RWANDA NATURAL RESOURCES AUTHORITY
INTEGRATED WATER RESOURCES MANAGEMENT DEPARTMENT

UPPER NYABARONGO CATCHMENT REHABILITATION PLAN

Kigali, January 2017

Introductory Note

The work presented in this report is a proposal for a physical rehabilitation n of the Nyabarongo Upstream Watershed. This is a technical component which is part of an integrated catchment management plan but focuses more on land restoration and rehabilitation. The presented rehabilitation plan should be taken as a guiding plan that will serve as a planning tool at district level and as an IWRM awareness tool, among others, for all concerned stakeholders.

The present work is a team effort led by the MINIRENA through the RNRA/IWRMD and other stakeholders at central, district level. It presents required physical measures to rehabilitate the whole catchment of Upper Nyabarongo, It presents where should focus efforts, It indicates ongoing efforts to address issues of siltation including required remaining efforts in sustainable land management but mostly in line with agroforestry. It finally comes up with a proposal of priorities areas which need t be treated in each concerned district with involvement of local communities, various projects, private sectors, and mainly miners.

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1. Introduction

Following the Nyabarongo I hydropower plant official inauguration by his Excellency on March 5th, 2015 in the district of Muhanga, and the recommendations made to manage its upstream area in order to protect the reservoir of the hydropower plant from heavy siltation; a distribution of tasks among governmental institutions was made in the meeting held on March 6th, 2015 in the same District and MINIRENA was tasked among others the task of developing a rehabilitation plan of the upstream area of the hydropower reservoir to control the siltation.

On March 31st, 2015 a first technical meeting was hosted by the RNRA/IWRMD and attended by representatives of RNRA/IWRMD&GMD, MININFRA, MINAGRI/RAB and MINALOC. The outcomes of that technical meeting recommended the RNRA/IWRMD to refine the available draft rehabilitation plan using a more appropriate methodology. It was also recommended to include all stakeholders (miners, ongoing projects and local population) in the implementation strategy of the rehabilitation plan.

On May 8th, 2015 an internal meeting within the MINIRENA and other concerned institutions involved mostly in watershed rehabilitation such as RAB, REMA took place where a first version of the revised rehabilitation plan was presented. The major recommendation from that meeting was to include all existing projects in the study area, also, on that same day an urgent meeting was called by the Honourable Minister of State in charge of mining
On May 13th, 2015 the plan was presented to mines operators in the area of interest and sensitizing them about the available technical expertise and facilities that are now available for their effective implementation, and their role in the implementation of the rehabilitation plan.

On June 9th, 2015 an inter-ministerial meeting hosted by the MINIRENA which was attended by MINAGRI, MININFRA, MINALOC and MINECOFIN took place. The objective of the meeting was to discuss the proposed rehabilitation plan and agree on it with all the major stakeholders before moving to further steps. The major recommendation from that meeting was to physically include in the plan the LWH/RSSP activities from MINAGRI and finalize the rehabilitation plan in line with the concerned districts land use master plan.

On July 16th and 21st, 2015 two meetings at province level took place. Both were chaired by the Honourable Minister of Natural Resources. The first meeting was held at Nyanza and was attended by the Southern province Governor where else the second one was held at Karongi and attended by the Western province Governor. Both meetings were attended by the respective head of security, the mayors of all the concerned districts or their representatives, the districts and sectors agronomists, environmental and natural resources officers; and finally the technical team from the RNRA who conceived the rehabilitation plan. The plan was discussed in details with all

the concerned districts and each districts explained the challenges they face and what they were planning on doing to control the siltation problem in the area of interest. The final step agreed on during both meetings was that the technical team together with the districts and sectors officers will validate on site the proposed rehabilitation plan and proceed to budgeting the rehabilitation plan.

On July 30th, 2015 a last technical meeting took place at MINIRENA chaired by the Permanent Secretary of the MINIRENA. The meeting found the rehabilitation plan well done and then focused on integrating other projects planned activities in the area of interest in order to know the zones left out, their required budget and then develop a monitoring and evaluation plan to ensure that the implementation of the rehabilitation plan is efficient.

From August 24th to August 28th, 2015 the RNRA/IWRM did together with the concerned districts and sectors a fieldwork for validating the proposed rehabilitation plan. Many observations were made a recommendations for more practicability of the rehabilitation plan. However, it was found that the rehabilitation plan is practical and matches technically with the field although minor changes especially for radical terraces in relation to their field valorisation had to be adapted in the rehabilitation plan to finalize it. During this same day, the RNRA/GMD did a field visit to identify and map all illegal mining activities and clarify to what extent these are contributing to the heavy siltation problem existing in the area of interest.

In October 2015 to November 2016 on request from MINIRENA, USAID and RIWSP project undertook a finger print study to clearly identify the areas that contribute more to the sedimentation of the various streams in Upper Nyabarongo Catchment. The report indicated clearly the priority areas that need specific attention with types of geological units that contribute more the siltation

From August to September 2016, with support by the Kingdom, of Netherlands a total area of 1430 ha on upstream of Nyabarongo Power Plant was rehabilitated by Reserve Forces with support of PAREF Project.

In November 2016 an Investment project was approved for treating a total area of 1104.2 ha with agroforestry, afforestation, progressive terraces. Modalities and all logistical arrangements have been finalised and the implementation will be carried out by Reserves Forces under supervision of RNRA/SPIU.

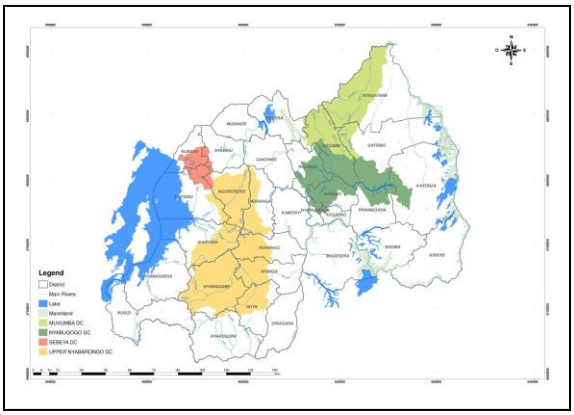
In 2016, Water For Growth Program undertook a process of Catchment development Plan which will include an integrated catchment development plan that will l touch various aspects such as physical measures, social welfare of the population, proper allocation of water resources, investment plans of non-regret projects. The integrated catchment plan will address not only

issues of physical rehabilitation but also aspects of improved livelihood and economic development of the catchment

This document presents the physical rehabilitation plan of the Upper Nyabarongo Catchment. It presents also implementation strategy that indicates required area for agroforestry and afforestation per concerned districts, a financial estimate of the required cost and recommendations for way forward are provided in this report.

2. Project localization

The project area reaches out over the following eight districts: **Ngororero, Rutsiro, Muhanga, Karongi, Nyamagabe, Ruhango, Nyanza,** and **Huye.** A small portion of the project area is located in the districts of **Nyamasheke** and **Nyaruguru.** The sectors concerned within the project area are fifty six (56) sectors as illustrated on Figure 1.



3. Objectives

3.1. Main objectives

The main objective of this plan is to present a sustainable land management framework using appropriate land husbandry technology for the upstream area of the hydropower reservoir located in the Nyabarongo Upstream watershed. The ultimate goal is to minimize soil losses and water pollution in order to protect various infrastructures in the catchment including among others the Hydropower plant reservoir from heavy siltation.

3.2. Specific objectives

In order to achieve the main objective of the plan the following steps were done to ensure that all the development processes, involving all the concerned stakeholders, are effective and efficient. The following were:

- Creation of a platform for participatory approach in developing a practical watershed rehabilitation plan with all the stakeholders,

- Development of an appropriate watershed rehabilitation plan based on appropriate land husbandry technologies,
- Validation of the developed watershed rehabilitation plan with all the stakeholders (including district officers and private sectors) prior to its finalization,
- Budgeting of the validated and finalized rehabilitation plan.
- Prioritizing the implementation approach of the proposed plan based on critical areas.

