Farmers Perceptions on soil erosion in Sebeya catchment, Rwanda

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Abstract

Soil erosion is one of the major causes of land degradation which result in low agriculture productivity. Especially, western part of Rwanda including Sebeya catchment has high susceptibility to erosion leading to huge amounts of soil loss. This study held to explore the actual status of soil erosion in Sebeya catchment. Global Information System data were used for catchment delineation. Qualitative and quantitative data were collected and analyzed. Specifically, 75 farmers living and having farm lands in the catchment were interviewed in terms of knowledge on soil erosion, causes and control measures. The results showed that streambank erosion is due to the erosive power of runoff from uplands areas with (18.7%). The main natural causes of soil erosion in Sebeya catchment are heavy rainfall (69.33%) and the slope steepness (28%). Public and private land conservation agencies should be more involved in soil management centred on farmer's awareness and capacity building.

***Key words**: Sebeya catchment, soil erosion control, farmers' views, Rwanda*

1. Introduction

Environmental deterioration associated to soil erosion is one of the most serious threats in developing countries (Pravat et al., 2015). In Rwanda, 80% of economy is mostly based on agriculture while lands are degrading at an alarming rate due to high conversion of land to agriculture land use (Munyaneza et al., 2016); the agricultural activities being the most commonly known to accelerate soil erosion.

Generally, the high vulnerability to soil erosion in Rwanda is due to various factors such as abundant rainfall, hilly and mountainous relief, demographic pressure and agricultural expansion on steep slope terrain (Karamage et al., 2016; IWRM, 2018; MoE, 2018). In fact, the catchment topography varies between 1462 to 2902 m a.b.s.l (meters above sea level) with rainfall distribution ranging from 1200 mm to 1700 mm (IWRM, 2018; BirdLife, 2018). Green agriculture and improved mining are promoted and supported through different practices, but there are still several cases of unsustainable mining and agriculture leading to high accelerated erosion and terrible river sedimentation in this catchment during heavy rainfall (IWRM, 2018).

A recent study by the Rwanda Ministry of Environment has shown a very high risk of erosion in the north western Rwanda, covering areas of Sebeya catchment (MoE, 2018). Soil erosion increases the amount of sediments transported in Sebeya river. The eroded sand materials cause abrasion in hydro turbines and lead to change in flow pattern, losses in efficiency, vibrations and even final breakdown of turbine components (Munyaneza et al., 2015, Thapa et al., 2017) while high sediments load imposes high turbidity and high cost of coagulants to Gihira water treatment plant. At Sebeya outlet, nutrients lost from agriculture and high turbidity reduce significantly the aesthetic quality of Lake Kivu, having a harmful impact on recreation and tourism.

Therefore, it is imperative to prevent soil loss from agricultural land and consequently reduce the amount of sediment load in Sebeya river. This research held to explore the actual status of soil erosion in Sebeya catchment by investigating its causes and factors affecting it and by assessing the existing soil erosion control measures for their improvement. All data presented in this paper were primary collected by conducting interviews to the local farmers and site visits in the catchment.

2. Methodology

2.1 Study area

The study area of this research is focused on Sebeya catchment located in the western province of Rwanda and shared by four administrative units namely Rubavu, Nyabihu, Rutsiro and Ngororero Districts (Figure 1).

