A Summary of the survey report of Hydrological Systems in the Great Virunga Landscape (Uganda, Rwanda and DRC)

A brief technical report to:

By

INSTITUTE OF TROPICAL FOREST CONSERVATION

INSTITUT D'ENSEIGNEMENT SUPÉRIEUR DE RUHENGERI

GOMA VOLCANO OBSERVATORY

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Abstract

Communities in the GVL face water shortages inspite of living adjacent major catchment areas. The water sources are unevenly distributed and few. Still much fewer water sources flow permanently. This makes the local community members to travel long distances and risk to collect water from the protected areas and other unprotected water sources within the landscape. Water demand far outstrips the supply so that where protected water sources have been installed there are marked with long queues and/or rationing of water. Each household uses between 20 – 60 litres of water per day. This is far below the required standard of 15 litres per person per day. Some domestic chores like keeping good hygiene are foregone because of lack of enough water in the households. Water from unprotected sources is often of poor quality making it a hazard to local community livelihoods. The water from all unprotected water sources was found to be contaminated with feacal material making it unfit for human consumption. Water sources are also adversely affected by high rates of erosion within the protected areas due to the steep slopes and outside the protected areas due to poor agricultural practices. Several action points are recommended, key being the protection of the current sources, expansion of rain harvesting technologies, and improvement in community sanitation to make the water safe. Soil and water conservation methods should be implemented in areas under agriculture to avoid siltation and pollution of water sources like wetlands and rivers.

Rationale

Communities in Greater Virunga Landscape continue to face water scarcity yet the afro-montane forests of the Virunga Massif and Echuya are major watersheds in the landscape. Previous studies attribute this to high infiltration rates of the volcanic soils and rocks in the area that lead to a scarcity of surface water sources in the dry lava zone outside the protected forested area where the local communities live. This is in spite of the fact that there are many streams that emanate from these forested protected areas. Natural springs are scarce because the rain that falls on these high altitude forests seeps into the soil and re-emerges largely through regional flow system springs at lower altitudes, leaving high altitude areas on the hill and mountain sides devoid of spring water. People living near the two high altitude tropical forest blocks are therefore forced to trek long distances looking for water sources. As a result of limited surface water sources, community members end up collecting water from springs, streams, lakes and swamps within the protected areas.

Previous studies showed that a sizeable proportion of the people in the GVL relied, both illegally and legally, on the water that is collected in surface streams within the protected areas. Collecting water within parks is not ideal for either the people or the parks. People, especially women and children, walk far looking for water and risk encounters with dangerous wildlife or park staff, the protected areas are degraded, there are increased likelihood of mountain gorillas contracting human diseases due to increased chance of contact, and people using the opportunity of being in the protected areas to extract resources such as bush meat, fuelwood and other forest products. Therefore, understanding the status and use of existing water regimes provides a basis for addressing local community water needs and wellbeing as well as maintaining and restoring the ecological integrity protected areas within the Great Virunga landscape.

Methodology

Semi-structured household interviews were conducted on households selected by stratified random sampling to determine water use and demand. The stratification was based on front-line and non-frontline communities. Front-line communities are those who live in the administrative units (parishes for Uganda, sectors for Rwanda and groupements for DR Congo) immediately adjacent the protected area. Water supply was determined by interviewing the households on their sources of water, permanency, consistency and physically visiting and assessing the water sources.

Water quality was determined by measuring the physicochemical variables of the water sources like water temperature, dissolved oxygen, pH, turbidity, electrical conductivity, total dissolved solids, water transparency, and flow velocity. Water samples for water chemistry analysis were collected from representative water sources of different types and localities within the landscape and delivered to the laboratory for analysis of variables such as nutrients and inorganic ions. The water samples were also tested for ions including Alkalinity, Calcium, Fluoride, Magnesium, Phosphorous as Phosphates, Total suspended solids, Alkalinity total, Hardness total, and Nitrates. Sample handling and preservation closely followed guidelines in Bartram and Balance (1996).

Risks to water sources were determined by determining areas in the landscape prone to flood/soil erosion using ArcHydro modeling tools in ESRI ArcGIS 9.3 software.