4. Project beneficiaries

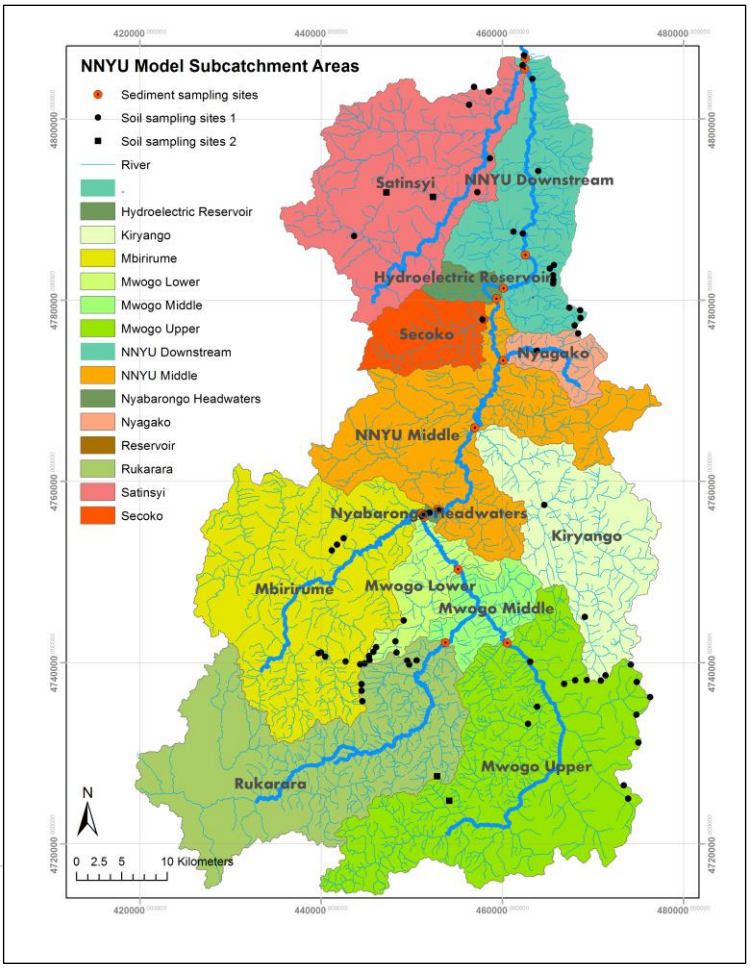
The local population of the districts where the project area lies will be the principal beneficiaries since they will be directly involved in the implementation of the proposed rehabilitation measures. On a general perspective, the country also is a beneficiary because the project will be improving the national environment and protect among the major rivers constituting the national water tower i.e. the Nyabarongo Upstream Watershed (not to mention that this project will be a bench mark for other watershed rehabilitation in the country) but also increasing the awareness and practice of integrated watershed management approaches in the country.

5. Study area description

5.1. Hydrological concept

The surface areas of the different parts of the Nyabarongo Upstream catchment are as follows:

- Total area of the NNYU catchment: 3.348 km² (entirely located within Rwanda).
- Concerned project area: 2.736,32 km² (up to the Nyabarongo 1 Hydropower Plant outlet).
- Area covered by natural forest: 233 km² (7% of total area).



The area can be further subdivided into level 2 sub-catchments

- Mbirurume sub catchment (NNYU_1) with the Mbirurume River draining an upland catchment with steep longitudinal and lateral slopes which is partly covered with the Nyungwe forest area (area of 511 km² in Rwanda).

- Rukarara/Mwogo sub catchment (NYU_2) comprising the Mwogo river in combination with its tributary the Rukarara River. This sub catchment is quite similar in nature to the Mbirurume sub catchment (area of 1.284 km² in Rwanda).

- Nyabarongo sub catchment (NNYU_3), the remainder of the catchment is drained by the upper Nyabarongo which originates at the confluence of the Mbirurume and Mwogo rivers. This sub catchment is again similar in nature to the preceding ones; a mountain stream cutting through the hills with a gradually increasing flow (area of 1,553 km² in Rwanda).

The principal water resources in the catchment, according to the National Water Resources Master Plan, are as follows:

- The average annual rainfall is 1.365 mm/annum which equates to some 4.570 hm³/annum from the total land surface area of 3.348 km². The combined average annual surface flow generated from the numerous small catchments stands at 41 m³/s or some 1.290 hm³/annum.

- The groundwater annual recharge / safe yield are about 978 hm³/annum. With a total groundwater storage estimated at about 25,000 hm³/annum this leads to a mean residence time of groundwater of some 25 years.

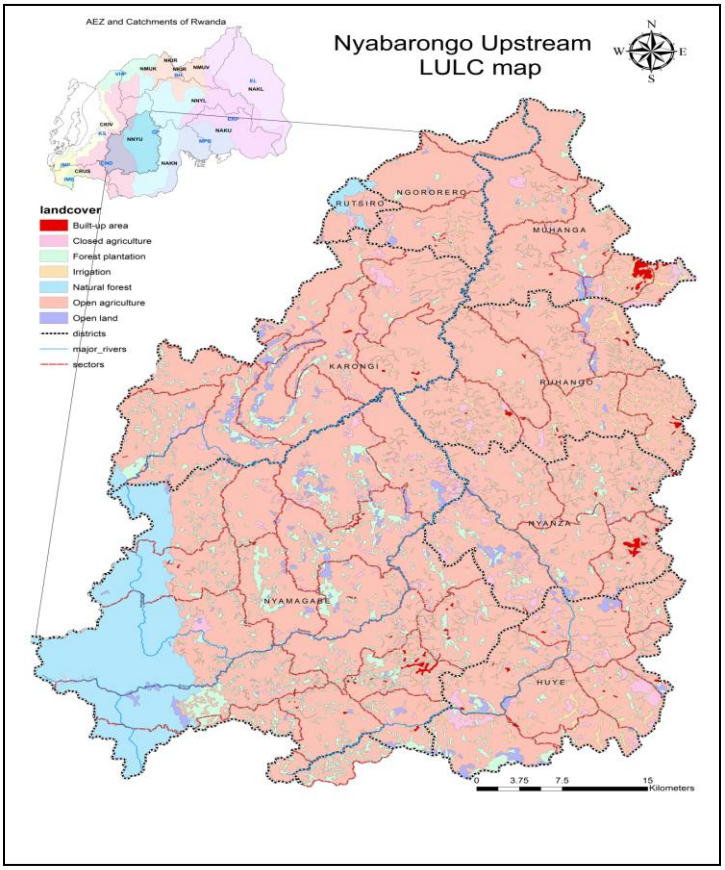
The catchment is reputed to constitute the water tower of Rwanda and boosts a significant number of tributaries of which the most important are from south to north:

- Mwogo River with a length of 81.1 km
- Rukarara River (length of 47.4 km) springing from the Rubyiro and the Nyarubugoyi rivers
- Mbirurume River (51.6 km)
- Mashiga River (12.2 km)
- Kiryango River (10.4 km)
- Munzanga River (24.4 km)
- Miguramo River (15.0 km)
- Satinsyi River (59.7 km)

Land characteristics in the catchment, form the same National Water Resources Master Plan, are summarily presented as follows:

- The lithology of the catchment is made of granite and pegmatite in its southern region and a small area in the north-west part. The central part is dominated by shale with intrusions of (quartz rich) schist and rather thin bands of quartzite. Due to a deep weathering, these aquifers have a reasonable storage capacity; apart from the quartzite deposits, conductivity is generally low. The lithology is completed with alluvial deposits and volcanic material at some rare locations. Apart from occasional fault zones and the alluvial deposits, boreholes will have low yields.

- The majority of the soil classes found in the catchment belong to the 'nitosol - acricol -alisol - lixisol' class followed by ferralsol and cambisol classes. These soil classes present high infiltration rates. The picture is completed with mineral soils conditioned by flat topography with some dominance in the south western and central parts of the catchment and small areas of clay soils with low infiltration rates.



5.2. Land Use Land Cover

The land cover of the catchment (refer to figure 1) is mainly rain fed agriculture. The eastern and southern parts have a relatively high number of irrigated/agricultural wetland in rather narrow valley bottoms. The catchment further presents natural forest (Nyungwe forest) in its south-western part and a very small portion in the north-west (Gishwati forest). Other land uses encountered are: natural open land, forest plantations and built-up area in urban centres (Nyamagabe, Nyanza, Ruhango and Muhanga). These last categories cover a small surface area in comparison with the other two mentioned above.

5.3. Major economic activities

Heavy mining activities are observed in the project area, especially in the districts of Muhanga, Ngororero, Rutsiro, Ruhango, Nyamagabe, Huye and Nyanza. Few coffee washing stations and Tea factories are observed in the watershed as well.