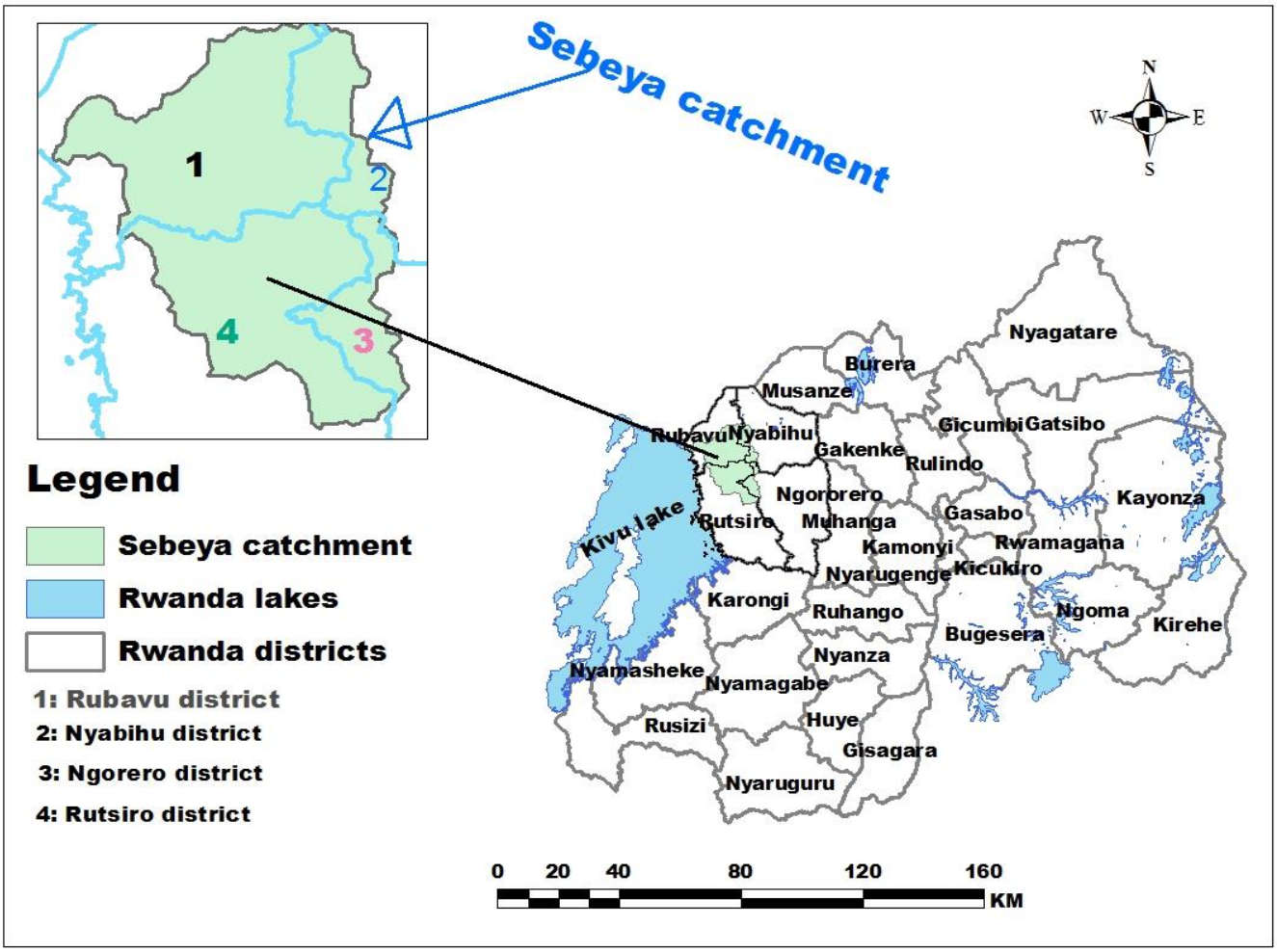

Figure 1. Sebeya catchment location

Sebeya catchment is part of the Congo-Kivu catchment in the upper part of the Congo basin. It is one of the larger of many small catchments that drain the western slopes of the Nile Congo watershed in the western part of Rwanda (BirdLife, 2018). The total surface area of Sebeya catchment represents 1.38 % of the total surface area of Rwanda (26,338 km² including water bodies), which totalizes 363.1 km². The population density in Sebeya catchment is 644 hab/km^2 while the average population density of Rwanda is about 415 hab/km^2. The soil in this catchment favors agriculture due to its high infiltration rates and its high minerals content. Located in the high elevation region of the country with altitude varying between 1,462 m to 2,979 m a.b.s.l. (meters above sea level), this catchment is also characterised by steep slopes and abundant rainfall varying between 1,200 mm to 1,700 mm per year (IWRM, 2018).

