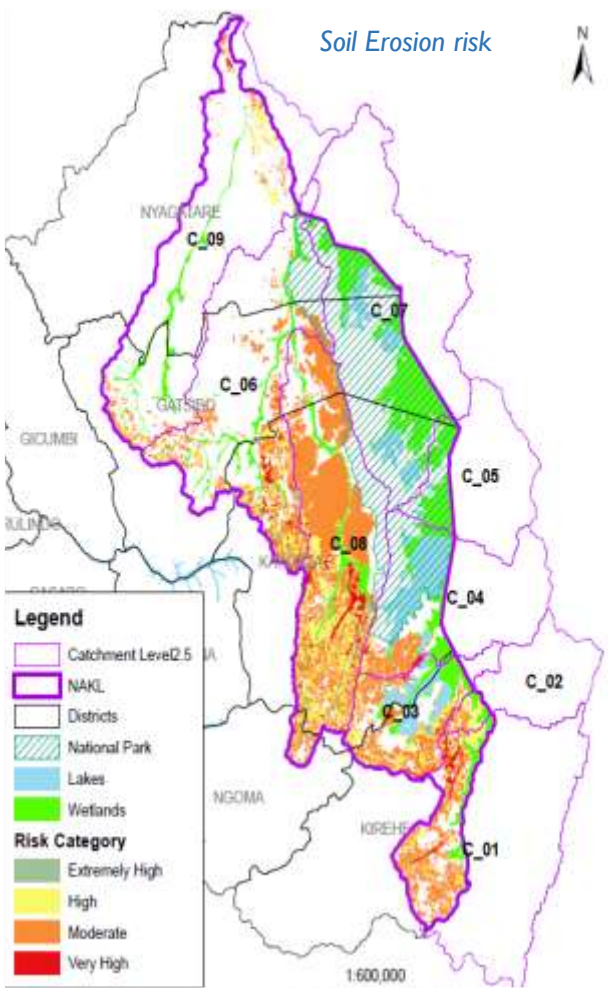
Elevation



Land use Land Cover (2018)



Soil Erosion risk



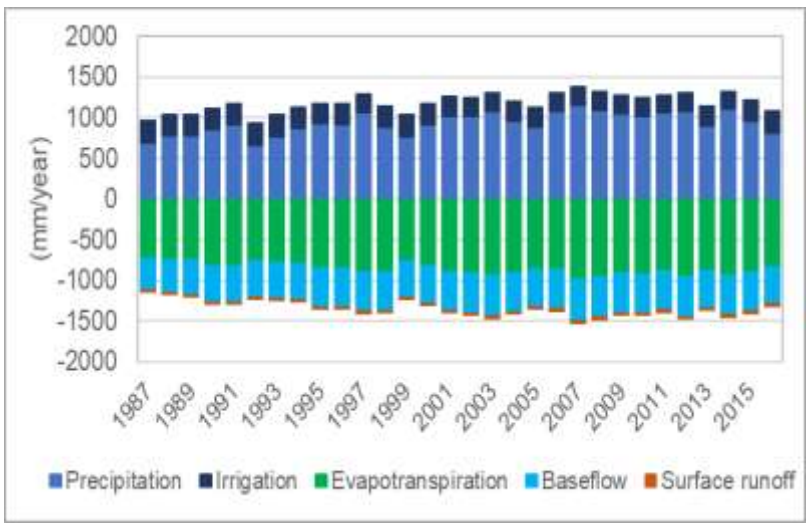
The land use in the study area is mainly made of grassland (approximately 50% of total), agriculture (approximately 30% of total) and others (approximately 20% of total). The wetlands and lakes mostly cover the most eastern part of the catchment.

There are 59 wetlands in NAKL with a total area of 57,189 ha. Some of the well-recognized lakes and wetlands in NAKL, which are classified under total protection (Akagera aval, Kivumba, Kizi, Rwandazi-Rwamuconco, Nyamwashama, Rwampanga and lakes such as Hago, Ihema, Kivumba, Mihindi, Ngerenke and Rwanyakizinga).

The gently sloping landscape makes the catchment suitable for large-scale irrigated agriculture, even though it's the driest part of the country (835mm/yr annual rainfall). An estimated 99000 ha of land in the catchment is suitable for irrigation (Rwanda Irrigation Master Plan, 2020)

Water Balance for baseline conditions

- NAKL receives inflow from upstream from the Akagera river and from the Ruvubu (Burundi) that confluences with the Akagera river just upstream of NAKL catchment. There is no streamflow data available in Akagera Lower, only upstream at the Rusumo station.
- The inflow from the Ruvubu catchment is not quantified as there is no recent data available. The total average inflow from from Upper Akagera is about 220 m^3/s
- About 92% of average annual precipitation is used for evapotranspiration, and the runoff/precipitation ratio is 0.21
- The water balance shows a surplus of water resources for the existing/baseline conditions.