A hydropower dam on the Nyabarongo River is located downstream at the project area outlet in the sector of Mushiro, the district of Muhanga. The dam reservoir is located in a mountainous area with steep slopes around it. Figure 2 provides a general overview of the reservoir location surrounding environment.

Figure 1: Nyabarongo 1 hydropower plant dam

In situ observation indicated rolling stones from high altitudes, gravel and soil in the reservoir. All these debris endanger the turbines as well as the reservoir itself through loss of storage volume and the catchment trough heavy soil losses. An activity map of the project area is provided in Figure 3, where the major stakeholders' activities especially the private sectors are located.

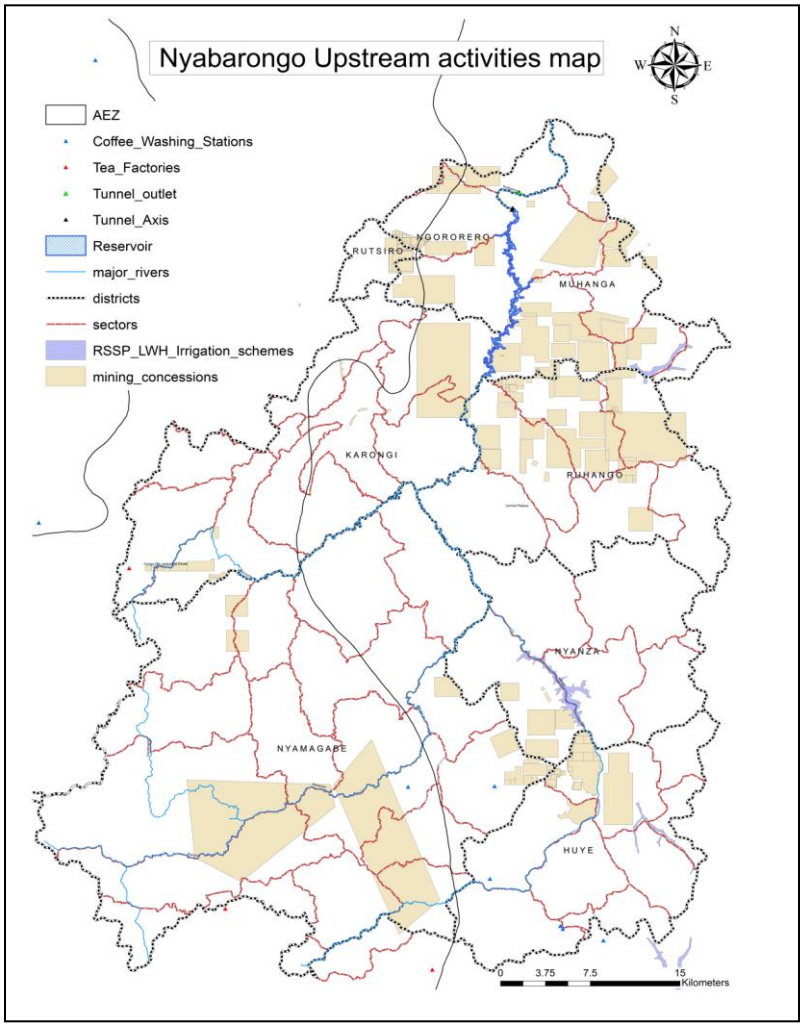


Figure 2: Nyabarongo Upstream Activity Map

5.4. Issues identified

A summary of all the identified issues causing heavy siltation in the Nyabarongo River is provided in this section. Additional information are provided in the field reports annexed to this document. The main issues identified as causing heavy siltation in the Nyabarongo River were illegal mining activities, deforestation and poor agriculture.

5.4.1. Mining activities illegal mining activities

Heavy land degradation and erosion due to mining activities was observed in Rurangazi cell, Nyagisozi sector, in the Nyanza district. The Mwogo river wetland is under heavy pollution as a result of the mining activity using the stream Nyanza for cleaning minerals. Havilla mining company had the site before then Mawaid Company took it, although measures are being put in place there is still alarming degradation that need to be fixed urgently. An illustration is provided on Figure 4.

Figure 3: Mining Site on the left draining sediment downstream in the Mwogo wetland

It was also observed that the Mbirurume River has a high sediment load due to mining activities in its upstream by the mining company named KOKAMIKE. Figure 5 illustrates the current aspects of the Mbirurume River in the Gasharu cell, Mutuntu sector in the Karongi District.

Figure 4: Mbirurume River under heavy siltation

Observation made indicated the current pollution and potential for pollution of the dam from irresponsible mining activities in its vicinity. The biggest sediment contributors were identified as Secoko and Rubanda streams flowing from the former Gatumba Mining concession. A group of mining companies operate in this concession in an illicit manner. High sediment load from this streams is directly discharged in the reservoir as it is illustrated on figure 6.

Figure 5: Secoko and Rubanda streams current aspects

In most operational and closed mining sites, there is an issue of persisting illegal mining despite all the efforts put in place by the existing companies (like hiring security services). Complaints from license owners to the RNRA/GMD are mostly that illegal miners caught red-handed are presented to the relevant organs but usually released without any punishment. Local authorities in the concerned districts have been flagged as less involved in the enforcement of existing regulations therefore giving room to illegal mining and other malpractices such as unregulated dredging of rivers. Cases of illegal mining were found more pronounced in the Gatumba, Muhororo, Ndaro, Bwira, Mukuru, Nyange sectors in the Ngororero district as well as in Kabacuzi, Muhanga, Nyarusange and Kiyumba sectors in the Muhanga district.

5.4.2. Poor agricultural practices

Agricultural practices all around the shores of the dam reservoir also contribute to the reservoir siltation. It was also observed that the major economic activity in the Nyabarongo Upstream watershed was agriculture. In many areas poor agricultural practices were observed as reported by the technical team.

The riverbank of Nyabarongo River after the confluence of Mwogo and Mbirurume was observed among other sites to be under heavy degradation due poor agricultural practices on the side of the Karongi as well as the Ruhango Districts.

A similar case was also observed as poor agricultural activity in the Rurangazi wetland, where the wetland is slowly being deteriorated illegally. A necessity of either protecting the wetland buffer zone of improving the agricultural activities in the wetland was found necessary to be done.

Figure 6: Poor agricultural activities in the Rurangazi wetland

5.4.3. Deforestation

Many cases of deforestation were also observed in the project area. This particular issue is related to biomass energy consumption in a sense that wood is used as source of energy for the local population in the project area.

A typical case of intensive illegal deforestation for wood and charcoal production in Nyamirama Cell, Muhanga sector in the Muhanga district was observed. This is illustrated on figure 9.

Figure 7: Deforested area in Nyamirama cell for biomass energy and wood production

5.5. Methodology

The methodology used to develop the Nyabarongo upstream rehabilitation plan was based on land husbandry technologies, stakeholders' engagement taking into account the need of the local population and prioritisation of actions based on sediment finger print analysis. The approach

consisted of 4 major stages. The first stage was to identify the land resilience units in the area using available data. The second stage was to incorporate agro climatic parameters in the land resilience units in order to design the appropriate land husbandry technologies (or measures) that have to be applied in the area to control erosion and therefore solve the siltation problem of Nyabugogo Upstream watershed. The third stage was to validate on the field the developed rehabilitation plan with the aim of assessing its practicability and also raising awareness among the local authorities about adopting the developed rehabilitation plan once validated in their future planning and finally the last stage was to carry out a sediment finger print to identify exactly the sources of sediments through a scientific approach.

5.5.1. Stage 1: Land Resilience Units

To identify the land resilience units in the project area, a comprehensive approach consisting of combining the slope classes and soil depth classes spatially in the project area based on the land unit matrix provided in table 1, was applied.

	Slope Categories				
Soil depth	**0-6%**	**6-16%**	**16-40%**	**40-60%**	**>60%**
0-50 cm	9	10	11	12	15
50-100 cm	4	5	6	8	14
>100 cm	1	2	3	7	13

Table 1: Land Unit classification matrix

In the above matrix, 4 categories of land units were deduced as illustrated in table 2. The first 2 categories were set for a similar kind of treatment know as agroforestry because of 3 main reasons. The first reason was the reduced coverage of rangelands compared to the croplands in the project area. The second reason is the zero grazing policy in place in Rwanda resulting in no need for rangelands. The last reason is the governmental efforts in place which is promoting agro forestry instead of traditional agriculture in the country.