2.2 Data collection

Literature review, site visits, questionnaire and interviews were used to get sufficient information on the actual status of soil erosion and its control measures in Sebeya catchment. DEM data have been collected from the Center of Geographical Information System (CGIS Rwanda) for delineation of Sebeya catchment.

During the study period, different site visits were frequently conducted to get primary data through informal and structural interviews on main cultivated crops and agriculture practices, main features of Sebeya river, site topography, hydrographic network, soil characteristics and about the existing soil erosion control measures in Sebeya catchment.

The figure 1 shows that Sebeya catchment extends on many sectors of 4 Districts while the table 1 below shows that the overlapped area between Rubavu and Sebeya catchment is the largest and equal to 44.6%. The next largest overlapped area comes to be 41.3% between Rutsiro and Sebeya catchment.

Table 1. Overlap between Districts and Sebeya catchment (RNRA, 2012)

Catchment		**Area of each District**		**Overlap between District & Catchment**		
Name	**Area km²**	**District**	**Area km²**	**Area km²**	**% Catchment**	**% District**
Sebeya	**363**	Ngororero	679	37	11%	5%
catchment		Rutsiro	1,157	139	41.3%	12%
		Nyabihu	532	38	11.3%	7%
		Rubavu	388	150	44.6%	39%
		Total		**363**	**100%**	

Following to this fact, the sampled sectors for farmers' interview in Sebeya catchment have been limited to these 2 Districts of large overlapped areas. The table 2 below shows the sampled sectors and the number of farmers interviewed in each sector.

Table 2. Selection of sectors for farmers interview in Sebeya catchment

SN	District	Sector	Number of interviewees
1	**Rubavu**	Gisenyi	12
2		Rugerero	14
3		Nyundo	15
4		Nyakiriba	4
5		Kanama	15
6	**Rutsiro**	Nyabirasi	15
TOTAL			75

Questionnaire is one of the methods used to find information related to this study. On the site, structured interviews were conducted to get constructive views from 75 farmers on the current status of soil erosion rates and the implementation of its control measures in Sebeya catchment.

3. Results and discussions

3.1 Identification of respondents

Among the farmers surveyed, 54.67% were men while 45.33% were female with ages ranging from 18 to above 55 years old. However, some researchers agree with large numbers of men in farmers interviews (Pravat et al., 2015; Senkoro, 2010). A large number of farmers were found in the age range of 31-40 years old because they are more stressed to fulfill their family needs such as food security and school fees for their children. Again, 81.33% of the interviewed farmers are married. Comparatively, the number of farmers in the range from 18 to 25 ages were very small because they are still at school and some of them are not interested in farming activities after completion of their secondary studies.

3.2 Socio-economic issues of farmers

This research found that the main cultivated crops in Sebeya catchment are groundnuts, bananas, coffee and tea, beans, maize, cassava, potatoes, rice and vegetables like eggplant & cabbage (MINAGRI, 2010; NISR, 2015). The results from this interview showed that several farmers are engaged in farming for agriculture business (40%), lack of other jobs (37.33%) and food security (22.67%). The main challenge of farmers in Sebeya catchment is to struggle in fulfilling their basic needs such as food, health care, school fees, clothes, domestic water, etc

3.3 Farmers knowledge about soil erosion and types of soil erosion in catchment

Soil erosion is considered to be severe when visible signs such as rills and gullies appear on the field. Various soil erosion signs given in the table 3 indicate that soil erosion in Sebeya catchment is well known by about 80.67% of farmers. Similarly, the research conducted in central highlands of Ethiopia shows that 72% of the farmers reported high rated erosion requiring soil conservation measures to be erected (Aklilu & De Graff, 2004).