Findings

Water use and demand

Water use was found to be very minimal. Generally, majority (over 70% of 1,408 repondents) of the households in all the three countries use 20 to 60 litres per day. Nevertheless, these amounts of water used do satify people's real demand for water but is what currently available for household use. Respondents attributed the low use of water to water scarcity and long distances to water sources. Water use in the households is always highly regulated due to its shortage. Water from sources like gravity water schemes and rain water harvesting tanks is highly regulated. Community members are allowed to fetch water from these sources at specific times of the day and in specified quantities. Water sources and systems are regulated so that water is available consistently or on a regular basis to all community members. This shows that if people had other options of having more water, the amount used would be much more than is currently used in each household. There is also significant differences in water usage during the dry and wet seasons. During the wet season, the usage of water for homestead chores is quite high compared to the dry season when it is used sparingly. Given that the recommended average water use for drinking, cooking and personal hygiene in any household should be at least 15 litres per person per day, water available per person in GVL is very low and not enough given that an average household has 5 - 6 members. Personal hygiene is the water use that is more likely to be ignored when water is scarce. This can lead to prevalence of hygiene related diseases like scabies and bad body odour among the local communities.

Water supply

Water supply varied by country. In Uganda, (n=614 respondents) the majority of the respondents around Echuya collected water from unprotected sources like rivers (42%) followed by swamps (18%) and ponds (15%); while in Mgahinga, (apart from Rukongi and Gitendere parishes), the main souce of water for domestic use were from protected water sources installed by government and other development organisations and these included gravity water schemes and rain water roof catchments. The rain water roof catchments included community tanks, household tanks, water jars and protected taplines. The use of protected water sources in Mgahinga is more than in Echuya. The difference is attributed to a few available permanent water sources and the seasonality of most water sources in the former landscape.

In Rwanda, the main source of water are protected springs, rain water roof catchments and public water supply (WASAC taps). Thirty nine percent of the respondents (382) reported that they do not have constant water supply because they only rely entirely on rain water harvesting which is not enough to cater for their needs, especially in the dry periods.

In DR Congo, the households mostly use unprotected water sources. Among the unprotected water sources, 48.5% of the 382 respondents reported a river to be the major and reliable source of water. Other water sources include rain water harvesting, wetlands, mountain rocks, reservoirs and ponds. The use of different water sources by the households is attributed to the unequal and seasonal distribution of most of the water sources in the catchment. The households also use stored water in times of shortage.

Water quality

Uganda

Mean pH values across the sampled water sources in the region were generally acidic and thus below the recommended national standard range of 6.5 to 8.5. Most protected spring water sources had acidic water and thus would require treatment with soda ash before domestic consumption. Around Echuya forest for example, parishes of Kashasha and Kishanje had the most acidic waters among all the sampled sites.

Generally water transparency was above 120 cm in most of protected spring sources and rainwater sources sampled. The transparency tended to get poorer with intensification of human activities within the watersheds of the different water sources. The variable was identified as simple measurement that communities could use to monitor the quality of their water sources and in assessing the effectiveness watershed management practices in the landscape.

Turbidity was also generally low in all the rainwater sources and protected spring sources sampled. The mean turbidity values in all parishes were below the national standard value of 5 NTU. Turbidity was very high in agriculturally impacted water sources such as headwater sources and the streams and rivers they drain into. Water conductivity in all the sampled water sources was below the maximum permissible value of 1,000 μS/cm. The conductivity values tended to increase with the intensity of human activities such as cultivation on steep slopes and removal of vegetation around water sources.

Color apparent tended to be higher in water sources impacted by agriculture activities and in wetland water sources. Although drinking water should ideally have no color, most water sources had some color and would therefore require treatment before consumption but may be useful for other purposes such as watering animals and in small-scale irrigation of crops. Total suspended solids were above national standard in most water sources. This implies that most water sources inputs from terrestrial sources such as agricultural and road runoff that add the suspended materials to the receiving water sources.

Phosphates values were generally low across the sampled water sources but with very low values in rainwater sources and protected spring sources. Relatively higher values were associated with water sources close to livestock grazing areas such as Ginya perched aquifer and Hakisementi stream that drains a cattle farm. Runoff from the grazing fields and sources used for watering animals may be the cause of the slightly increased phosphate levels in the water sources. Nitrates were also very low in most water sources sampled. The only likely sources of nitrates maybe the animal kraals and other animal tethering facilities in the homesteads. Phosphorous and nitrate pollution is not yet a problem in the landscape because of the low use or no application of artificial fertilizers.

Fluorides in sampled water sources were below the maximum permissible standard for portable water. This implies that the water in all parishes does not pose a health risk to the communities.

Total coliforms and *E. coli* were the microbiological tests performed for water quality. In all sampled sources, mean values per parish were above the standard value of 0. Low values of total coliforms were common in rainwater sources, protected spring sources, and water sources located inside the protected areas. The high levels of coliforms in water sources located in communities are an indication of poor sanitation facilities such as open defecation that contaminate the water with fecal material. Communities need to be sensitized on the importance of sanitation facilities and on boiling water especially for drinking.