#	Code	Land Unit
1		Croplands/Agroforestry
2		Rangelands/Agroforestry
3		Forest plantation
4		Natural forest

Table 2: Land Resilience Unit

The following combination and categorization was applied to the project area in a GIS environment and an overall spatial distribution of these categories in the project area was obtained.

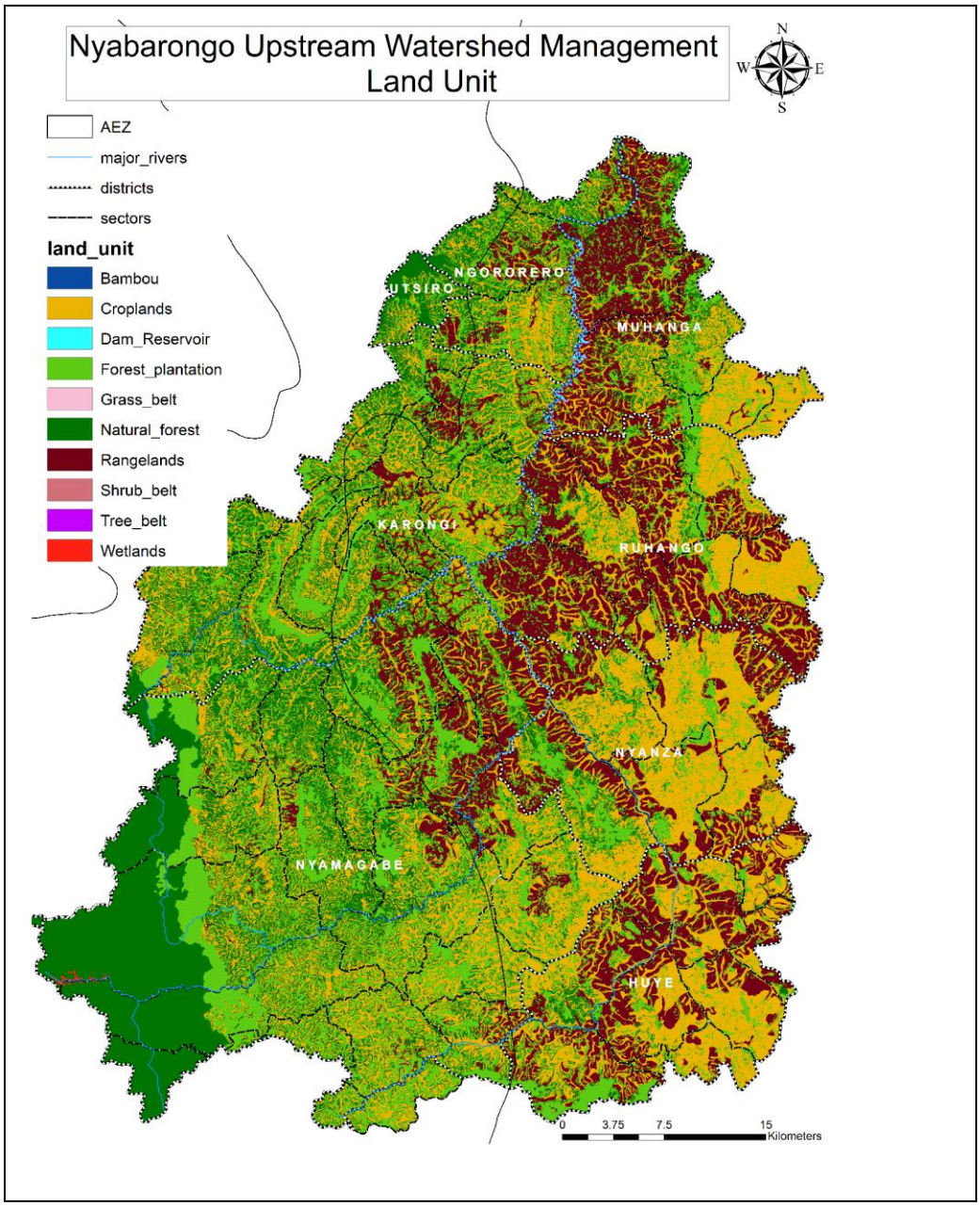


Figure 8: Land Resilience Units

5.5.2. Stage 2: Implementation measures

In order to design the adequate measures to control erosion in the project area agro climatic factors were considered. These measures are implemented as land husbandry technologies which depended on resilience of soil and its agro climatic situation. The agro climatic situations were mostly categorised into agro climatic zones where the western part of the project area consisting of the Ngororero, Karongi, Nyamagabe and Rutsiro districts are located in the Congo-Nile watershed divide agro ecological zone and the eastern part consisting of the Ngororero, Karongi, Nyamagabe, Muhanga, Ruhango, Nyanza and Huye are located in the central plateau agro

ecological zone. Additionally, the altitude and annual rainfall were considered in the project area to complement its agro climatic parameterisation. Four zones were determined as wet highland (W. H. L), wet mid land (W. M. L), moist mid highland (M. M. H. L) and moist low land (M. L. L) in the study area.

Table 3 illustrates the classification matrix that was used for implementation measures. The technical specification related to this matrix is provided as annex 8.1. in this document.

		Land Units			
		Croplands	**Rangelands**	**Forest plantation**	**Natural forest**
Agro climatic zones	**M. L. L**	Agro forestry + simple management	Agroforestry + + average management	Agroforestry + advanced management	Natural forest
	M. M. H. L	Agro forestry + average management	Agroforestry + advanced management	Agroforestry + advanced management	Natural forest
	W. M. L	Agro forestry + advanced management	Agroforestry + advanced management	Agroforestry + advanced management	Natural forest
	W. H. L	Natural forest	Natural forest	Natural forest	Natural forest

Table 3: Classification matrix of implementation measures

5.5.3. Stage 3: Validation of the rehabilitation plan

In this stage, an occasion of field visit with the aim of assessing the field practicability of the plan was done. It was also an occasion to discuss the plan with the local authorities as they will be the owners of this plan and will therefore have to ensure the plan implementation in their respective administrative entities.

The validation mechanism applied was designed in a point to point validation approach. In this approach, firstly using 2015 satellite imageries a ranking of the most degraded cells based on the number of degraded sites included in the cell was done. These cells as illustrated on figure 11 were then selected as calibration targets. The idea was to go onsite with the districts and sectors technicians and compare the proposed measures on the map against the field reality. During that session, further brainstorming on site were done and noted so that they can be used in the improvement and finalisation of the plan.