Table 3. Various signs of soil erosion in Sebeya catchment

SN	Erosion sign	Number of respondents	Percentage (%)
1	Damaging Flood with mud flow	5	6.67
2	Channels formation in the fields	14	18.67
3	Soil detachment by rain and runoff	24	32.00
4	Soil detachment, transport and deposition of soil materials	12	16.00
5	Landslides	15	20.00
6	Floods: High runoff which overtops channels and can damage agriculture crops, lives and properties	5	6.67
7	Wind erosion: Soil detachment, transport and deposition by wind	0	0.00
Total		75	100.00

The majority of farmers argued that soil erosion appears in the form of gully, rill, steam bank and sheet erosion as shown in the table 4. The results are supported by Misebo in 2018 who reported that sheet and rill erosion are considered as the most common types on cultivated hillsides in Rwanda. Both sheet and rill erosion considerably damage the croplands and reduce the productivity while the break in vegetation cover provides gully erosion to start. For Sebeya river, streambanks erosion is due to the erosive power of runoff from uplands areas.

Table 4. Types of soil erosion in Sebeya catchment

SN	Type	Number	%
1	Sheet erosion (or interrill erosion)	14	18.7
2	Rill erosion	15	20.0
3	Gully erosion	32	42.7
4	Streambank erosion	14	18.7
Total		75	100.0

3.4 Causes of erosion in Sebeya catchment

3.4.1 Natural causes of soil erosion

The table 5 shows that the main natural cause of soil erosion is heavy rainfall which generate high runoff. The results are not far from that reported by (Clay & Lewis, 1990) who stated that a combination of a hilly landscape, extensive land use, and intensive rainy seasons leads to high erosion risk in Rwanda. (Yang et al., 2003) confirmed that heavy rainfall is the cause of enhanced erosion on hillside lands.

Table 5. Natural causes of soil erosion

SN	Cause	Number	%
1	Slope of the terrain	21	28
2	Rainfall and runoff causing sometimes floods	36	48
3	Rainfall and runoff causing sometimes landslides	16	21.33
4	Earthquakes	1	1.33
5	High wind	1	1.33
Total		**75**	**100**

3.4.2 Anthropogenic activities causing soil disturbance

The anthropogenic activities causing soil disturbance in Sebeya catchment include mining, excavation for road and building construction, quarries for roads (lateritic soil and construction stones) and borrow pits for power transmission lines. For land use, soil erosion is caused mainly by agriculture, mining and roads construction sites.

3.4.3 Negative impact of farming practices in Sebeya catchment

The table 6 is reporting negative impact of farming practices as mentioned by farmers in Sebeya catchment with a very high percentage of deforestation for agriculture. IWRM in 2017, justified that the increase of deforestation in Sebeya catchment is due to insufficient land for cultivation and settlement.

Table 6. Negative impact of farming practices in Sebeya catchment

SN	Impact	Number of respondents	Percentage (%)
1	Deforestation for land agriculture	31	41.33
2	Soil disturbance by agriculture machinery	2	2.67
3	Soil disturbance by agriculture terracing	2	2.67
4	Soil disturbance by tea plantations channels	4	5.33
5	Remove of vegetative cover (overgrazing)	3	4.00
6	Land becomes harden due to pasture	3	4.00
7	Remove of soil due to soil erosion on agriculture land	14	18.67
8	Water pollution (turbidity) due to erosion from agriculture fields	10	13.33
9	Others	6	8.00
Total		**75**	**100.00**

3.4.4 Steps taken to make farming more environmentally friendly

According to farmers in Sebeya catchment, steps taken to make farming more environmentally friendly are shown in table 7. For more environmentally friendly, most of farmers in Sebeya catchment voted for cultivation of slope stabilization grasses to avoid soil erosion during the rainy season and they are cutting illegally trees due to lack of land for agriculture. Deforestation

is primarily a concern for the developing countries of the tropics as it reduces the areas of tropical forest and exposing the land to soil hazards and loss of biodiversity (Angelsen, 1999).

