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MSc PROGRAM IN AGROFORESTRY AND SOIL MANAGEMENT

**ASSESSMENT OF SUSTAINABLE INTEGRATED WATERSHED MANAGEMENT
APPROACH CASE STUDY SEBEYA WATERSHED.**

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DECLARATION

I, **IRATUZI Jean Claude** do here by declare that this thesis titled “Assessment of Sustainable integrated watershed Management approach case study Sebeya Watershed ” is my own original work and that it has not been presented elsewhere for any academic award.

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Signature

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Date

ABBREVIATIONS

VUP: Vision Umurenge Program

LODA: Local Economic Development Agency

REMA: Rwanda Environmental Management Authority

MINALOC: Ministry of Local Government and Social Affairs

MINAGRI: Ministry of Agriculture and Animal Resources

CIP: Crop Intensification Program

RAB: Rwanda Agriculture Board

FAO: Food and Agriculture Organisation

UR: University of Rwanda

SHORT DEFINITIONS OF KINYARWANDA WORDS

Ubudehe: Self-help community participation

Girinka: “One cow per poor family”

ABSTRACT

Nowadays, integrated watershed management approach is key element for sustainable watershed management for achieving social , economic and environment aspect within watershed .The purpose of this research is to evaluate the sustainable integrated watershed management approach for the different activities implemented by Government of Rwanda for managing Sebeya watershed.

Ninety seven people were randomly selected from four district covered sebeya watershed NYABIHU,RUBAVU, RUTSIRO and NGORORERO , interview and Questionnaires methods were used for investigating the integrated watershed management approach , the Data was subjected in STATA software for analysis. The result show that 17.53% use water harvesting system while 82.47% they did not adopt, area occupied with bench terraces was 30.93% while 69.07% did not conserved with bench terraces, progressive terraces was occupy with 26.80% and 73.20% did not protected ,agroforestry was implemented at 68.04% while 31.96% remaining unprotected with agroforestry, sebeya River bank protection was at 77.32% while 22.68 % did not protected ,the improved cooking stoves was used at rate 8.3% while 91.7% use three stone open fire, the main cause of Sebeya degradation was illegal mining in upland at rate 98.97%, increasing in settlement at 79.35% and intensive agriculture at 69.07%, the participation of local people is at rate 20.62%. Integrated watershed approach is required for improving livelihood of peoples and Government must protect all catchment in Sebeya watershed.

Key word : Integrated , Watershed , Management approach

CHAPTER I: INTRODUCTION

1.1 Background

Natural resources are gradually pretty a controlling aspect intended for achieving the food needed of a rising world residents. Included concepts for handling usual resources in a maintainable and ecologically complete method show heartening effects, if used on a huge scale (Karpuzcu & Delipinar, 2014)

Natural assets in Rwanda are highly exploited due to overexploitation. SEBEYA watershed is faced with different issues such as illegal mining activities that aggregate siltation to SEBEYA streams; agriculture activities which affect negatively forestry that decrease the land cover; Overpopulation lead people to make intensive agriculture and livestock, lack of rainwater harvesting materials at households level and flooding which cause land degradation (MINIRENA, 2018).

Integrated watershed management approach is the process of conveying and realizing a progress of act including natural and anthropological resources in a watershed, by referring societal ,economic, administrative, and official factors functioning inside the watershed and the adjacent streams bowls plus other related areas for achieving particular social goals and is usually accepted as best action for enhancing water worth and ecosystem services by maintaining local economic feasibility(Karpuzcu & Delipinar, 2014).

The activities within watershed development is observed on biophysical , ecological and socio-economic factor (Merkinah.M.M., 2017).

The agriculture of the Sebeya Watershed based toughly on rain-fed farming , both for stable and export crop . tea and coffee is dominated in Sebeya watershed and horticulture by producing vegetables (REMA, 2018) .

The sandy mining activities in Sebeya river is very commercial action in region . Part of Gishwati National park located in Nyabihu District was converted into agricultural land and grazing area, the production of milk in Rwanda is observed in Nyabihu District . Sebeya watershed is targeted area for proper conservation as its outlet is Kivu lake and some of its catchment it attach on Volcano National park. Government of Rwanda have implemented

different strategies to overcome the problems such water harvesting system , agroforestry , terrace ,gabions , water ways but still now the flooding is observed in Sebeya dawn stream , this research highlight different sustainable practices for proper protection of sebeya watershed.(Water for Growth, 2017)

1.2 *Problem statement*

Recently integrated watershed management has been prioritized in developing country for solving problem of water pollution and soil deterioration unfortunately the implementation remain problematic due to different barriers and challenge along landscape(Mekonnen & Fekadu, 2015)