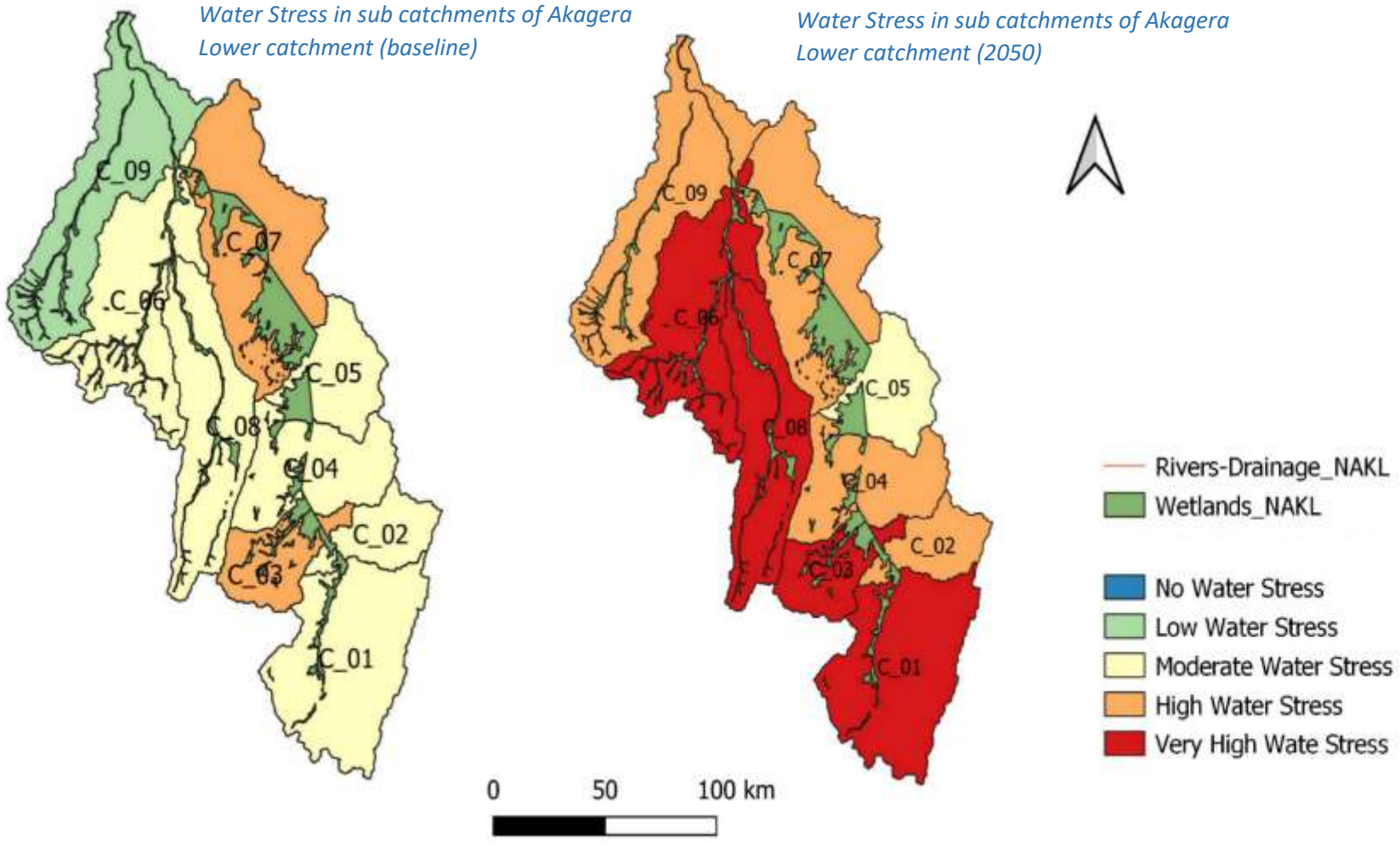


Annual Water Balance in Akagera Lower catchment

Water Stress: Current and Future situation

Water Stress in sub catchments of Akagera Lower catchment (baseline)

Water Stress in sub catchments of Akagera Lower catchment (2050)



Overview of Current and projected Water Demands and required interventions

While there are no major unmet demands in the present situation, there is a major threat of unmet water demands in the future in almost all sub catchments. Especially the wetland areas that are not close to the Akagera River (in C_06 and C_08) face competition with the irrigated agriculture. Livestock in these sub catchments could also face unmet demand. The irrigated agriculture will also face challenges, to supply the required demand. To alleviate the challenge of unmet demand, demand management measures need to be implemented in areas and times of negative water balances. The following demand management measures can be implemented in the Akagera Lower catchment:

a) The "potential" unmet demands for the large components of irrigation and wetlands can be recovered through the structural measures (i.e., river intake) or non-structural/nature-based solutions (i.e., construction of wetland)
b) The "potential" unmet water demand in sub-catchments C_01 – C_04 can be recovered through structural measures from the river system. The structural measures from the river system will have access to the inflow available at the upstream boundary of NAKL, (approximately 7000 MCM/year).
c) Alternatives that support increased storage (IS), sustainable land management practices (SLM) and water saving (WS) measures on water demand, water allocation and corresponding unmet demand.
d) The preferred solution to minimize "potential" future unmet demand can be sought through an optimal combination of structural and non-structural/nature-based solutions by including
    i) river intake,
    ii) crops with reduced water requirements and higher revenue generation types,
    iii) storage facilities in the vicinity of proposed irrigation areas to allow recovery of water deficit months,
    iv) implementation of water savings, SLM practices, and
    v) Protocols for transboundary water management to recover water deficit conditions across the neighboring countries.

Conclusions

1. Catchment degradation is an important challenge that the Akagera Lower catchment faces. Sustained efforts to restore degraded lands are required in the catchment to ensure the catchment remains an important
2. Water resources in the catchment are not enough to meet future demands e.g. to support expansion of irrigation areas.
3. There is a clear need to ensure that water resources management in the catchment are planned well with a clear strategy prioritizing key actions to ensure sustainability, ensuring ecosystem service supply and meet water demands to meet national development goals.

The full report for this assessment can be found at: www.iucn.org/

Catchment Management Plan for Mukungwa catchment, Rwanda

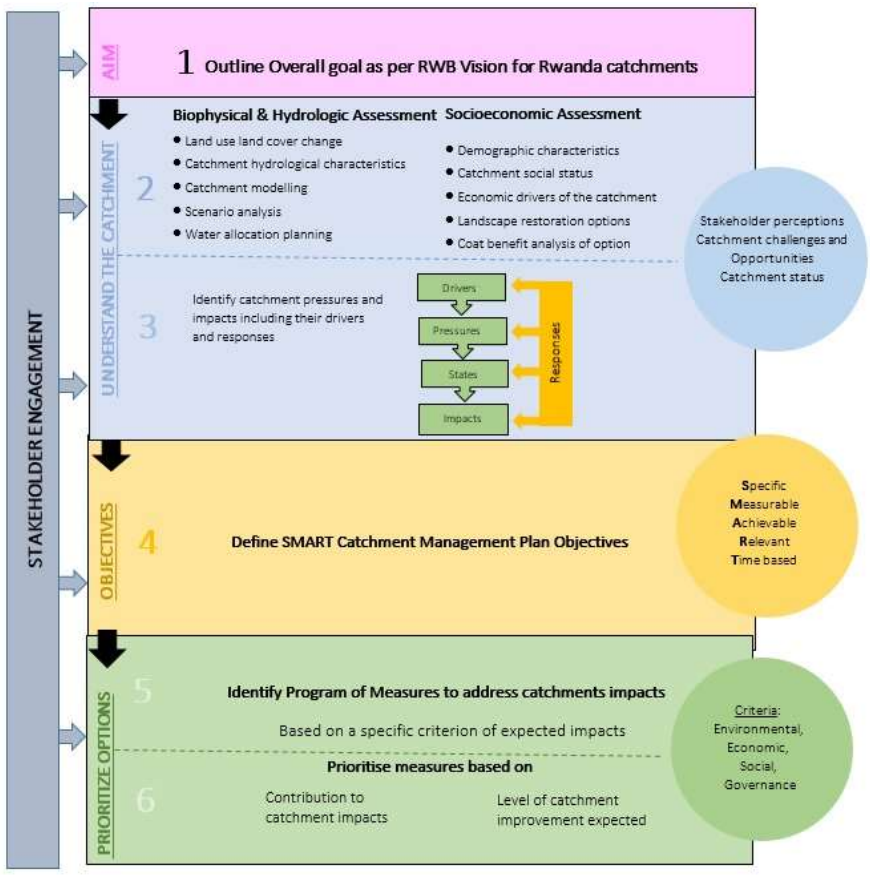
Catchment and Integrated Water Resources Management