Water quantity as measured by discharge was generally low because of the location of streams and rivers in headwater areas. The flow rates despite being low in most streams and springs, can sustain gravity flow schemes to supply downstream communities. The main outflow out of Lake Bunyonyi was high enough to even support a micro-hydro power plant.

Rwanda

The general situation for water quality in terms of physical parameters is that most of sampled water sources were in normal range of quality for drinking water as recommended by standards. In terms of turbidity, the most sources were slightly in higher ranges compared to standards. The sampled rainwater captured in tanks and temporary rivers were the ones with high levels of turbidity. Comparing wet and dry seasons, you find that water quality during wet season was better that dry season. Especially for non-treated water sources, like rainwater harvesting, rivers and lakes. For pH, the general view is that the water was slightly acidic. For conductivity, the level was high in certain sources and in normal range for others. Certain sources were sampled in wet season only. These are temporary rivers that are Susa in Kinigi sector and Rwebeya in Nyange Sector.

The chemical parameters of water sources around PNV were compared with the standard specifications by the Rwanda Standardisation Board (RSB). In general, the quality of water during rainy season is better that water quality in dry season. In parameters analysed, aluminium content proved to be very low. The quality of water in terms of chemical parameters is influenced by the type of source. The hardness for example is high for water sources from rainwater harvesting and unprotected water sources. It is also influenced by the level of calcium and magnesium. High level of these elements is not very dangerous to the consumers but they are a problem since they influence water hardness. Concerning nitrates and phosphates, the level was in normal ranges except for Kagano source, which had higher than average level of phosphates.

There was a high presence of faecal coliforms and *E. coli* especially in unprotected water sources. This is an indication of poor sanitation among the communities around PNV and makes the water sources unfit for human and livestock consumption.

DR Congo

The different water sources sampled showed that the water pH varied between 5.8 and 7.10. The pH is slightly acidic but within the WHO standards (6.5 to 8.5). The Indata source has an acidic pH compared to other sources. The water temperature varies between 16 and 20°C. The conductivity is high only in the Indata River and source (675 and 673 µS/Cm). The conductivity of a natural water ranges from 50 to 1500 µS/Cm. The waters sampled of the region have conductivities between that ranges. This conductivity indicates the presence of dissolved ions in the water. The high conductivity in the river and Indata source would be probably due to the nature of the mother rock from where the water comes. The waters sampled in this region are well oxygenated with variation rate of dissolved oxygen varying between 5.42 to 7.78 mg / L. The concentrations of the other parameters like alkalinity (23-114 mg / L), sulphate (121-140 mg / L), chloride (0-49 mg / L), Hardness (5.19 to 11.09°F), calcium hardness (3.4 to 9.6°F) and magnesium hardness (0.3 to 1.79 ° F) are within the WHO standards. The biochemical oxygen demand (BOD5) in the two rivers is low. This shows that the bacteria to decompose partially or completely oxidize the biochemical oxidizable materials in the water are relatively few. The chemical oxygen demand (COD) varies between 17.6 and 34.4 mg / L. The concentration of total nitrogen, ammonium, nitrate, phosphate and total phosphorus are low in all samples. As far as physico-chemical is concerned, the waters of the study area have concentrations values low than the WHO standards. But the bacteriological point of view, the Idanta River and the Rwembwe source are contaminated with faecal coliform specifically *Escherichia coli* at a high rate (50,000 col/µL for Idanta River and 32,400 col/µL for Rwembwe source)

Water risks

Uganda

Parishes surrounding Echuya landscape were evaluated for soil erosion risk, considering tolerance limits (3 to 11 t/ha/yr) that define the maximum acceptable level of soil loss from an area (Mhangara *et al.*, 2011; El-Swaify *et al.,* 1982). Percentages of the areas affected by soil erosion per parish were computed for the Echuya landscape and the outputs are shown in Figures 1 and 2. From the two figures, Kagezi parish with an area of $24km^2$ (about 20.8%) of the area, Chibumba parish with an area of $16km^2$ (about 18.8%), Muhindura parish with an area of $22km^2$ (13.6% of the area) and Karengyere parish with an area of 16 km^2 (12.5% of the area) all experience soil erosion above the acceptable tolerance limit. The above values however, indicate moderate levels of soil loss in the landscape. For Ikamiro, Kacherere, Kashasha and Kishanje the soil loss was below the tolerance limits. This might be due to lower elevations and slope steepness, and compact soils (with clay particles) than in the other parishes. Furthermore, this might also suggest that the local communities around these parishes may be practicing soil conservation practices such as agroforestry and the establishment of woodlots in the landscape.