Table 7. Strategies to make farming more environmentally friendly in Sebeya catchment

SN	Step	Number	Percentage (%)
1	Avoiding to cut trees illegal	8	10.67
2	Avoiding to burn grasses	5	6.67
3	Avoiding tillage cultivation	6	8.00
4	Use of recommended chemicals for soil fertilization	6	8.00
5	Cultivation of recommended crops	6	8.00
6	Cultivation of slope stabilization grasses	31	41.33
7	Cultivation on recommended area	8	10.67
8	Others	5	6.67
	Total	**75**	**100.00**

3.5 Effects of soil erosion in Sebeya catchment

The table 8 lists various effects of soil erosion in Sebeya catchment. It is shown that during rainy season, floods and landslides may cause damages of buildings, loss of human lives and domestic animals. Soil erosion changes fertility status of the soil by removing top soils which is rich in nutrients and organic matter. Soil undergoes compaction and reduce aeration, permeability and hence changes physical, chemical and biological properties of the soil. These findings are in agreement with (Mwakubo et al., 2004) who reported that 3mm top soil are lost due to soil erosion each year. Soil erosion is the major cause of land degradation with large decrease of soil productivity.

Table 8. Effects of soil erosion in Sebeya catchment

SN	Damages	Number	Percentage (%)
1	Crops removed with landslides	13	17.33
2	Crops covered by soil erosion materials	7	9.33
3	Crops roots exposed up due to erosion	2	2.67
4	Soil loss due to landslides	6	8.00
5	Agriculture soil and nutrient losses	3	4.00
6	Loss of human lives	8	10.67
7	Loss of domestic animals	7	9.333
8	Buildings	14	18.67
9	High concentration of sediments at Keya and Gisenyi HEPPs	1	1.33
10	Silting up of waterways	1	1.33
11	Deposit of erosion materials in roads	2	2.67
12	Gullies formation on the side of a road	2	2.67
13	Cutoff road access due to progressive gullies	3	4.00
14	Abrasion of bridges piers by various types of sediment	6	8.00
	Total	**75**	**100**

3.6 Existing soil erosion control measures in Sebeya catchment

The interview results in table 9 indicate that among the 22 listed erosion control measures, about 4.57% of farmers confirmed their existence while 95.43% expressed the need of their implementation in Sebeya catchment. Also, it is reported that various soil erosion control measures including trees planting, agro-forestry and terraces have been applied to rehabilitate 1,373 hectares in Sebeya catchment (IWRM, 2017). This means that there is a need of improvement of soil conservation measures in Sebeya catchment. Soft BMPs are those measures that are implemented easily with low cost including: mulching, cover crops and vegetation, trees planting, protective grasses on river banks, no tillage method and buffer zones. Existing hard BMPs in Sebeya catchment are mainly terraces and anti-erosive ditches. Radical terraces and progressive terraces are still few; they were implemented to reduce the impact of topographic factor that influences soil erosion in this catchment (IWRM, 2016).

3.7 Improvement needed in implementing soil erosion control measures in Sebeya catchment

Adding the number of voices from farmers who need improvement and the number of voices which don't need improvement on the existing soil erosion measures, the following steps describe the computations in the table 9. Let's Xn be the percentage of farmers who need the implementation of a soil erosion remedial measure and Xp the percentage of farmers confirming the existence of a soil erosion control measure in Sebeya catchment. Then Xn-Xp = NG is the Needed Gap. As a result, IN will be Improvement Needed if NG>0 while INN will be Improvement Not Needed if NG≤0. The data in the table 3 revealed that the Needed Gap (NG) values for all the 22 items of 6 categories ranged from 4.76 up to 2.86 and were all positive. This indicated that farmers needed improvement in all the 22 cultural practices in soil erosion prevention and control in Sebeya catchment. The results of the study showed that farmers of Sebeya catchment need improvement on various BMPs of erosion control (in agricultural fields, for slope and river bank stabilization, for sediments control and in reducing the velocity and volume of Sebeya river and its tributaries).