Sustainable and effective management of water resources in Rwanda is a cornerstone to the success of the country's Vison 2050. Water resources are a backbone for key sectors of the Rwanda economy including agriculture, hydropower generation, agriculture, fisheries, industrial and domestic water supply, and navigation, among others. With the country planning to scale up access to water from 87 % (1987 estimate) to 100% by 2024 and increase renewable water resources per capita from 670m3/capita/annum to 1000 m3/capita/annum, there is a clear need to promote, implement prudent water resources management programs that will ensure these goals are reached. Rwanda is divided into nine catchments (hydrological units), and management is based on these hydrological boundaries. As hydrological boundaries do not follow administrative boundaries it is therefore critical that water resources management is undertaken in a holistic and integrated manner to ensure effectiveness. Catchment based water resources planning and management is in line with the Integrated Water Resources Management (IWRM) approach promotes holistic catchment-based planning and management for landscapes, water and associated resources in a coordinated manner. A key component of IWRM is catchment long term planning and development of the Mukungwa Lower catchment management plan falls in line with the Government of Rwanda goal to ensure all nine level one catchments are managed following clearly defined plans.

Purpose and Objectives of Catchment Management Plans

The catchment management plan purpose is to serve as a long-term strategic blueprint that guides management, and utilization of natural resources with a view to ensure sustainable ecosystem service supply benefiting the environment and communities and the country at large. The catchment plan for Mukungwa catchment in Rwanda has been built with the following objectives in mind:

- Understand the catchment status including biophysical, hydrological and socio-economic situation.
- Develop likely future scenarios of catchment characteristics based on the expected development plans for the catchment and other factors including climate change projects.
- Outline program of measures, which specify the management activities and strategies to be adopted to ensure protection and sustainable use of ecosystem goods and services.
- Engage catchment stakeholders to collaboratively develop the plan and develop ownership of both the plan and the landscape for supporting plan implementation.
- Outline an investment requirement for implementing prioritized actions in the catchment.



The Mukungwa catchment plan development is based on a participatory approach that involves deliberation, planning, implementation, and assessment, learning, and adjustment steps in a continuous and iterative process. Beyond the development of the plan, sectoral planning by agencies and stakeholders, informed by this overarching planning will guide implementation and monitoring. The planning process is aligned with other main National strategic plans like NST 1, Sector Strategy Plans (SSPs) and District Development Strategies (DDSs).

Mukungwa Catchment

The Mukungwa catchment is located in the northern headwaters of the Akagera basin and covers approximately 1,830km². The catchment is home to an estimated population in excess of 1,250,000. Rivers from the east side of the catchment drain into the Rugezi wetland (a Ramsar site) and lakes (Burera and Ruhondo) from which the Mukungwa River emerges. Mukungwa river flows in a mostly southern direction towards its confluence with the Nyabarongo River and joins the Nyabarongo River at Ngaru (boundary between the Mukungwa, Nyabarongo upper and lower catchments), before it joins the Akanyaru River upstream of Kanzenze, where it becomes the Akagera River. The land use in Mukungwa is mainly made of agricultural land (44%), and forest cover (approximately 38%). The Rugezi wetland, a protected area, is one of the major features of Mukungwa. Additionally, the Volcanoes national park covering an area of 160 km2, with a natural alpine forest cover, is also an important landscape for its biodiversity and its contribution to the national economy through tourism.

Environmental and Social Issues in Mukungwa catchment

Through a participatory process, key issues identified in the catchment include topography- soil degradation, soil erosion, and improper land use, and population density, floods in the Volcano area, Illegal mining, land scarcity, climate change, agricultural extension, poverty, and limited information on soil. Characteristics and water catchment, over reliance on firewood, lack of off farm opportunities, water pollution, and unequal water sharing,

Existing Opportunities in Mukungwa Catchment

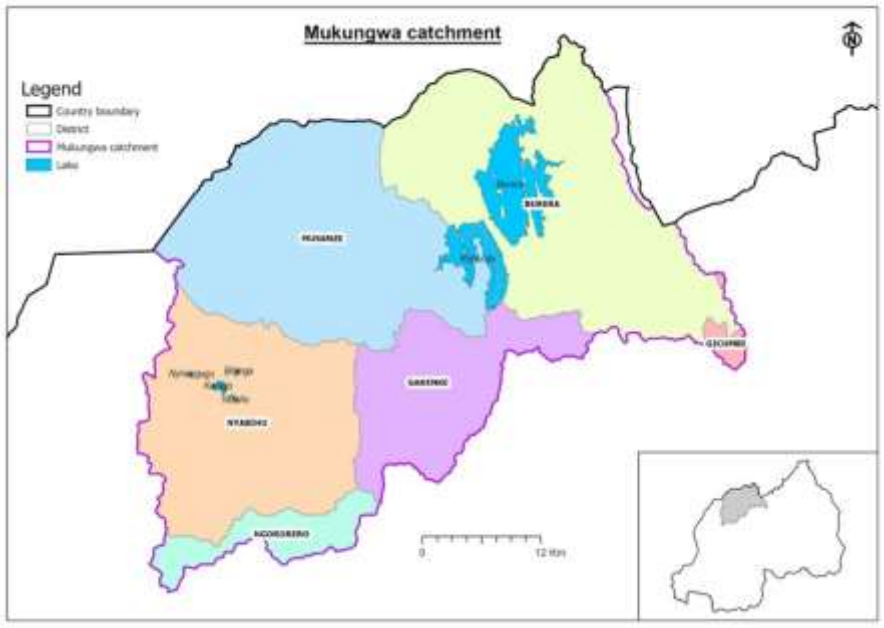
Opportunities include political will, Priority area in the national economic development- tourism opportunities, hydropower generation, national road, fertile soils, good weather, water resources, enabling policies, strategies and laws.

Catchment Plan Vision

"A Mukungwa Catchment with Sustainably Managed Water and Related Natural Resources, Driven by a Strong Agriculture base and Tourism, Resilient to Climate Change, for sustained Prosperity of its Communities." The Overall catchment management plan objective is to ensure an "Effectively managed catchment that ensures sustainable ecosystem services supply, providing community development, reducing impacts of natural hazards while contributing to climate change resilience"

Specific objectives

1. Ensuring sufficient water availability (quantity and quality) for communities in Mukungwa catchment.
2. Ensure equitable water allocation of available water resources for all users.
3. Landscape restoration measures to reduce soil erosion, rehabilitate degraded areas and increase soil productivity;
4. Ecotourism development for community benefit and biodiversity conservation
5. Protect downstream communities and infrastructures from floods.