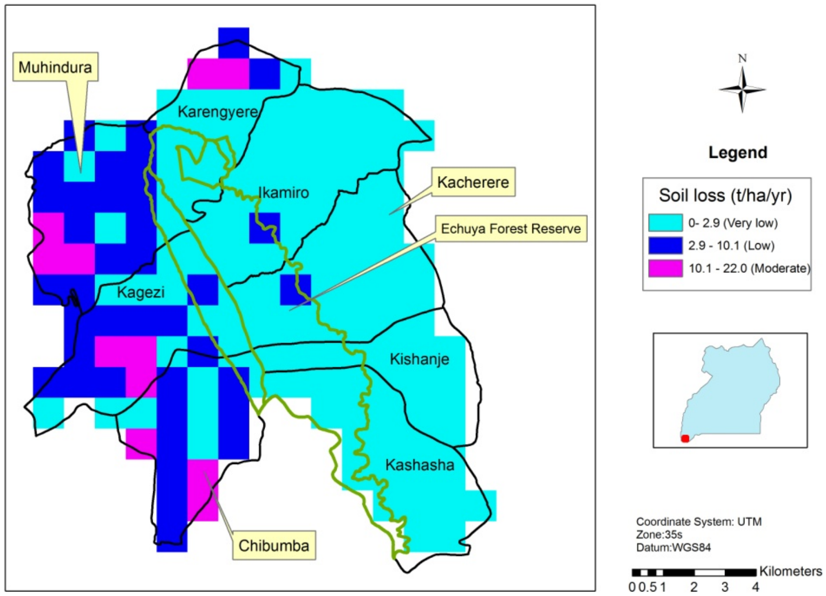


Figure 1. Soil erosion map for Echuya Central Forest Reserve landscape, Uganda, by parish

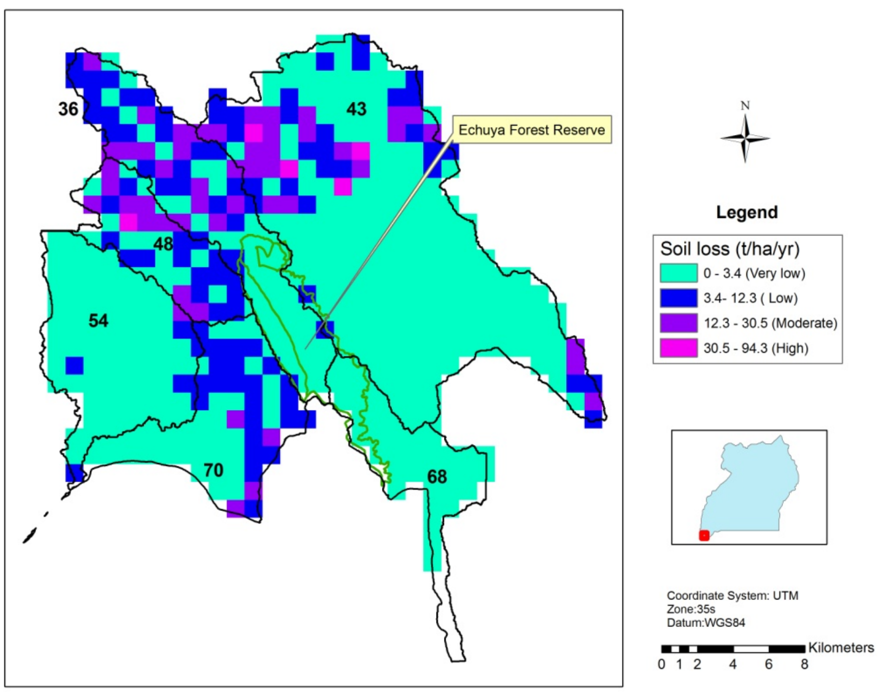


Figure 2. Soil erosion map for Echuya Central Forest Reserve landscape, Uganda, by watershed

For Mgahinga area, the model output suggests that the landscape experiences high proportions of soil loss inside the park and most especially in Rukongi and Gisozi parishes that were above the set tolerance limits (3 to 11 t/ha/yr). This could be due to the high slope (>30) in the area and less vegetation cover type. For Gitenderi parish soil loss is within set tolerance limit levels (Figures 3 and 4). For all the parishes, areas outside the park, soil loss is at low levels than in the park perhaps contributed by the fact that areas outside the Mgahinga National Parks are at lower elevations than those in the parks and this affects the slopes and elevations used to model the flood hazard areas output.