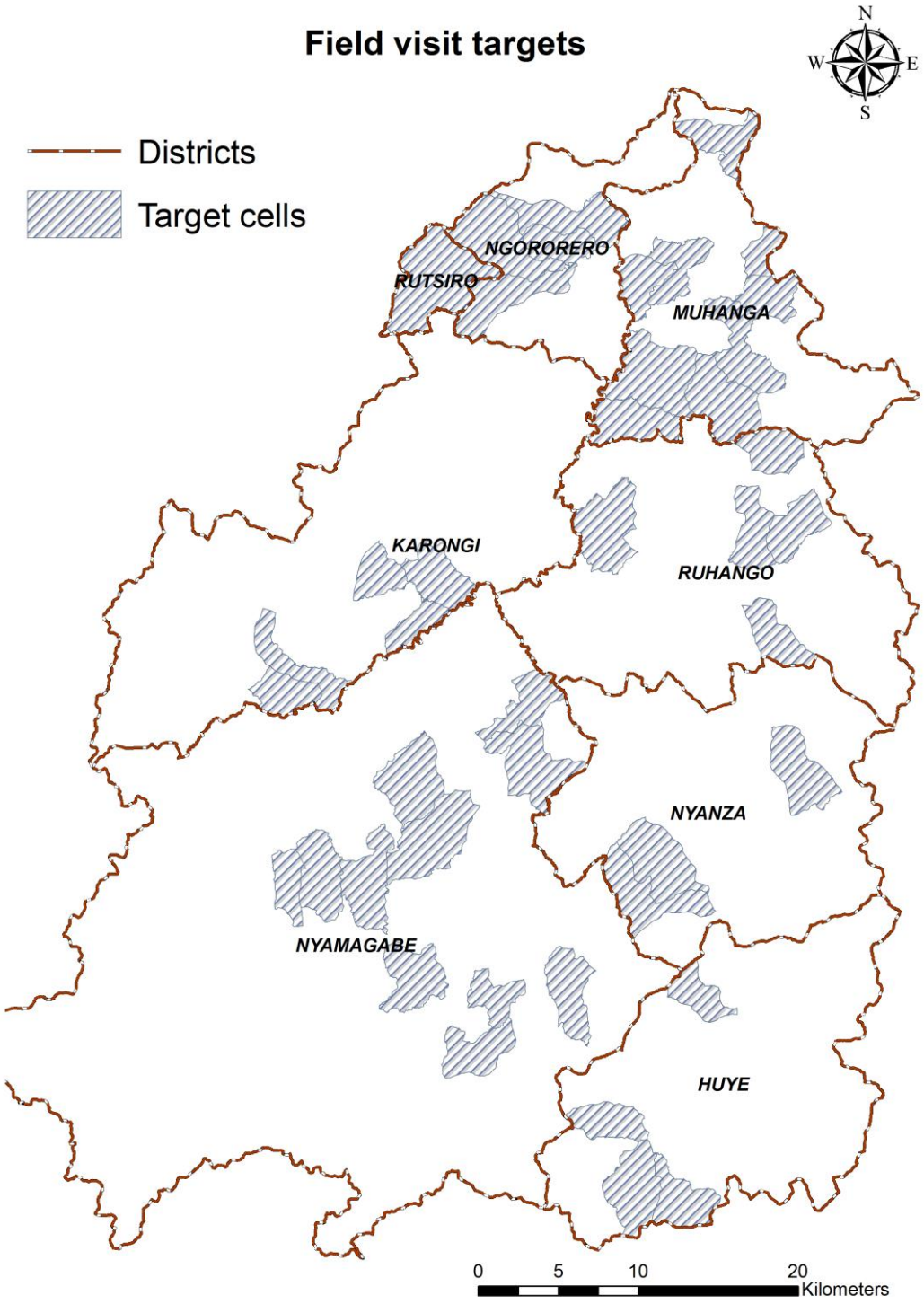


Figure 9: Situational illustration of the validation targets

A statistical comparison between the observed areas and the proposed measures onsite indicated that the plan was highly practical for all the measures proposed reference made to the annex 8.3. in the comparison table. However, it was found necessary to include the soil fertility parameter

in order to ensure the economic valorisation of radical terraces as these are very expensive to implement.

5.1.1 Stage 4: Sediment Finger print analysis

Sediment fingerprinting involves a statistical comparison of the elemental composition of suspended sediments in rivers with the elemental composition of soils belonging to the various geological types throughout the catchment. Elements are chosen that reliably distinguish between the different geological types in the catchment. The final results indicate the most likely levels of sediment contribution from the different geological types.

The process of sediment fingerprinting as carried out in NNYU involved five basic steps as follows:

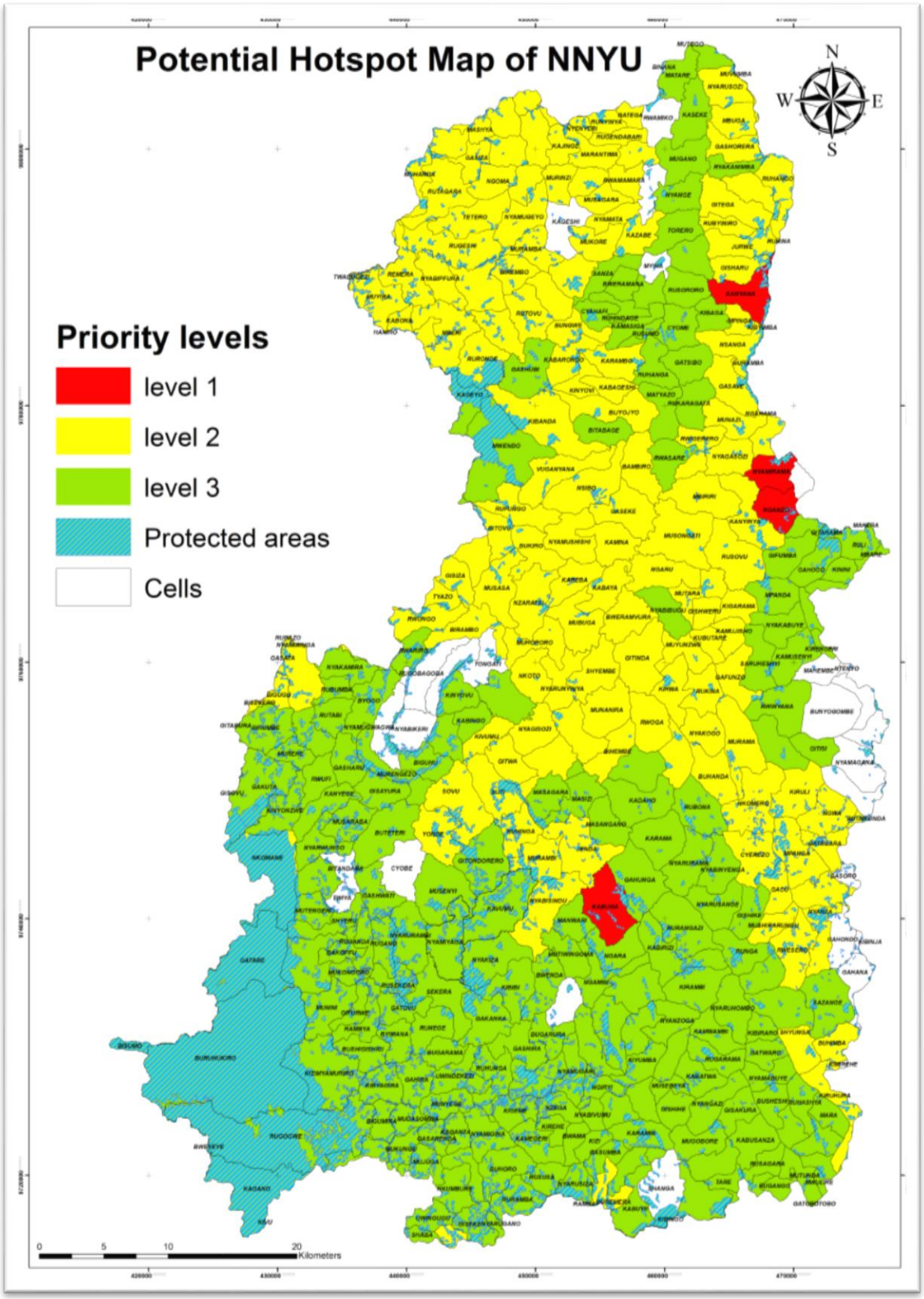
i. *Collection of soil samples from all geological types present in the catchment*. There are 14 geological types in the NNYU. For each geological type, five composite samples were collected (with the exception of the Ho alluvial soil type that was not included).

ii. *Collection of suspended sediment samples from the river system.* This was done at 14 locations at the confluences of major tributaries as well as at the Nyabarongo Hydropower Reservoir. Five collection campaigns were carried out at each site at intervals of 2 weeks, from January 21 to April 25, 2016, to also observe seasonal variations in sediment load distribution in the river in relation to their sources.

iii. *Laboratory analysis of soil and sediment samples*. This was done at FIU using an inductively coupled plasma mass spectrometer which determines the elemental composition of soils and sediments with a very high level of accuracy and sensitivity. Results were also obtained using an X-ray fluorescence spectroscopy technique at the RSB lab, which had lower levels of sensitivity but still showed relatively similar results.

iv. *Statistical analysis of laboratory results*. The first part of the analysis identified a set of elements that can reliably distinguish between geological types (sediment sources). The second part used a mixing model that compared the elemental composition of a sediment sample to those of the geological types in the watershed. The product of this step is to have a probabilistic distribution of each geological unit contribution within a particular sample. The analysis was performed on each sample per collection campaign.

v. *Identification of potential hotspots for prioritization of rehabilitation.* The potential sources identified (in terms of geological types) were located on a map and the land use and land cover were analysed to determine the probable causes leading to soil erosion and sediment load in the river. A three level system was devised with level 1 indicating the areas with the most serious erosion, and Level 3 contributing relatively less sediment. Such a map allows focusing of site visits to locate the precise spots and causes of erosion, followed by deciding and embarking on site-appropriate catchment rehabilitation efforts.