Highland landscape supply the nearby lowlands with water, over half of world population be governed nonstop on highland watersheds for water in to get food , for generating energy, engineering and home use (Fazli et al., 2016). Economic activities development applied on steep slopes lacking conservation without respect land suitability and capability as high population density that cause, land degradation, which affect biodiversity in lowland and reduce water quality lead to eutrophication of aquatic body (Mekonnen & Fekadu, 2015) . Rwanda, and other counter paying attention for founding different method for proper conservation of Natural resource as saving for future generation. (MINILAF, 2017). Sebeya watershed is located in four District of western province which are NYABIHU , RUBAVU, NGORORERO and RUBAVU and this watershed is characterized by flooding in lowland , land Degradation through land sliding, soil erosion, decline of soil fertility and water pollution due to high population pressure (REMA, 2018) . The main cause of pollution of surface water in SEBEYA include different activities done in upland sand mining , steep farming which lead to erosion , sedimentation from upland erosion , deforestation and lack of Rain water harvesting material. This issue affect, GIHIRA water treatment industry, as sediment affect functioning of turbines and different infrastructure in hydropower station. The sediment are increased during rainy season as result of high erosion and this effect GIHIRA water treatment industry , this increase cost of water as it requires capital for removing sediment. Impurity from Rutsiro mining site also increase the cost of water treatment industry. (MINIRENA.,2018)

Government of Rwanda have implemented different strategies to overcome the problems such Rain water harvesting system , agroforestry , terrace , water ways ,River bank protection, one cow per family ,afforestation and Gully protection but still now the issue of flooding is observed in Sebeya downstream (MAHOKO) , this research will assess the different strategies implemented for protecting SEBEYA Watershed and highlight different strategies needed to proper mitigation of flooding in SEBEYA watershed and proper sustainable watershed management practices.

1.3 Research Question

- ✓ Does all SEBEYA watershed protected ?
- ✓ To know if integrated watershed management approach have been integrated in all catchment?
- ✓ Which practices have been implemented for protecting Sebeya watershed ?
- ✓ To what extent local peoples have participate in Sebeya Watershed Management ?
- ✓ What are the main factor among Socioeconomic, Biophysical causes degradation of Sebeya watershed ?

1.4 Objectives

1.4.1. General objective

- To evaluate sustainable integrated watershed management approach in Sebeya Watershed

1.4.2 Specific objectives

- ❖ To evaluate socioeconomic, biophysical and institutional factors affect integrated watershed management in Sebeya.
- ❖ To assess community based participation in sebeya watershed management

- ❖ To ascertain sustainability implemented watershed management practices in Sebeya
- ❖ To determine different practices implemented in sebeya watershed for management
- ❖ To understand the main factor that cause degradation of Sebeya watershed

CHAPTER II: LITERATURE REVIEW

2.1. The Concept of Integrated Watershed Management (IWM)

Watershed is not only the hydrological element but include also economy, social and political components that shows vital title role offering food security and basic need in general (Wani & Garg, 2009).

Watersheds are disjointed by water ridges , integrated watershed management is a method of protecting , finest usage of the existing natural resources within watershed by conserving land and water for improving livelihood of local people(Mena, Madalcho, & Dana, 2017). Integrated watershed management require participation of different discipline and local people as decision makers in watershed. (FAO, 2004).

Fundamentally, the objectives of integrated watershed management is to increase agriculture productivity , climate change mitigation and proper conservation of natural resources .By balancing economic activities with their negative effect on environment this help decision maker to select the best economic activity which have less negative effect on environment (Wang et al., 2016).

The aim of integrated watershed management is incorporation of local people with their informal knowledge on watershed management ,local Skills, local materials for enhancing their capacity.

2.2. Effect of Deforestation in SEBEYA Watershed

The main cause of forest deterioration in Rwanda are: over exploitation of land with traditional agriculture for subsistence farming on small land and degraded land with decline of soil fertility due to erosion ,overcultivation and mining activities .Urbanization with increase of informal settlement , illegal mining and un restoration of mining area by plantation of agroforestry and forestry , and all 90% of Rwandan population depend on biomass energy especially from forestry product like charcoal, firewood with low extensionist agents (MINILAF, 2017).

Currently, the high population density cause deforestation and changing land use from forestry to agricultural land which is a serious environmental problem (VINCENT, 2014). Urbanization reduce soil caver which effect negatively infiltration rate, leading to lowland flooding, river bank erosion, with destruction of different infrastructure . (REMA, 2018)

Rwanda belong to the most densely populated country in East Africa respectively 471 people/km² and 59people per km².