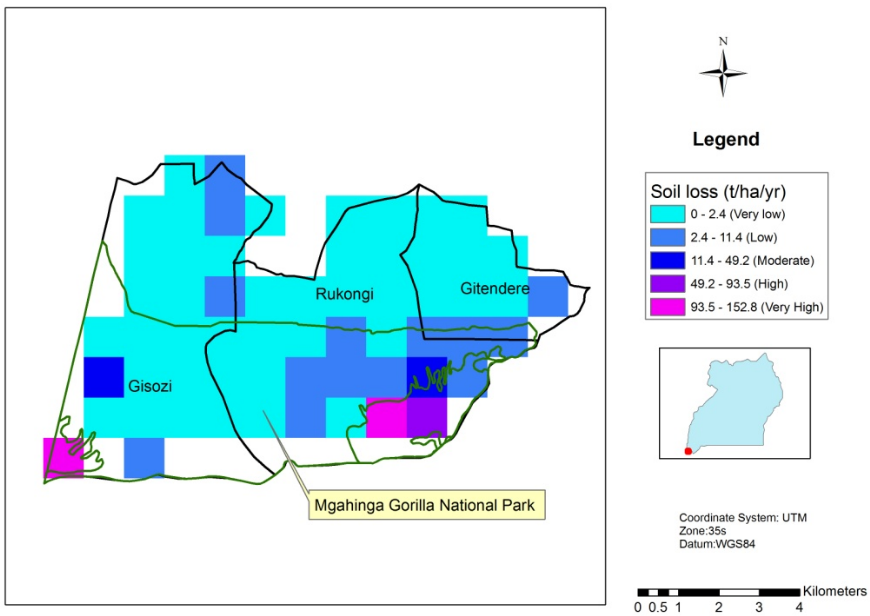


Figure 3. Soil erosion map Mgahinga Gorilla National Park Landscape, Uganda, by parish

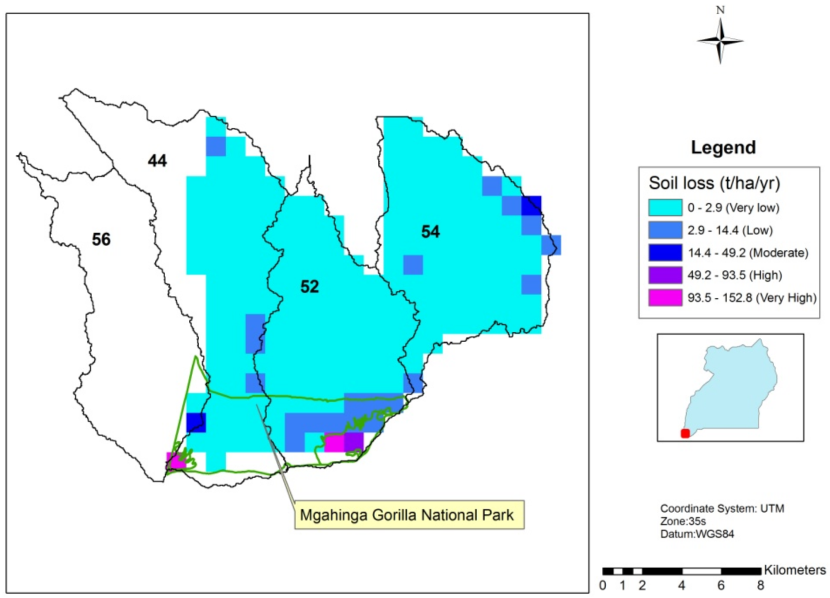


Figure 4. Soil erosion map Mgahinga Gorilla National Park Landscape, by watershed

Model parameterization could be improved in future by mapping the different soil conservation practices being applied in the study area, using a detailed land cover map and having more weather stations to allow for interpolation of precipitation data in the study area.

The models highlight the level of runoff and soil erosion around Echuya and Mgahinga landscapes. It is noticeable that the low levels of water runoff/soil erosion are closely linked to the boundaries of Echuya forest reserve and that the high levels of runoff in the Mgahinga landscape start within the park. This could be due the differences in vegetation structure and the rate of change in elevation in the two landscapes. Flooding is less likely around the Echuya landscape since a significant portion of rainfall is absorbed in the forest ground floor and is slowly discharged to streams/rivers that reduce the amount of runoff into streams and rivers during a storm event.

For the parishes in which soil erosion was predicted to be above the acceptable tolerance limits, soil conservation practices that are economically viable can be encouraged.