Program of Measures

Program of Measures (PoM) are suites of actions aiming at sustainable resource management of Mukungwa catchment. Measures outlined targeted, in terms of type and extent, to ensure that main catchment pressures are addressed to deliver improvements towards achieving the desired catchment status. In line with the main objectives of the RWB and taking into consideration the major pressures in Mukungwa catchment, the PoM were developed following four main themes:

Water Allocation

Despite the abundance of water resources in the catchment, the multiplicity of competing users including domestic and industrial use, hydropower generation, agriculture, and wetland water demand, among others, makes it imperative to have clearly defined water allocation plans. Threats posed by climate change leading to unpredictable, erratic and rainfall patterns, makes it even more important. Therefore, PoMs must give careful consideration of how demands by the different sectors/water users can be met, for both current and future scenarios.

Support to human livelihoods

Mukungwa catchment is a water tower of the country with fertile soils for agriculture. In addition, it is a tourism hub. Given the twin advantage that the catchment has, it is imperative in this catchment plan to prioritize actions to improve the livelihoods of communities in the catchment. District Development strategies identify the need to support initiatives to reduce poverty and improve people's livelihoods by directly providing basic needs, creating jobs and increasing incomes. Stakeholders in Mukungwa also note the need to develop off farm job opportunities as a priority. The program of measures for this catchment therefore targets to develop the eco-tourism value chain (planning and development)

Flood risk mitigation

The challenge posed by flooding in Mukungwa catchment, especially in the Volcanoes region is a major risk to human life, infrastructure and the socio-economic development of the region. As such, this catchment plan prioritizes actions to reduce the risk of flooding and mitigate against the impacts. Additionally, this action speaks directly to the RWB mandate to reduce the impacts of flooding in the country. While RWB already has a major project, to rehabilitate some of the major gullies in the Volcanoes region, additional work and resources are required to cover the entire region as well as other parts of the catchment.

Landscape Restoration

Degradation of landscapes ranked as a major issue by stakeholders from Mukungwa catchment. The negative impacts of landscape degradation are manifested in a multitude of negative impacts, including soil erosion, sedimentation, loss of fertility and decreasing agricultural productivity, biodiversity loss, reduced ecosystem services capacity, impaired water sources, reduced hydropower production, as well as severe floods and landslides. Hence, addressing land degradation is a key entry point to improved water resources and to enhance landscape resilience for the benefit of local people and nature. Therefore, it is prudent that the PoM for the catchment prioritize restoration of degraded lands. PoM targeting landscape restoration aim to reduce soil erosion; promote dispersed water storage while ensuring sustained high land and water productivity, in line with national development goals. Water flows and quality are intrinsically connected to both people and landscapes. By changing landscapes through development and altered land use, the water flows and quality are altered too and this in turn alters the benefits people obtain. These interactions are particularly challenging when landscapes are in a degraded state as people, society, landscape and water resources form a complex system.

It is important to note that the IWRM packages identified apply to this catchment management plan and as some of the actions are multi-year actions that go beyond the lifespan of this play, there is need for re-evaluation depending on levels of implementation and re-prioritization as Annual Implementation plans are formulated and District development strategies are revised.

Reservoir optimization

In Mukungwa catchment, an important water user is hydropower. In order to meet the twin demands of water for downstream users and water for hydropower production, an optimization analysis for Mukungwa was undertaken using WEAP. Hydropower optimization was done for the 2030 projection, since hydropower generation is mainly influenced by water availability, which will change over time due to climate change and autonomous developments. To reduce the probability of water shortages in the downstream reaches, the buffering capacity of the two lakes needs to be optimized. Optimization was structured with the following targets:

- Highest total hydropower output from the hydropower cascade that depends on the lakes: Ntaruka, Mukungwa 1, Rwaza and Mukungwa 2, and
- Reduced water shortage downstream of the outlet of NMUK.

The optimized settings yield a hydropower production that will cover the demand in almost all months. Hydropower generation data from REG shows that hydropower generation has been close to zero or zero in certain periods. With optimized releases, hydropower generation will be more stable and could potentially be higher.

Reservoir release rules

For Mukungwa (Lakes Burera and Ruhondo), the reservoir release guidelines were developed for the 2030 scenario. Modern and large reservoirs are operated on real-time inflow and demand information. For Mukungwa operational rules are needed to effectively manage water demands. The WEAP model was used to derive these rule curves by extracting the statistics from, Reservoir storage volume, Reservoir elevation and Reservoir releases. These statistics are transformed into percentiles (10th – 90th) so that depending on the dry-wet status, the releases can be planned. The operational rule curve tables can be used for operations of the reservoir in two steps:

1. Identify the dryness of the year based on the lake level and the month of the year, and,
2. Based on the dryness level, read from the table how much water can be released.

Priority Integrated Water Resources Management Packages for Mukungwa catchment

IWRM Package 1 Landscape restoration in Giciye, Nyamutera, Rubagabaga, Karago Sub catchments

CPIP 1: Landscape restoration and rehabilitation in Giciye sub catchment
CPIP2: Landscape restoration and rehabilitation in Nyamutera sub catchment
CPIP 3: Landscape restoration and rehabilitation in Rubagabaga sub catchment
CPIP 4: Landscape restoration and rehabilitation in Karago sub catchment

IWRM Package 2 Burera –Ruhondo –Rugezi Eco-tourism Development

CPIP 1: Establishment of ecotourism product(s)
CPIP 2: Ecosystem rehabilitation and conservation

IWRM Package 3 Flood control and management in Volcanoes region (Mukungwa 2, Susa, Muhe and Rwebeya sub catchments)

CPIP 1: Structural flood control projects
CPIP 2: Non-structures flood control Projects
CPIP 3: Development of early warning system

Cross Cutting Measures

Gender

The population in Mukungwa catchment is dominantly constituted by women (around 52%) compared to men (about 48%). IWRM takes serious consideration of gender in planning and implementing holistic catchment management actions. This is based on the premise that:

1. Involving both women & men in IWRM initiatives increases effectiveness & efficiency.
2. Participation by both women & men improves performance the likelihood of sustainability.

An IWRM Gender strategy has been prepared under the W4GR, recommending equal access and participation, control, women's empowerment and equitable benefits from the water resource program of measures. The strategy identifies four priority gender mainstreaming actions catchment planning:

1. Strategies to enhance equal participation of women and men in planned measures;
2. Strategies to enhance empowerment of women;
3. Ensuring equitable benefits from water resource management and productivity;
4. Gender transformative strategies to alleviate unequal power relations within households and for reduced unpaid work.

Youth Engagement

In line with Rwanda's National Youth Council (NYC) Strategic Plan (2021-2025), the CMP places emphasis on strategies to increase human capacity, especially amongst the youth. Implementation of CMP actions will ensure that youth's role as economic agents is promoted through ensuring equal access to productive resources and to decision-making mechanisms at the catchment level.