1.6% of total land occupied by forestry was reduced annually in Rwanda as result of high population pressure which convert forest into agriculture land. Forest is main source of rainfall oxygen and reduce erosion by reducing rain drop speed and this cause water clean in stream and rivers.

Flora removal for agricultural purpose cause soil to be exposed on rain and sun which cause erosion and disturbance of soil biota. This affect land productivity by reducing soil fertility and removal high quantity of essential nutrient (Nitrogen, Phosphorus and Potassium) and recline of organic matter which lead to negative impact in lowland. (REMA, 2018).

2.3. Effect of Mining in SEBEYA Watershed

Mining is the removal of valued ore or physical ingredients from the ground, generally from an minerals form. Resources recovered by mining include bauxite, coal, copper, gold, silver,. Every tools that cannot produced by agricultural activities , or manufactured artificially in industry (Geelani et al., 2016).

Quarrying processes which require ore extraction from the underground must take a extraordinary effect on the Watershed . (Singh et al., 2010).

Main issue followed with mining activities are releasing different pollutants into surface waters, those pollutant contain toxic and non –toxic element . The rainfall cause the mobility of soluble pollutant into the water which flow in Sebeya River. And the pollutant is from different mineral toxic from mining site in upland it require more treatment (REMA, 2018).

Apart from surface water contamination Mining in Sebeya upland affect watershed in different factor like loss of soil fertility, siltation, sedimentation, ecological disruption , acidic drainage and ground water contamination.

2.4. Impact of SEBEYA River Bank Erosion

Riverbank erosion is the degradation of the coastal of a river. It happen when the upper soil that surrounds a river wash-downs away, River bank erosion is one of the natural degradation that lead migration of people near River.(Das, Haldar, Gupta, & Sen, 2014).

Impact of Sebeya river bank erosion affect different infrastructure around river such as agricultural land , house and infrastructure like schools, health center ,church , where many family are homeless due stream bank erosion that prompts people to migrate. After migration people suffer for hungry , lack of their job and loss of their assets which them to participate in illegal activities in RDC(MINIRENA ,2016).

2.5 The Causes of the Flooding in SEBEYA Watershed

The main cause of flooding are extremes precipitation, soil which have low infiltration capacity which cause runoff ended by flooding in lowland.

(Asumadu-Sarkodie, 2015).

The deterioration of different agriculture product and infrastructure by flooding have been increased over year due to change in land use change such as agriculture, urbanization due to increase in population density. Towns located in flat area are highly exposed to floods risk compared to rural as in town there is high economic activities.

It was observed SEBEYA watershed has high list of flooding due high anthropogenic activities in both upland and lowland even it's environmenta factors. SEBEYA watershed is belongs Nile crest Divide watershed which has high rainfall and land slide due to soft rock. With high rainfall intensity as means of (> 1200 mm). Environmental factors are difficult to handle as flood mitigation, as it accerelated by anthropogenic activities . among natural factor are fragile land which cause land slide. (Water for Growth, 2017).

Government of Rwanda participate in different practices for mitigating flood by making terraces in upland , plantation of agroforestry, Sebeya river bank protection and construction of protection wall around Sebeya River (REMA, 2018).



Picture show flooding in Bigogwe sector as catchment of Sebeya watershed

2.6. Important of integrated watershed management in sebeya watershed

Integrated watershed management (IWM) is the best way to stop soil deterioration. It combines protecting and restoring of both upland and lowland areas with the purpose of reducing the issue of runoff and floods, restoration of deteriorated soil, improve groundwater, by rising agriculture productivity and regeneration of vegetation cover.

2.7. DIFFERENCE STRATEGIES DONE TO RESTORE SEBEYA WATERSHED

Watersheds are multifaceted arrangements where water, soil, geology, flora, fauna and anthropogenic activities work together. As watershed degradation affects every element in the watershed. The benefit from the watershed must be shared with local, regional and global.

2.7.1 Landscape restoration in SEBEYA Watershed

Soil deterioration is explained as an alteration of soil condition status causing a reduced capability of the biota to offer different needs required by organisms. Soil rebuilding is to increase soil structure by keeping soil sponginess for root growing and soil biota activity, and to deliver a origin of organic substrate to retain water and nutrients for plant growth. Organic manure

, is the essential soil amendment material that improve soil structure by increasing soil holding capacity , water retention , infiltration rate and soil aeration . This reduces runoff by increasing soil porosity that effect positivly infiltration rate (Sample & Barlow, 2013).