The field surveys about the water sources accessed by the different communities in the two landscapes indicates that the people living around the Echuya landscape have a wide variety of water sources compared to the communities living around the Mgahinga landscape. The runoff suggests that the rate of groundwater recharge in the landscapes might be linked to the severity of surface runoff, which could be impacting on the number of water sources available to the communities in the two landscapes.

Rwanda

Identification of flood prone areas can lead to better understanding of disaster risk and putting in place measures for risk reduction. Consequently, as Rwanda is prone to a wide range of natural hazards, especially in the three sub-catchments surrounding PNV. Adequate information is essential for effective disaster risk management. This study addressed the flood proness in Sebeya and Mukungwa basins. As the available DEM was with low resolution of 30.0, the effluents of both Sebeya and Mukungwa rivers were not modelled. The finding results gave the overall information on flood prone areas in the three sub-catchments by analysing and interpreting the river behaviours when both Sebeya and Mukungwa, and their effluents cannot carry away all the extra water that falls as rain. The water rises in the rivers and streams and overflows onto normally dry land. Floods destroy farmland, wash away people's houses and drown people and animals. Those floods result from heavy rains from the PNV, the Crest Congo-Nile as presented before in rainfall maps and overexploitation of lands by rapid urbanization (population pressure) and agricultural activities in the three sub-catchments.

The results revealed that some areas of the North-Western part of Rwanda are highly prone to floods and landslides, namely Nyamyumba, Rugerero, Rubavu, Nyundo and Kanama in Rubavu District; Bigogwe,Jenda, Mukamira, Karago and Kabatwa in Nyabihu District; Kinigi, Shingiro, Gataraga, Kimonyi,Gacaca,Rwaza and Muko in Musanze District; and Cyanika, Rugarama and Gahunga in Burera District. This is aggravated by some triggering factors such as steep slopes, soil instability, heavy rains, low level of drainage system, land-use type, land tenure type and others. Intensity and frequency of disaster events vary from region to sector to sector.

Because of low resolution of the map and length of Mukungwa River, the map in figure 5 presents a portion of MukungwaRiver. The complete map can be found in the GIS database. In addition to this, effluents of Sebeya and Mukungwa River were not modelled due to DEM 30.0 with a low resolution but affected areas have been identified with multi-criteria, such us elevation and slope maps, land cover and soil maps and rainfall map. This should deeply be studied using high resolution DEM (DEM10.0).

Finally, flood prone areas have been identified and made societies to be vulnerable at various degrees. This should be manageable at the catchment level by education and strengthening awareness of land cover restoration and river bank protection. From this statement, a policy of developing such awareness and putting it into application by escaping people to live in very critical zones, such us houses in the areas characterized by steep slopes and swamp areas and afforestation of critical terrain sensitive to erosion are needed.

DR Congo

About 80% of the study area is experiencing very low to low soil loss. Sixteen percent of the area is experiencing moderate soil loss, about 0.8 % of it is experiencing high soil loss. Only 0.1% of the study area is experiencing very high soil loss.

Soil erosion class "Very Low" followed by low dominantly covers Rutshuru. Patches of moderate to high soil loss rate occupy small area. Areas of Low soil erosion class, and a quasi-similar area of "Very Low" and "Moderate" soil loss rate dominantly cover Birambize. Patches of High and Very high soil loss rate exist. Rwanguba is dominated by area of moderate soil loss, followed by "Low" class. Patches of very low soil loss only represent about 5.7% of the total area. There are no patches of Very High soil erosion rate, but those of high soil loss rate covers about 1.74% of the total area.

Figure 5. Flood prone areas in Sebeya and Mukungwa sub-catchments, Volcanoes National Park, Rwanda