In absence of BMPs, soil erosion rates continue to increase. That's why improvement on soil erosion control will be always needed because reaching T-value (allowable soil loss tolerance rate) seems to be an idealization. A similar study in Nigeria revealed that farmers needed improvement in all the existing soil erosion control measures in Kogi state (Onu & Mohammed, 2014).

Table 9. Improvement needed in the implementation of BMPs in Sebeya catchment

SN	Measures category	BMP	Xn(%)	Xp(%)	(Xn - Xp)% = NG	Remark
1	**In agriculture field**	Mulching	4.13	0.63	3.49	IN
		Terraces	4.63	0.13	4.51	IN
		Anti-erosive ditches	4.76	0.00	4.76	IN
		Contour bunds	4.44	0.32	4.13	IN
2	**For slope stabilization**	Trees	4.76	0.00	4.76	IN
		Vetiver grass planting	4.19	0.57	3.62	IN
		Reed	4.63	0.13	4.51	IN
		Cetaria	4.76	0.00	4.76	IN
		Tripsacum	4.32	0.44	3.87	IN
		Paspalum	4.44	0.32	4.13	IN
		Grevillea	4.38	0.38	4.00	IN
		Use of gabions	4.57	0.19	4.38	IN
3	**For river banks stabilization**	Protective grasses	4.76	0.00	4.76	IN
		Stone revetment: use of riprap and gabions	4.76	0.00	4.76	IN
		Use of sand bags	4.76	0.00	4.76	IN
4	**BMPs of sediments control**	Sand trap	4.57	0.19	4.38	IN
		Sediment basin	4.36	0.18	4.18	IN
5	**BMPs to reduce the velocity of runoff**	Check Dam	4.70	0.06	4.63	IN
		Grass-lined channel	4.63	0.13	4.51	IN
		Stones blocks in a channel	3.81	0.95	2.86	IN
6	**BMPs to reduce the volume of runoff**	Hillside water pond	4.63	0.13	4.51	IN
		Roof runoff and cisterns	4.76	0.00	4.76	IN
TOTAL			95.43	4.57		

3.9 Existing constraints for implementation of soil erosion measures in Sebeya catchment

This study revealed that challenges faced in adopting soil protection measures are poverty which is in agreement with (Barbier, 1990) who reported that lack of money is the main factor limiting the adoption of soil water conservation (SWC) techniques in Java. (Bidogeza et al., 2007) reported that most of SWC techniques are costly and there are hence less adopted in Rwanda by poor resources farmers. Also, the Government should facilitate farmers access to microfinance credit.

The majority of farmers suggest trainings and mobilization of a specialized technical team to assist them in implementing soil conservation measures and to generalize the application of fertilizers in the whole Sebeya catchment. (Bizoza, 2011) confirmed that sharing knowledge

among farmers through trainings could enhance adoption of soil protection measures in Rwanda.

4. Conclusion and recommendations

This research was conducted to collect sufficient information required to analyze the situation of soil erosion in Sebeya catchment. Farmers reported high rated soil erosion with its negative impacts such as loss of buildings, loss of human lives and crop removed requiring implementation of soil erosion control measures. As remedial measures, farmers in Sebeya catchment have not yet implemented soil conservation measures in their fields. However, these investigations revealed that there are some efforts made in terms of soil erosion control.
Intended to assess the level of satisfaction by assessing the socio-economic issues, the interview revealed that several farmers are engaged in farming for food security, agriculture business or due to lack of other jobs.

The Government and NGOs should motivate farmers who are applying well the BMPs in their farming system, facilitate the access of farmers to microfinance credits and generalize the application of fertilizers with priority on farmer's trainings and mobilization of a specialized technical team to assist in implementation of soil erosion control measures in Sebeya catchment.

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