Sebeya watershed need different practices fitted in each catchment for achieving good protected watershed in future . These measures include terraces (bench and progressive), agroforestry, afforestation , river banks protection ,Gully rehabilitation , and gullies rehabilitation. Reduction of soil erosion and increase of soil and water productivity to achieve this require to set landscape restoration according to Land capability and Suitability by using integrated approach(REMA, 2018).

2.7.2. *Bench terraces*

Land degradation due to water erosion can be observed on : soil depth, soil organic matter content and soil texture. A deteriorated soil have thin depth, little organic matter c and low clay fraction (Zuazo *etal.*, 2006). The criteria for installing of bench terraces are soil depth , slopes, soil texture and structure . The cbuilding of bench terraces require technical knowledge (Bizoza, 2012).

The main cause of pervert in developing country is reduction of agriculture productivity due to decline of soil fertility status. Bench terraces is one measure to handle the issue of land degradataion. (Pascal, 2014)

Bench terraces are poeticized in highland and Nile crest Divide agro ecological zone by Government of Rwanda for the purpose of achieving food security and erosion control by mitigating flooding

After making terraces in SEBEYA Watershed , application of lime , organic fertilizers, plantation of agroforestry trees (alnus acuminate) are needed for stabilizing terraces and soil fertility improvement(REMA, 2018).

2.7.3 *Agroforestry*

Agroforestry (AF) can be explained as land-use systems in which woody perennials (trees, shrubs, etc.) are grown in combination with herbaceous plants (crops, pastures) for getting multipurpose product. (Murthy, Dutta, Varghese, Joshi, & Kumar, 2016).

Matocha et al. (2012) explain the important of agroforestry system in different way, Multipurpose use where tree act as source of nutrient by fixing Nitrogen in Soil, organic matter amendment, crop shading, fruit production, fodder timber product, ornamental product, pest control, prevention of disease and climate change mitigation by carbon sequestration,

Agroforestry land use help in watershed management For pumping loosed nutrient by leaching like calcium, phosphorus and magnesium (Samra & Sikka, 1998).

Sebeya watershed is protected in upland by planting agroforestry (Ha) with different agroforestry like *alnus acuminata*, *Greveria robusta*,.....for the purpose of soil fertility improvement, climate change mitigation and improvement of livelihood (REMA, 2018)

2.7.4. *Afforestation and Reforestation in Sebeya watershed*

Viable forest controlling and restoration stay at Government priority for achieving 30% of land occupied by forest. Afforestation on new degraded land and reforestation of degraded forestry as woodlot.

65% of total land occupied by forest was decreased in Rwanda from 1960 until 1994, this was caused by increasing in population density and returnees of refugees (Dyszynski & Hogarth, 2011)

2.7.5. Rain house water harvesting

One of factor that limit agriculture is water and it is essential element required in environment. The main source of water is precipitation but inadequate and unpredictable precipitation regularly results in reduction of agriculture yield and loss of essential nutrient required by crops and animal. Runoff can be reduced by using rain water harvesting strategies. (Xiaoyan & Ruiling, 2002).

Referring the advantage of rain water harvesting as solving problem of water insecurity, as the crucial role of rain water harvesting , Government of Rwanda try to set policy ,regulation and different incentives for promoting Rain water harvesting in Rwanda.

(MINIMFRA ,2010). The methodology used is to promoting Rain water harvesting equipment at different building and will also start for Government buildings like school, health center ,different governmental institution for increasing water storage.

The Government policies promoting rain water harvesting system in different infrastructure constructed like roads, construction of different irrigation infrastructure for achieving water security goal in 2024.

The strategies for achieving water harvesting system is promoting different factor that affect positively infiltration rate and water recharge in watershed .

Water harvesting is strategies to reduce SEBEYA flooding by collecting rain water from different infrastructure like private and public infrastructure and House of people(REMA, 2018).

2.7.6. Improving cooking staves

The high demand of forestry product like fire wood , charcoal, timber due to high population density is major cause of deforestation .

Different part, countryside people depend only on forest product for getting energy used in cooking. One strategies to reduce rate of deforestation is promoting improved cooking stoves in Africa (Wallmo & Jacobson, 1998).

Climate change issue is associated with deforestation where rural people use more than 730 million of tones of biomass for getting energy to cook their food and this activity increase carbon dioxide in high quantity in atmosphere as green house gas that cause climate change and to handle this issue improved cooking stove is fundamental strategies.