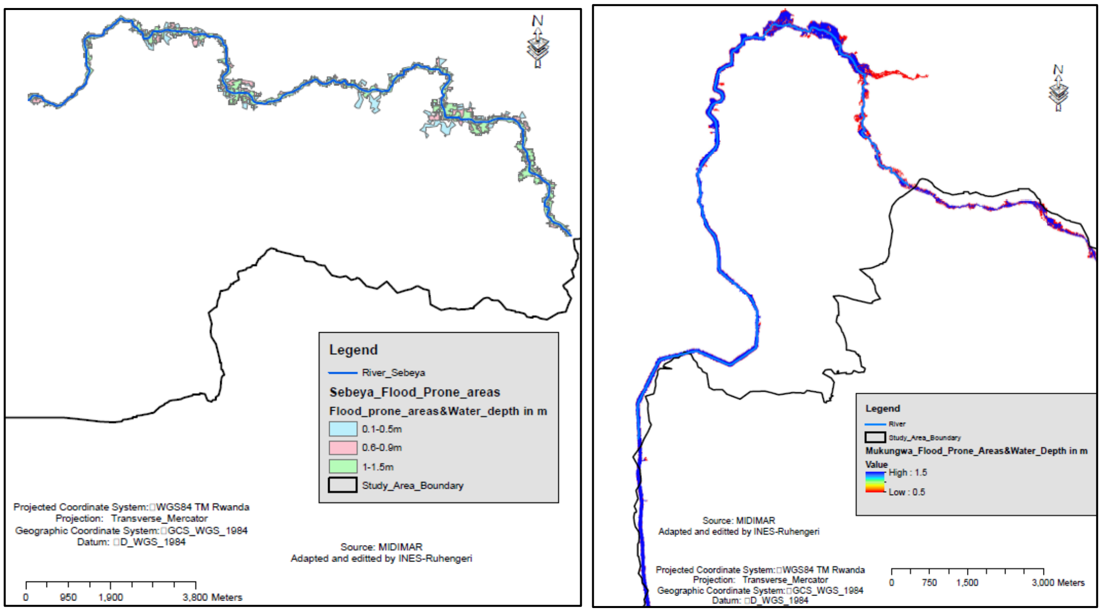
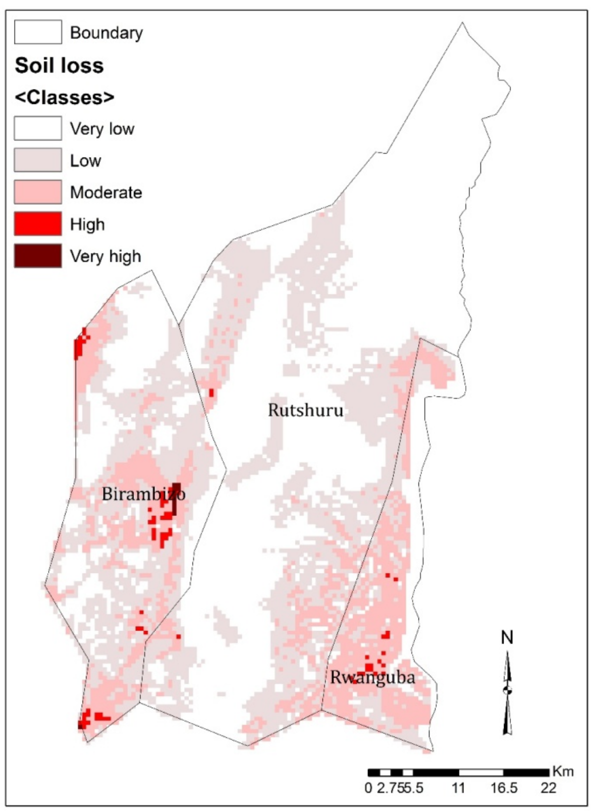


Figure 6. Soil erosion map Virunga National Park Landscape, DR Congo, by watershed



Conclusion

Water demand far outstrips the water supply in the GVL. Therefore, the local communities do not have enough water for the domestic chores. It becomes worst when there is more demand for water for livestock and crops. The water sources are few and unevenly distributed making people move long distances in search of water. This leads to people use unprotected water sources, some located within the protected areas, and whose water quality is often very poor. Sometimes they share water sources with livestock. In areas where the water sources are very few and/or highly seasonal, governments and other organizations have tried to alleviate the problem by putting in place gravity water schemes and rain water harvesting tanks. Still the water is not enough so that it has to be rationed so that each household at least gets some water, especially for domestic use. The rationing is made worst by the dry seasons that occur in the landscape. This leads people to search for more water from unprotected sources that is of poor quality and is often contaminated by faecal material because of poor sanitation within the communities. There is need to invest in rain harvesting technologies since the landscape receives high amounts of rainfall (twice a year) and the water harvesting technologies can be installed at a household and community level and are easy to maintain. There is a high risk of erosion because of the high rainfall and steep slopes within the forests and poor farming methods outside the forests. This makes rivers and swamps contaminated and silted making them unfit as sources of water for human use. There is an urgent need for soil and water conservation to be implemented to lessen the risk of erosion especially on community land outside the protected areas.

Study limitations

1. Some permanent water sources outside the study area were not assessed but are still used by the local communities in the study area especially when the dry seasons are severe;
2. Heavy metal assessment is still ongoing because of late arrival of laboratory equipment;
3. Flooding/soil erosion risk model parameterization could be improved in future by mapping the different soil conservation practices being applied in the study area, using a detailed land cover map and having more weather stations for interpolation of precipitation data in the study area.