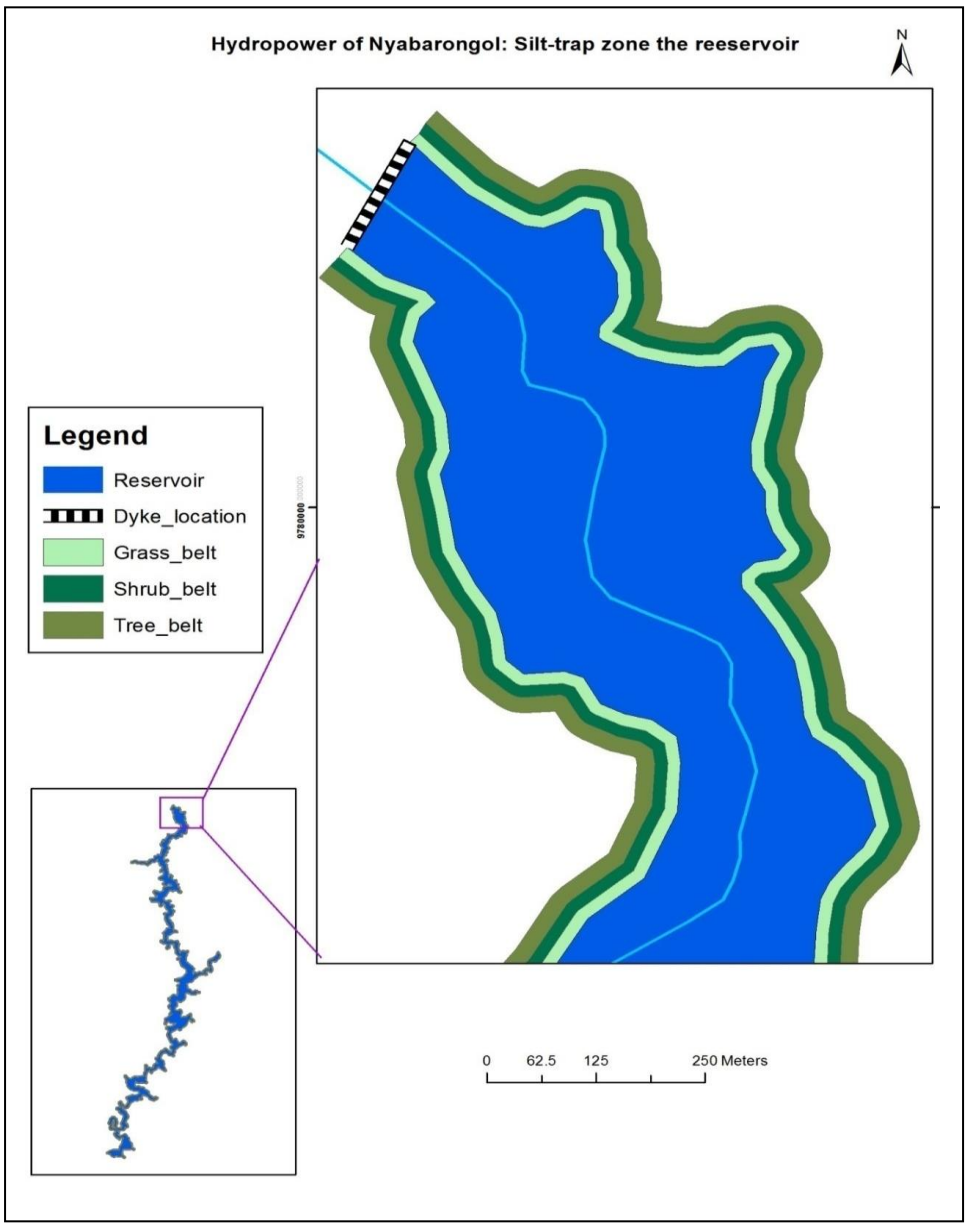

Potential Hotspot Map of NNYU
N
W
E
S
Priority levels
level 1
level 2
level 3
Protected areas
Cells
0
5
10
20
Kilometers

5.6. Upper Nyabarongo rehabilitation plan

Two main categories of implementation measures are proposed in the rehabilitation plan of the project area. These are basically the implementations measures on buffer zones of the main rivers and reservoirs as well as the implementation measures on hillsides.

5.6.1. Implementation measures for buffer zones

According to the organic law of environment of 2005 in place, 50 meters of buffer zones are applied for lakes and reservoir while 10 meters are applied for main rivers (in this case the hydropower reservoir and the river Mbirurume, Rukarara, Mwogo and Nyabarongo Upstream).



The 50 m buffer zone of the reservoir was divided into 3 zones, as illustrated on figure 12, for the reservoir vicinity erosion control as follows:

- 15 m of a thick **grass belt** which will act as a silt trap.

- 15 m of **shrub belt** following the grass belt. This zone will act as gravel trap. The shrubs will be planted along contour lines in a spacing of 0.5 meter along the same contour line as well as between consecutive contour lines.
- 20 m of **tree belt** after the shrub belt which will act as a boulders trap during heavy rains. The tree spacing of 1 m along the same contour line and between consecutive contour lines was recommended.

The 10 m buffer zone of main rivers will be protected with a bamboo belt. The following will protect the concerned river banks from being eroded.

5.6.2. Implementation measures on hillsides

A variety of land husbandry technologies were defined as implementation measures on hillsides in the rehabilitation plan. These are illustrated in a situational context of the entire project areas in figure 13. A distribution of these implementation measures over the concerned districts and aerial extent are provided in the table 4.

Measures	Huye	Nyanza	Nyamagabe	Ruhango	Muhanga	Karongi	Rutsiro	Ngororero	Nyaruguru	Total per measures
Agroforestry/cut off drains/ horizontal trenches	2,915.78	1,851.05	1,473.47	3,963.09	1,870.95	647.86	387.52	3,053.14	9.52	16,172.38
Agroforestry/progressive terraces	5,331.13	5,108.13	4,629.48	5,280.40	3,192.34	2,658.98	368.64	3,068.80	182.35	29,820.25
Agroforestry/ radical terraces/gully treatment	12,547.50	9,397.73	18,950.50	12,969.99	9,458.19	12,185.51	1,487.63	11,972.14	560.90	89,530.09
Forest plantations	1,270.12	1,410.24	10,335.41	2,664.91	6,067.10	9,731.41	2,229.71	12,498.10	193.03	46,400.03
Natural forests to be restored	930.35	1,314.37	8,442.99	1,065.90	3,646.66	5,482.79	1,136.08	6,383.55	100.83	28,503.52
Main river buffer zones	58.21	34.51	102.14	85.34	88.76	81.74	0.41	194.34	10.90	656.35
Grass belt	-	-	-	-	32.70	7.83	-	21.77	-	62.30
Shrub belt	-	-	-	-	46.60	6.85	-	17.48	-	70.93
Tree belt	-	-	-	-	54.29	12.83	-	32.16	-	99.28
Dam reservoir	-	-	-	-	216.05	26.39	-	72.52	-	314.96
Wetlands	-	80.17	-	-	6.58	-	-	13.56	-	100.31
Protected areas (urban areas, existing forests, etc.)	6,287.55	10,332.07	57,711.84	5,572.61	7,226.59	11,593.67	4,033.72	18,679.56	999.83	122,437.44
Total per District	29,340.64	29,528.27	101,645.83	31,602.24	31,906.81	42,435.86	9,643.71	56,007.12	2,057.36	334,167.84

Table 4: Implementation measures per districts per unit area in hectares

Figure 10: Situational context of the Nyabarongo Upstream Watershed Rehabilitation Plan

5.6.3. Financial estimates of the Rehabilitation Plan

The following financial estimation of the whole rehabilitation plan in the project area was done using unit rates adapted from existing projects LVEMP and PAREF. The approach in these estimations is based on the unit rate of an implementation measure per hectares done, this implies that all quantification in the budget were done on aerial basis in a unit of hectares.

The results of this financial estimation are provided in table 5.