Capacity Building

Lack of adequately trained staff at different levels places a major challenge to effective implementation of the catchment management plan. The District Development Strategies identify capacity building as a key element to successful implementation of strategic actions across all sectors- economics, social and governance. This also is emphasized in the socio-economic and livelihoods conditions assessment performed in Mukungwa as part of developing the catchment management plan. Capacity building is proposed in this management plan to ensure stakeholders can effectively work towards achieving objectives set out in this catchment management plan. With the approval by Cabinet of the guidelines for establishment of Catchment committees, it is imperative to develop capacity-building programs that target to empower the Mukungwa catchment committee once it is established. Cross-sectoral training and capacity building programs that are targeted in this management plan include:

- Micro catchment and Village land use planning
- Community Approach to Landscape restoration
- Integrated Water resources management training
- Training on ecotourism business development and management
- Trainings on Landscape restoration techniques
- Community participation in flood early warning system implementation
- Trainings for mapping and developing catchment inventories
- Capacity Building on disaster risk management (DDS)
- Support Projects/initiatives of women to access finance
- Animal Husbandry techniques
- Governance mechanisms

Capacity building will be a continuous development action, promoting assimilation, analysis and dissemination of knowledge to and among communities in Mukungwa in skills related to landscape management.

Implementation Framework

The measures identified in this catchment management plan are cross-sectoral and therefore the implementation of the plan will require multi stakeholder collaboration. The catchment management plan is an IWRM strategic framework through which the various stakeholders/implementing agencies can develop respective sectoral and agency plans for implementation. With the approval by Rwanda Government of the Ministerial Order in December 2021, a Catchment Committee will be established for Mukungwa catchment to support the Districts and other partners in the development, revision and implementation of catchment management plans. The catchment committee is to be supported in its functions by a Catchment Committee composed of a RWB staff and staff from each District, within the Catchment, in charge of agriculture, forestry, livestock, water supply and sanitation, environment, land use and management, urbanization and rural settlement, and planning.

Sectoral Planning

Catchment Management Planning and implementation is deeply embedded in the strategic actions to meet Rwanda's Vision 2050 and the National Strategy for Transformation. Therefore, implementation arrangements for identified measures must follow the planning and implementation framework for the National goals. To this end, Annual Implementation plans will guide the implementation of this catchment management plan. This catchment management plan is coming towards the end of the planning period (2018-2024). It can form the basis for related AIP for starting with the 2022-2023 financial year and a basis for the revision of the DDS for the next cycle (2024-2031). For each annual planning cycle, and basing on available resources, a geographical assessment will be made to ascertain the type and location of actual activities to be implemented in each district. The catchment committee will assist in this process to ensure sectoral and district plans and budgets take deliberate considerations of the catchment management plan priorities as they relate to the goals of the DDS, NST and ultimately Vision 2050. While the primary source of funding for actions under the catchment management plan is the government, sectoral planning must also involve investment campaigns to obtain additional funding from development partners, and private partners.

Multi sectoral Plan Implementation

While the Government of Rwanda has the ultimate responsibility for safeguarding and conserving the Mukungwa catchment and the ecosystem services it provides, a wide range of actors will be involved in the implementation of the catchment management plan. This therefore calls for coordinated implementation. However, it is important to note that the required co-ordination for effective action is complicated by the varied vested interests. Coordination requires stakeholders combining inputs and fostering co-operation. The proper functioning of the catchment committee with representatives from relevant government departments, private and civic entities is been crucial to the success of long-term management of the catchment.

As with any effort, the realization of the management plan's objectives depends, in part, on the realization of critical assumptions beyond the control of the implementers. These assumptions include

Timely availability of funds. The plan is ambitious and requires a vast capital resource outlay. As it is clear that Government resources cannot fully meet the requirements for implementing this plan, stakeholders have to make significant strides to mobilize resources to implement programs under this plan.

Timely execution of Program activities. The plan is a 6-year plan and timely implementation of activities will help alleviate and avert some of the challenges that come with environmental degradation and unstainable use of natural resources.

The Management plan will be embraced by relevant stakeholders. The Government of Rwanda places a strong priority on environmental conservation for sustainable water resources availability for its people. It is assumed that by including all relevant stakeholders – from each sector – in the development of the catchment management plan, this will help develop significant buy-in on the prioritized program of measures and their implementation.

Summary Catchment Plan Implementation Investment Requirements

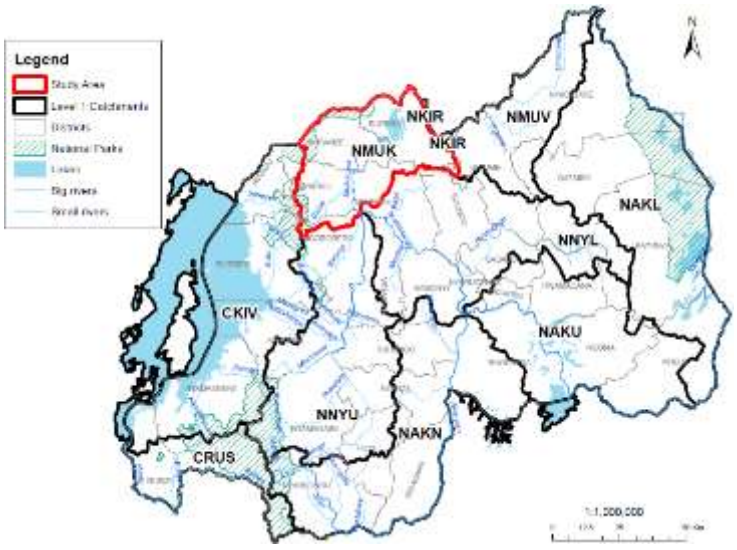
Investment requirements for catchment plan implementation

	ITEM	COST(RWF)
1	*Action card and associated costs for landscape restoration IWRM Package*	27,925,373,064
2	*Action card and associated costs for Ecotourism development IWRM Package*	3,050,000,000
3	*Action card and associated costs for flood control and management IWRM Package*	30,002,434,225
4	*Actions for Capacity building for stakeholders in Mukungwa catchment*	90,000,000
	GRAND TOTAL	61,067,807,289

Bio-Physical Assessment and Hydrological Analysis for Mukungwa catchment - Rwanda

Background and Context

The study summarized here is part of the strategic environmental assessment contributing to the development of a catchment management plan for Mukungwa catchment in Rwanda. Mukungwa catchment is one of the two water towers in Rwanda. The catchment has a surface area of 1,828 km² the catchment, and receives an average annual rainfall of approximately 1,315 mm/yr. Annual evapotranspiration is approximately 851 mm/yr, and annual surface runoff is 464 mm/yr (900 million m³/yr). The main source of Mukungwa River is Lake Burera. In addition to high rainfall in Burera, the other important sources of water for Burera Lake include 1) Rwangabavu River crossing Rugezi wetlands and discharging into Lake Burera through Rusumo Falls, and 2) Cyeru and Kabwa Rivers with catchment areas of 109.91 km² and 21.1 km², respectively.