Key action points

Uganda

Action1: Establishment of community rainwater harvesting facilities in Kalengyere parish and extension of these facilities in Mgahinga parishes. In Mgahinga priority should be given to Gitendere parish.

Action 2: Initiate and enforce water source protection at all established water facilities such as gravity flow schemes and protected springs. In addition, overall catchment protection should be promoted in all parishes to maintain water quality and quantity.

Action 3: Establish riparian vegetation buffers to protect running water sources such as stream and rivers. This would result in improved water quality and quantity in these sources.

The forests of Echuya and Mgahinga are important water towers providing communities downstream with the valuable water resource. Echuya forest parishes had the most abundant freshwater sources serving the communities downstream. However, the quality of water originating from Echuya is of low quality because of the rampant human activities such as grazing and watering animals inside the forest. These activities need to be halted if the quality of water originating from the forest is to be improved.

Action 4: Liaise with National Forestry management to halt illegal activities especially around water sources. This will go a long way in improving water quality of receiving downstream communities.

On the other hand, the quality of water of sources located inside Mgahinga such as Kabiranyuma swamp and the seasonal Ntebeeko stream were of good quality (high transparency and low turbidity and low *E. coli* counts). Because of the scarcity of water sources around Mgahinga, emphasis needs to be put on rainwater harvesting facilities such as tanks and reservoirs that are big enough so as to continue supplying water even during the dry season.

The most clean water sources around Echuya forest were protected springs and gravity flow schemes with very high transparency and low turbidity. However, these water sources had little or no protection observed onsite. The sites need protection in such as the establishment vegetation buffers around them to avoid polluting the ground water sources. The most polluted water sources were streams and rivers draining agricultural landscapes. These had high turbidity levels and high faecal contamination. In order to improve the quality of water in these landscapes, communities need to engage in watershed management practices such as soil and water conservation to limit the amount of pollutants reaching the water-ways. In addition, sanitation and health education of the communities need to be strengthened and encourage them to used latrines and thus reduce faecal contamination of the water sources.

Action 5: promote soil and water conservation measures such as tree planting and other agroforestry practices especially in areas prone to erosion and landslides.

Action 6: Work with health and local authorities to sensitize communities on health and sanitation targeting the use of pit latrines to prevent fecal contamination of water sources.

The communities around the protected area systems need to be sensitized about the link between water resources and the protection of watersheds and how this influences livelihoods and human health. Incentives need to be given to communities that conserve watersheds and provide clean water to downstream communities. The incentives may be in form of market-based approaches to conservation such payment for water services.

Rwanda

Action 1: Construction of water tanks, and construction of rain harvesting water tanks on public entities especially in cells closed to the PNV in sectors of Bubeshi, Kabatwa and Jenda

Action 2: Rehabilitation of existing water taps and constructing new ones in regions where they are not available: Gataraga, Shingiro and the cells of Kinigi closed to the PNV

Action 3: Commissioning and training of the population in the region on water cleaning and water sanitation: Chlorination, filtration, boiling, SODIS, etc. the most concerned sectors are Bugeshi, Kabatwa, Bigogwe and Jenda where they are using inadequate rainwater harvesting technologies

Action 4: Relocate people living in flood prone areas, especially in the Sebeya river basin.

Action 5: Introduction of improved water drainage systems in cropland areas in Mukungwa and Sebeya river basins especially in Nyundo, Rugerero and Kanama in Rubavu district; Muko, Muhoza, Gacaca, Rwaza, Remera and Gashaki in Musanze District; and Kivuruga in Gakenke District.

Action 6: Put in place measures for river protection for both Mukungwa and Sebeya rivers and land cover restoration where steep slopes are sensitive to land degradation: anti-erosive planting, infiltration ditches, riverbank protection, rainwater retention in rural and urban settlements, etc. The most concerned sectors are those closed to the PNV and Congo-Nile Crest.

Action 7: Capacity building in water resources and environmental management especially for researchers involved in the water related field. Focus should be put on meteorological data collection and database creation, water resources modelling using GIS tools, information dissemination to beneficiaries and stakeholders.

DR Congo

Action 1: Initiate and enforce water source protection at all established water facilities such as gravity flow schemes and protected springs. In addition, overall catchment protection should be promoted to maintain water quality and quantity.

Action 2: Promote soil and water conservation measures such as tree planting and other agroforestry practices especially in areas prone to erosion and landslides.

Action 3: Work with health and local authorities to sensitize communities on health and sanitation targeting the use of pit latrines to prevent fecal contamination of water sources.

Action 4: Facilitate water access by building gravity water outlets, clothe washing, bath and toilet facilities

Appendices (all document)