#	Measures	Quantity (ha)	Unit cost (Rwf)	Budget (Rwf)
1	**Hillsides**			
1.1	Agroforestry/cut off drains/ horizontal trenches	16,172.38	250,000	4,043,095,000
1.2	Agroforestry/progressive terraces	29,820.25	580,000	17,295,745,000
1.3	Agroforestry/ radical terraces/gully treatment	89,530.09	1,200,000	107,436,108,000
1.4	Forest plantations	46,400.03	500,000	23,200,015,000
1.5	Natural forests to be restored	28,503.52	1,200,000	34,204,224,000
1.6	Horizontal trenches in existing forests	7,828.00	290,000	2,270,120,000
1.7	Main river buffer zones (bamboo)	656.35	500,000	328,175,000
2	**Buffer zones**			
2.1	Grass belt	62.30	450,000	28,035,000
2.2	Shrub belt	70.93	350,000	24,825,500
2.3	Tree belt	99.28	500,000	49,640,000
	Total			**188,879,982,500**

Table 5: Financial estimates of the rehabilitation plan

6. Phase 1

The following section provides information on the ongoing activities in the project area from different stakeholders as well as the planned activities to be started soon. These range from implementation projects to researches.

6.1. Ongoing activities

Many activities are ongoing in the concerned districts based on the available means. These activities are budgeted and ready for implementation. These are summarised in the table 7 following the available data. A spatial mapping of these activities could not be possible due to lack of data for mapping.

Projects	Districts	Sectors	Activities	Intervention Area
PAREF	Ngororero	Bwira, Nyange, Ndaro, Gatumba	progressive terraces, agroforestry	1100 ha
	Karongi	Murundi		
LVEMP II	Karongi	Twumba, Murundi, Mutuntu, Ruganda, Gashari, Murambi	Progressive terraces, agroforestry	250 ha
			Rehabilitation of Mashyiga river bank	53 ha
	Huye	Simbi, Kigoma, Maraba	Progressive terraces	400 ha
			Rehabilitation of Mwogo river bank	45 ha
	Nyamagabe	Mbazi, Kaduha, Mbazi	Progressive terraces	40 ha
			Radical terraces	20 ha
			Rehabilitation of Rukarara river bank	35 ha
	Muhanga	Rugendabari, kibangu, Mushishiro, Nyabinoni	Progressive terraces	404 ha
			Radical terraces	25 ha
			Rehabilitation of Nyabarongo river bank	35 ha
PAGREF	Muhanga	Nyarusange	Agroforestry and terracing	55 ha
FONERWA	Karongi	Bwishyura, Murambi	Progressive terraces	50 ha
			Agro forestry	107 ha
			Radical terraces	20 ha
			Afforestation	15 ha
	Nyamagabe	Tare, Kitabi, Kamegeri, Gasaka and Musange	Progressive terraces	500 ha
			Radical terraces	300 ha
			Buffer zones (bamboo)	40 ha
	Muhanga	Mushishiro, Nyabinoni, Rongi, Kiyumba, Kabacuzi,Rugendabari, Kibangu	Progressives terraces	3201 ha
		Huye	Progressives terraces	650 ha

LWH/RSSP	Nyamagabe	Musebeya, Buruhukiro, Kibirizi, Gasaka, Cyanika,Mbazi, Kibumbwe	Radical terraces	
	Nyanza	Nyagisozi, Cyabakamyi, Rwabicuma, Busasamana	Radical terraces	4814 ha
	Ruhango	Mwendo, Bweramana	Progressives Terraces	133,45 ha

Table 6: Ongoing Activities

6.2. Important achievements

The following section provides a summary of the major achievements since elaboration of Nyabarongo rehabilitation plan in May 2015. These are:

- Meetings with concerned stakeholders at central and district levels for gathering the information on the problematic issues, issues and approach to deal with them
- Afforestation campaign through PAREF under the MINIRENA/RNRA with support of Netherlands Embassy around the hydropower reservoir of the Nyabarongo Hydropower 1 in order to protect it against erosion from its vicinity
- Sediment fingerprinting funded by USAID which determined the source of sediments that are most polluting the catchment and which will indicate consequently constitute targets for early rehabilitation efforts.
- Implementation of afforestation and agroforestry early investment project with support of EKN for a total area of 1104,2 ha
- Development of the first generation catchment plans under the IWRM program funded by the Netherlands Kingdom which will identify opportunities for non-regret projects

- Development of mine landscaping in line with the model mine approach currently in the RNRA/GMD and FONERWA. The aim will be to develop a framework for sustainable mining activities through sediment control.

7. Other investment projects:

7.1. Afforestation by Paref Project

A total area of 1430 ha was treated with agroforestry, afforestation with progressive terraces, trenches, shrubs, fruit trees in Ngororero District / Ndaro Sector, Bijyojyo Cell in Bijyojyo, Rutonde, Kavumu and Birima villages.

Example of area treated by PAREF Project: Ngororero District /Nyange Sector, Bambiro Cell in Gakoma, Rwasankuba and Butare villages.

Progressive Terraces: Trenches, Grevillea robusta, Calliandra callotrysus, French Cameroon and Fruits (Avocado grafted, Mangoes and Papaya)

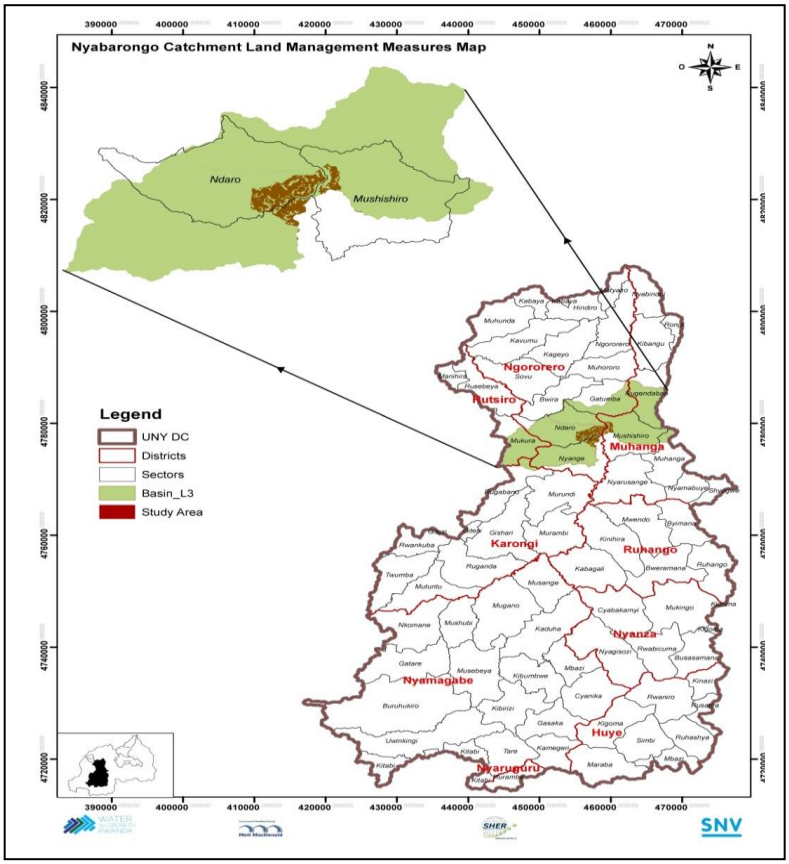
- Planting of French Cameroon on the visited area is around 99 %
- Digging of trenches done on the visited area is 100 %.
- Planting fruits trees, Agro-forestry and shrubs are done on 99%. (1 % Remaining is related on the beating up of the same seedlings damaged in agro forestry and Fruits)


Second example in Karongi District /Murambi Sector, Shyembe cell, village: -Nyamagana and Kavumu, Nyarunyinya Cell, Nyarusave village

- Planting of French Cameroon on the visited area is 94 %
- Digging of trenches on the visited area is 100 %.
- Fruits trees like Avocadoes and Papaya, Agro-forestry like *Greveria robusta* and sample of *Alnus acuminata*, shrubs like *Calliandra callotrysus*, are planted on the rate of 94 %. .


8. Early Investment Project

A total area of 1104.2 Ha will be treated around the Hydropower plant. Agreements with all concerned parties have been finalized. The work will be supervised by RNRA SPIU and implemented by Reserves Forces and will be implemented in two districts of Ngororero and Muhanga.