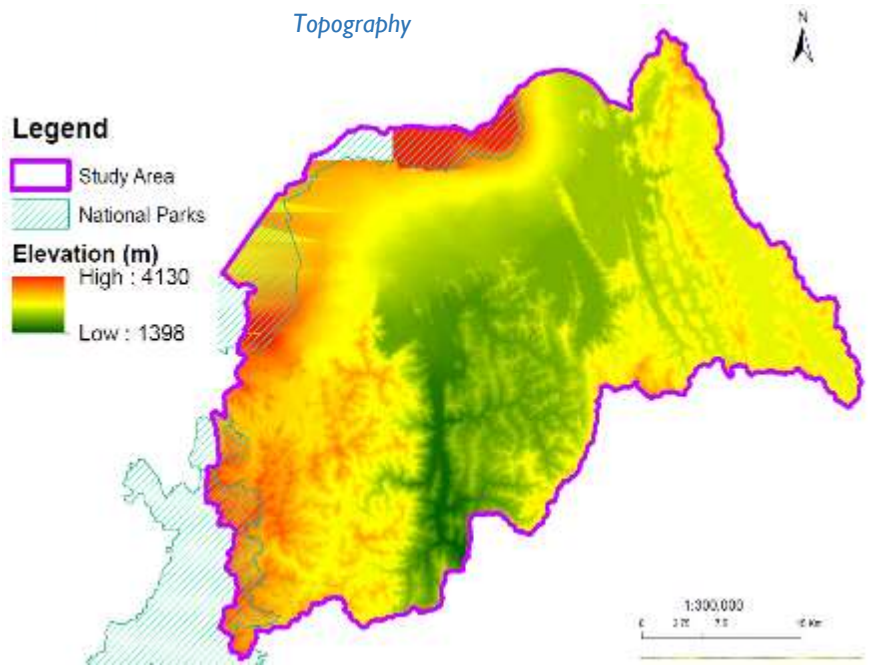
Mukungwa catchment (red boundary) in Rwanda

The population (2015) of the catchment is 1.3 million, with total current registered water demand less than 1% of renewable resources. Prior to the construction of Ntaruka Hydropower Plant in 1950, Burera Lake was connected to Ruhondo Lake by Mukungwa River. However, the damming and channeling of water to the power plant has affected the flow of Mukungwa River. Climate change impacts is an important consideration for assessing hydrological characteristics of the Mukungwa catchment. Simulation results show that , in terms of temperature:, in the short-term horizon (2015-2045), there is a likelihood of a 0.1-1.8°C temperature increase and 7.5% decrease to 20% increase in rainfall , while in the longer-term (2045-2075), a temperature increase of approximately 1-3.5°C is expected, and rainfall change of 7.5% decrease to 45% increase.

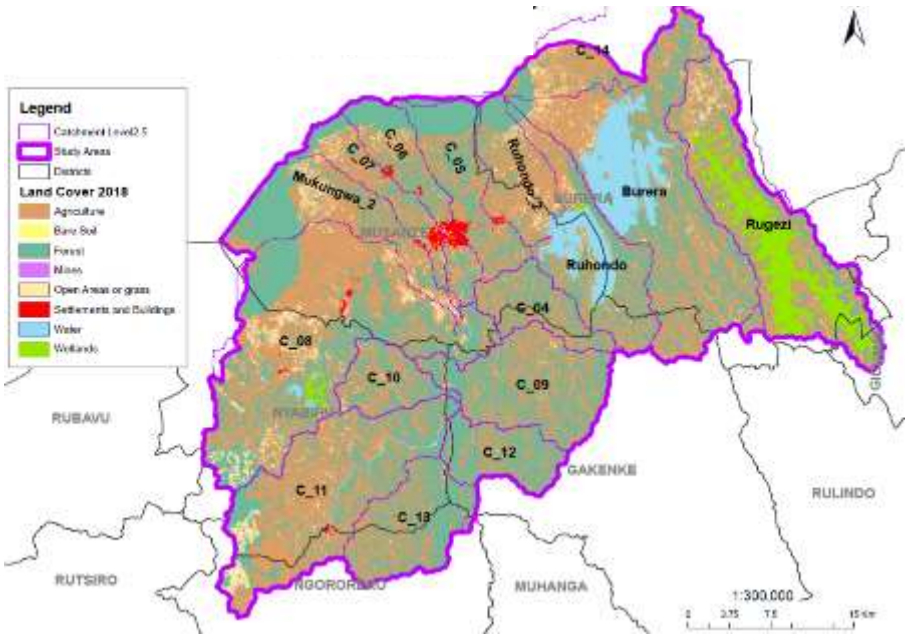
Biophysical Characteristics

Topography in the catchment ranges from 1400 around the twin lakes to 4100 m in the Volcanoes region. The land use in the study area is mainly made of agricultural land (44%), and forest cover (approximately 38%). The most common soil class is the andosol class of volcanic origin, which fully covers the North and North East of the catchment

Topography



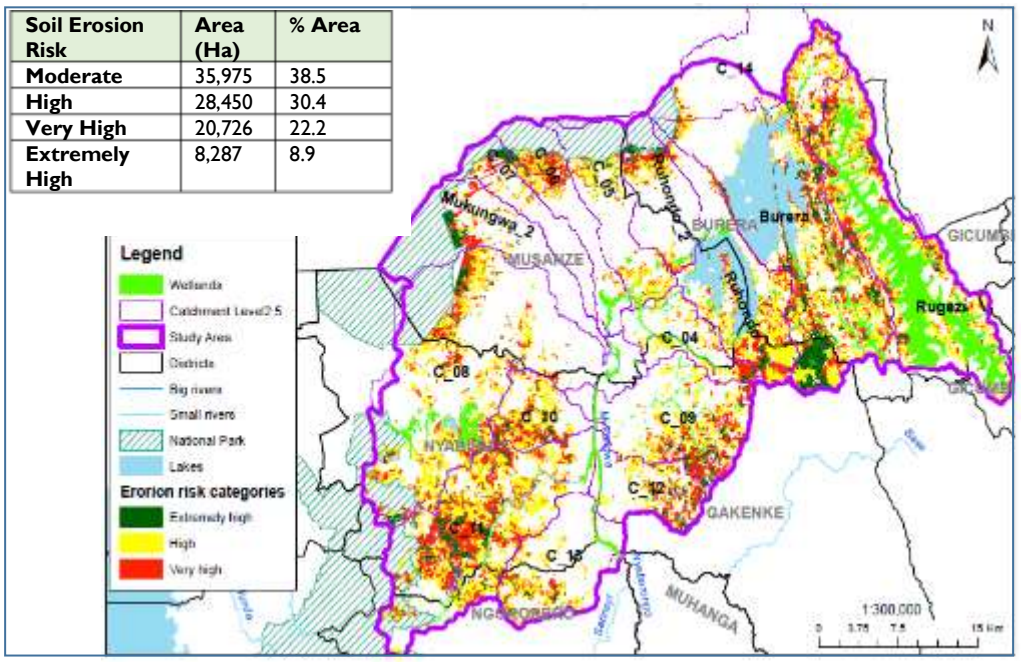
Land use Land Cover (2018)



The Catchment Restoration Opportunity Mapping (CROM) model identified at least 30% of the catchment area to be under very high to extreme risk of soil erosion. Erosion is the most serious problem resulting from unsustainable management of land and water resources, such as land use and vegetation cover loss, poor agricultural practices, topography, and fragile soils. This leads to high sediment loads in the water bodies.

There are 55 wetlands in Mukungwa with a total area of 15,267 ha. Some of the well-recognized wetlands include Rugezi wetland (International RAMSAR site), Nyabarongo Amont (proposed as RAMSAR site), Gihinga Lake, Gatungati-Rubagambavu-Rusumo-Rugezi complex, Mukungwa Marshland, Nyamukongoro-Gatagara complex, and Nyirabirandi wetland. Volcanoes National Park, on the northwestern part of the catchment is an internationally important biodiversity hotspot, and contributes a significant amount to the country's GDP through tourism. However, flooding in the broader volcanoes region is a serious challenge that needs to be addressed. The twin lakes Burera and Ruhondo are the results of volcanic activity of Birunga volcano, which caused outpouring of larva across a river valley that cooled and solidified. Lake Burera, 12 km long and 8 km wide, is situated on the southern slopes of Mt. Muhabura in Northern Rwanda with total active storage of 231 Million Cubic Meter at a water level at 1,864.4 m. It drains into Lake Ruhondo, which is 9 km long and 3 km wide and has an active storage of 61 Million Cubic Meter at a water level of 1,759.4 m.

Soil Erosion Risk	Area (Ha)	% Area
Moderate	35,975	38.5
High	28,450	30.4
Very High	20,726	22.2
Extremely High	8,287	8.9

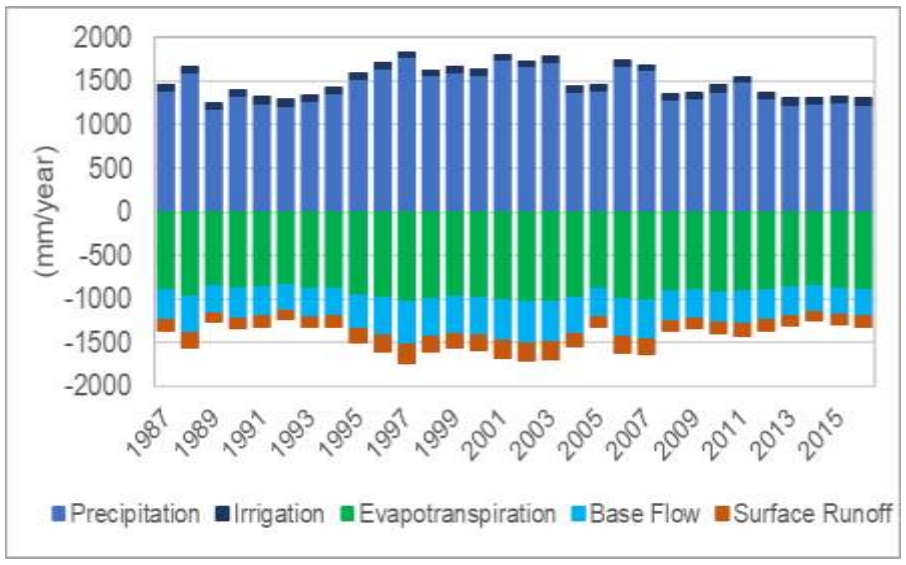


Soil erosion risk for Mukungwa catchment

Hydrological Characteristics

Water balance for NMUK for the 1987 – 2016 period

- Rugezi wetland serves as an important water tower of Burera and Ruhondo lakes with runoff from the wetland contributes at least 50% of inflows into the twin lakes, before the water is released into Mukungwa River. The Rwanda Water Resources Board has established six water-monitoring stations in the catchment.
- Annual water balance for the catchment shows that on average, the majority of precipitation results in evapotranspiration (65%), while 36% is converted into runoff, either into surface runoff (10%) or base flow (26%). In volumetric units, this translates to an annual runoff of approximately 900 million m^3/yr.
- Existing conditions indicate surplus of water resources in all level 2.5 sub-catchments.