Category	Unit	Ngororero District	Muhanga district	Total
Agroforestry	ha	16.3	1.7	18.0
Progressive Terraces	ha	63.4	8.5	71.9
Bench Terraces	ha	332.1	41.4	373.5
Narrow Cut Terraces	ha	262.1	47.0	309.1
Forestation	ha	83.6	18.1	101.6
Buffer Zones (Rivers)	ha	9.3	4.1	13.4
Buffer Zones (Reservoir)	ha	98.7	115.9	214.6
Total		866.7	237.6	1104.2

9. Phase 2

9.1. Agroforestry Plan with involvement of all stakeholders

Interventions were clustered into different level of timing (short term, medium and long term) in combination with the priority levels of the cells (obtained from the sediment fingerprinting study) within the District concerned parts. In parallel to the rest of the interventions, specific to the case of mining activities, the concept of model mining was incorporated in the strategy as a special standalone intervention that is not classified and should be implemented all the way and continuously adopted as a business as usual practice in the mining sector.

The short term plan will come up with the computation of required agroforestry in each administrative unit at level of Cells.

To facilitate the implementation of the interventions, it is proposed to come up with a strategy that will involve all levels of communities, from the grass roots to the highest authorities. All communities will be mapped out from their parcels which are available in the LAIS system. Required number of agroforestry trees will be computed for each parcel then seedlings will be available at each administrative unit, from the districts, Sector to Cell level. Farmers will enter into performance contracts with their direct Chiefs of Villages who will sign contract also with their Head of Cell. These ones will sign contract with the Head of Sector and these latter will sign with the Head of Districts. With available trees in nurseries, population will be required to plant in their specific farms the required agroforestry trees.
Existing projects and other private partners need to make sure seedlings are available in each sector, cell and village.
Specific agroforestry trees will be indicated by the Forestry Department of RNRA.

With the involvement of local communities, there will be more ownership in the process of tree planting and management and increase consequently the surviving rate.

A technical coordination unit will be set up in Upper Nyabarongo Catchment which will ensure the coordination of all preparatory work, the production of nurseries trees, the trainings of farmers, and the link with Administrative unities.

The objective will be to optimise land resources with providing agroforestry trees which will contribute in improving the land use.

Implementation terms	Type of Interventions measures
Short term: these are direct action that can be implemented in collaboration with the local communities without heavy investments.	1. Afforestation (forest plantation that can be harvested), 2. Local communities mind set change and training on forest harvesting and management, 3. Agroforestry/cut off drains, 4. Buffer zones (grass, shrub, trees around the reservoir as well as bamboos on the main rivers).
Medium term: these are direct actions that can be implemented generally in collaboration with the local communities without heavy investment but requires technical support from the government to ensure their proper implementation.	1. Continuation of interventions started in the short term (for areas not covered yet), 2. Agroforestry/progressive terraces/horizontal trenches, 3. Sediment removal from the reservoir using an appropriate technology to be defined, 4. Local community training and capacity development toward business development (focusing on forest harvesting, bamboo handcrafting, agribusiness, construction material supply from the excavated sediment, etc.) to ensure the sustainability of interventions.
Long term: these are direct actions that need advanced expertise and requires heavy investment from the government.	1. Continuation of the interventions started in the previous terms if not completed, 2. Afforestation (Natural forest which cannot be harvested), 3. Expropriation of all the private land that need natural forest coverage on it (to facilitate the management and protection of the natural restored forest by the government), 4. Agroforestry/radical terraces/gully treatment, 5. Construction of sediment traps technologies upstream the reservoir plus development of mechanism to remove periodically the retained sediments.

Table 9: Classification of interventions measures per implementation term

The spatial location that constituted the basis for the sequential phasing of the implementation of the intervention measures, classified by implementation terms, was be based on the prioritization of the cells as obtained from the fingerprinting results. The following section provides a distributive illustration of the intervention measures per Cell per District, in phases and implementation terms, which can be considered as the technical side of the implementation strategy.

9.2. Huye District

No	Sector Name	Area for Agroforestry (ha)
1	Mbazi	1426.54
2	Maraba	2757.77
3	Ruhashya	2215.73
4	Simbi	3026.39
5	Kigoma	3230.55
6	Rusatira	960.23
7	Rwaniro	3761.30
8	Kinazi	1618.87

Table 7: Required number of agroforestry trees in Huye District.

9.3. Karongi District

No	Sector Name	Area for Agroforestry (ha)
1	Mutuntu	4603.15
2	Twumba	3567.04
3	Ruganda	4404.33
4	Rwankuba	2240.06
5	Murambi	3704.94
6	Gashari	3674.39
7	Gitesi	387.37
8	Murundi	4443.20
9	Rugabano	3213.90

Table 8: Karongi District technical implementation matrix.

9.4. Muhanga District

No	Sector Name	Area for Agroforestry (ha)
1	Shyogwe	462.80
2	Nyamabuye	918.90
3	Nyarusange	4847.89
4	Muhanga	2508.94
5	Mushishiro	3893.01
6	Rugendabari	3132.01
7	Kibangu	3596.19

8	Rongi	743.27
9	Nyabinoni	2365.67

Table 9: Muhanga District technical implementation matrix.

9.5. Ngororero District

No	Sector Name	Area for Agroforestry (ha)
1	Nyange	3676.25
2	Ndaro	4042.23
3	Gatumba	2795.65
4	Bwira	2193.20
5	Sovu	4372.77
6	Muhororo	2672.45
7	Kavumu	4134.04
8	Kageyo	3927.09
9	Hindiro	2445.33
10	Ngororero	4232.08
11	Kabaya	1691.95
12	Muhanda	2784.44
13	Matyazo	1318.13

Table 10: Ngororero District technical implementation matrix.

9.6. Nyamagabe District

No	Sector Name	Area for Agroforestry (ha)
1	Kitabi	1449.05
2	Kamegeri	1957.17
3	Tare	2789.20
4	Uwinkingi	2794.23
5	Gasaka	5470.10
6	Kibirizi	3112.54
7	Buruhukiro	3931.61
8	Kibumbwe	3156.95
9	Mbazi	2217.05
10	Gatare	2571.22
11	Musebeya	3514.61
12	Mushubi	2779.72
13	Nkomane	3006.30
14	Kaduha	4702.17
15	Mugano	4791.59

16	Musange	4165.75

Table 11: Nyamagabe District technical implementation matrix.

9.7. Nyanza District

No	Sector Name	Area for Agroforestry (ha)
1	Mukingo	1.80
2	Busasamana	2713.11
3	Rwabicuma	3551.19
4	Nyagisozi	4336.78
5	Kigoma	186.65
6	Cyabakamyi	4732.10
7	Mukingo	5283.53

Table 12: Nyanza District technical implementation matrix.

9.8. Ruhango District

No	Sector Name	Area for Agroforestry (ha)
1	Bweramana	3764.00
2	Kabagali	4106.57
3	Ruhango	3220.17
4	Kinihira	4708.45
5	Byimana	2119.33
6	Mwendo	4201.61

Table 13: Ruhango District technical implementation matrix.

9.9. Rutsiro District

No	Sector Name	Area for Agroforestry (ha)
1	Mukura	2019.16
2	Manihira	1020.34
3	Rusebeya	3768.97

Table 14: Rutsiro District technical implementation matrix.

9.10. Development of integrated catchment plan

The process of development of Integrated Catchment plan has started and is expected to be completed early February 2017. The plan will be integrated and will complement the present rehabilitation plan by addressing other aspects including livelihood of population, economic and social aspects that hinder the proper development of the catchment.

What has been so far includes detailed characterisation both physical, social and economic aspect,, assessment of water balance, analysis of water users, analysis of expected projections on use of water and definition of appropriate alternatives for the overall optimum of resources toward sustainable development of the catchment.

10. Conclusion

The present rehabilitation plan for Upper Nyabarongo is a planning tool to support concerned districts.

The plan indicates clearly what, where and how to address physically the issue of siltation that is serious in catchment of Upper Nyabarongo.

Some efforts have started and are scattered throughout the catchment. Water for Growth Rwanda is going on with implementation of some investments projects, improving the joint planning and strengthening the coordination aspect.

Rehabilitation process needs full involvement of the communities, the local administrations, miners and other potential partners but this requires a strong coordination in the catchment.

With this plan, a clear computation of the required agroforestry has been carried out and it can easily be implemented with combined efforts of all stakeholders.

The plan needs to be validated and internalized in the performance contracts of the local administration.