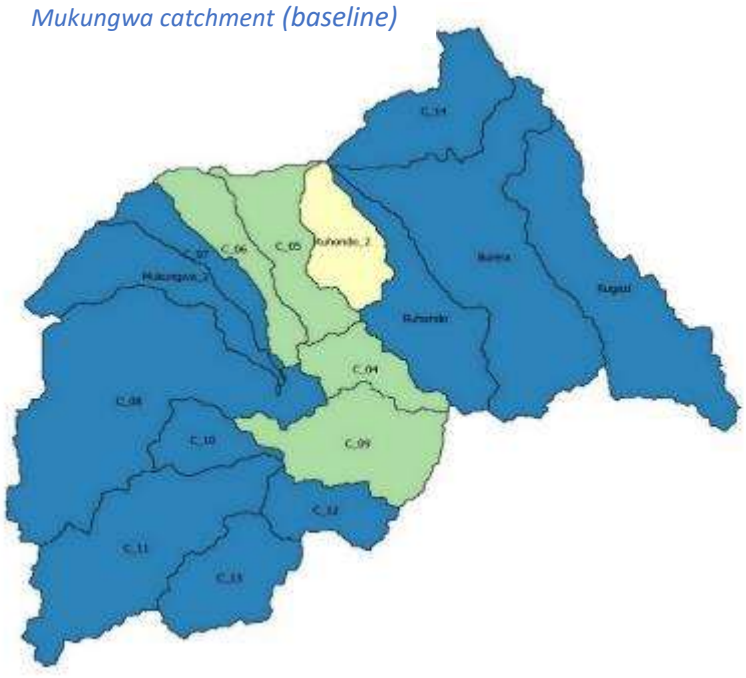


Annual Water Balance in Mukungwa catchment

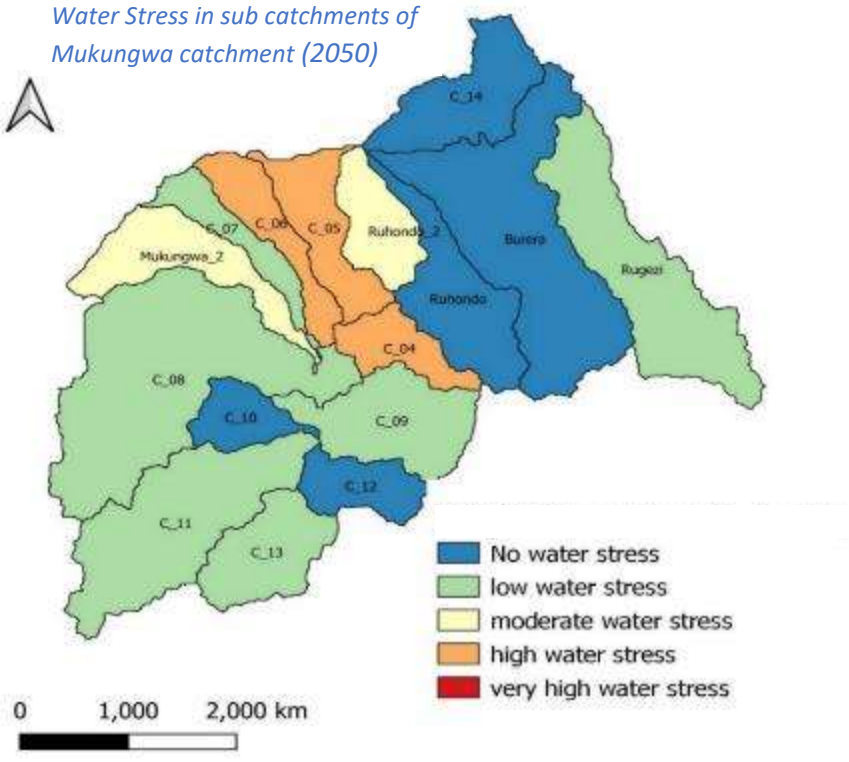
Water Stress: Current and Future situation

Water resources in Rwanda are under pressure due to high rate of population growth, intensification of agriculture, climate change accompanied with more weather extremes, adding to soil erosion and degradation, rapid urbanization (at 4.4% per year) and industrialization. At the same time, development projects are being implemented in different catchments, such as irrigation expansion, landscape restoration through terracing and other agriculture investments. These developments affect land use and water use, as well as the provisioning and regulating environmental services from land and water assets.Water scarcity in Mukungwa catchment was analysed using the Water Scarcity Index (WSI) expressed as the ratio of total annual withdrawals to available water resources. Moderate scarcity is when annual withdrawals are between 20 and 40% of annual supply, and high water scarcity is when withdrawals exceed 40% (Raskin, et al., 1997). For all the subcatchments the Water stress levels for current and future (2050) scenarios are shown below.

Water Stress in sub catchments of Mukungwa catchment (baseline)



Water Stress in sub catchments of Mukungwa catchment (2050)

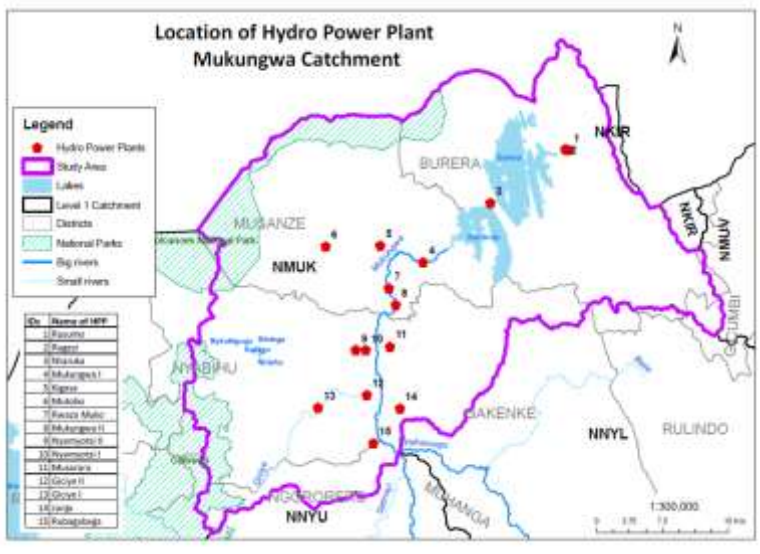


Overview of Current and Projected Water Demands and Required Interventions

- Predictions for 2050 show that the majority of the precipitation is lost to evapotranspiration and will increase to 68% (+3%). Total runoff (surface and groundwater) is expected to slightly decrease to 32% of the precipitation.
- As for the sectoral water demand for wetlands and for irrigated agriculture, gross demand of wetlands increases slightly and the demand of irrigated agriculture (marshland irrigation) is expected to increase from the current 12 Million Cubic Meter to 42 Million Cubic Meter.
- For the total water demand and unmet demand for the sectors domestic, industry and livestock, only very small risks of water shortage are projected of maximum 1%. The main sector that could face unmet demands is livestock.
- As the water stress increases, the ability to meet "environmental flow" requirements (wetlands, aquatic life and wildlife) may not be possible.

Hydropower Reservoir Optimization

- In the catchment, an important water user is hydropower. Data on existing hydropower plants shows that electricity demand is forecasted to increase on an annual growth rate of 10% (Rwanda Least Cost Power Development Plan (LCPDC)-2019-2040[1]).
- Hydropower can lead to losses in beneficial use of water, when the releases from reservoirs are not aligned with the interests of downstream water users and peaks in downstream water demand. For example, the driest months are from May to September and irrigation demand peaks around August.
- Optimization is required to ensure power production that will cover the demand during all months. With optimized releases, hydropower generation will be more stable, could potentially be higher, while minimizing impacts on the demands from downstream water users.



Location of Hydropower plants in Mukungwa catchment

Conclusion

- There are many competing demands for water resources in Mukungwa catchment.
- Landscape degradation is a critical factor affecting sustainability of water resources availability and ecosystem service supply in the catchment.
- Future conditions indicate that balancing water availability with increased demand, will require a combination of structural and non-structural/nature-based solutions including, i) optimization of surface area (ha) under irrigation to reduce water demand, ii) promotion of crops with reduced water requirements and higher revenue, iii) investments in storage facilities, and, iv) implementation of water savings, and sustainable land management practices.
- This calls for strategic water resource allocation planning with due consideration of upstream and downstream dependencies given that the catchment is a water tower for the country.

The full report for this assessment can be found at: www.iucn.org/

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