(Akbar, Barnes, Eil, & Gnezditskaia, 2011)

In Rwanda like East Africa Country they initiated improved cook stove program with the purpose of combating forest degradation due to high population density and really majority of population have not accessed to up-to-date energy source and relied on using forestry product as their daily source of energy needs, government of Rwanda in partnerships with SNV give improved cooking stove in Sebeya watershed for deducing issue of deforestation (Water, 2012)

2.7.7. *One cow per Family (GIRINKA Program).*

Since 2006 H.E. Paul KAGAME initiated One cow per family the aim of alleviating poverty, malnutrition and food security. Until June 2016, at least 248,566 families received a cow (VINCENT, 2014)

The purpose of Girinka program was reducing poverty through increasing soil fertility and milk production and generating income to poor families (RAB, 2017).

Girinka program per poor family generate more products like, organic manure and this organic manure reduce cost of inorganic fertilizers, reduce soil erosion by improving infiltration rate.

2.7.8. *SEBEYA River bank protection*

Living fences, bamboo protect river properly by stabilizing river bank soil (SEPA, 2016).

The advantages of using living fences and bamboo compared to other this reduce the sediment from upland and increase soil stability by roots penetration around river.,

2.7.9 *Involvement of all stakeholders within the watershed in* Planning

The Integrated watershed management planning is process that bring linkages of benefit between the implementers, local peoples and all stakeholders by conserving environment , improving livelihood of citizens for achieving development of country (Muhinda, 2014)

Decision making for watershed management must integrate local people in planning , implementing and monitoring activities (Luyet, Schlaepfer, Parlange, & Buttler, 2012)

CHAPTER III: METHODOLOGY

3.1. *Site Description*

The Sebeya River originates in the mountains of Rutsiro District in three sectors which are Nyabirasi, Murunda and Ruhango. Its watershed includes 286 square kilometres of the districts of Rutsiro, Ngororero and Rubavu and Nyabihu. It flows past the mission of Nyungo, established in 1901 on the banks of the river about 12 kilometres upstream from Gisenyi (RUBAVU). Below Rubavu the river powers a hydroelectric system that provides electricity to the town of Gisenyi and to the local brewery (Mugisha, 2012). Sebeya has an area of 336.4 km² which corresponds to 1.4% of the surface of Rwanda (26,338 km²).

3.2. *Geology, Soil and Ecology of SEBEYA Watershed*

Northern part, is located in volcanic region, the watershed has many small streams with high slope and high weathered soil. The soils are characterized by deep soil profiles, drained and high erosion rates. Although the catchment has an extensive mix of soil types, there are three main classes: Nitisol-Acrisol-Alisol-Lixisol in the south, clay mixed with Cambisol in the centre, and Andosol in the north. Small pockets of Histosols occur in the uplands in the south and east, and a small area of Ferralsol occurs in the mid-west of the catchment.

3.3 *Sampling techniques*

The assessment was done by using questionnaires addressed to local people, local administrative and environment-related specialists. Field observation, interview and focus group discussions were used. A systematic random sampling was used to select key informants for 97 selected in Rubavu District (Nyundo sectors, Rugerero Sector, Kanama), Bigogwe in Nyabihu District, Muhanda Sector in Ngororero District and Nyabirasi Sector in Rutsiro District where watershed management practices have been mostly used and four staff specialized in environment from (NYABIHU, RUBAVU, RUTSIRO and NGORORERO).

3.4. Method of Data collection

3.4.1. Primary Data

Data were collected by using Questionnaires addressed to specific group selected randomly through administered structure questionnaire and interview to the respondent.

3.4.2. Secondary Data

Official document, published document, report were consulted for generating secondary Data.

3.4.3 Method of Data Analysis

Stata were used for generating the real correlation ,significant of Data.

3.4.4. Expected outcome

- ❖ To provide information related to community based participation in sebeya watershed management
- ❖ show if implemented watershed management practices in Sebeya is sustainable
- ❖ recommend different strategies needed for Sebeya sustainable watershed Management
- ❖ Effectiveness of implemented measure to restore Sebeya watershed .

CHAPTER FOUR RESULT AND DISCUSION

4.1 Rain water harvesting

Water harvesting (RWH) strategies is using as one way improving hygiene in rural ,livelihood of people and climate change adoption (Munyaneza, Majoro, Hagenimana, & Usabyisa, 2016) .

Figure 3 illustrate the acceptance level of Rain Water harvesting system in Sebeya watershed after talking interview at 97 dissimilar people. Result show that simply 17 peoples i.e. 17.53% use RWH at house level and farm levels, whereas 80 people i.e. 82.47% did not adopt.

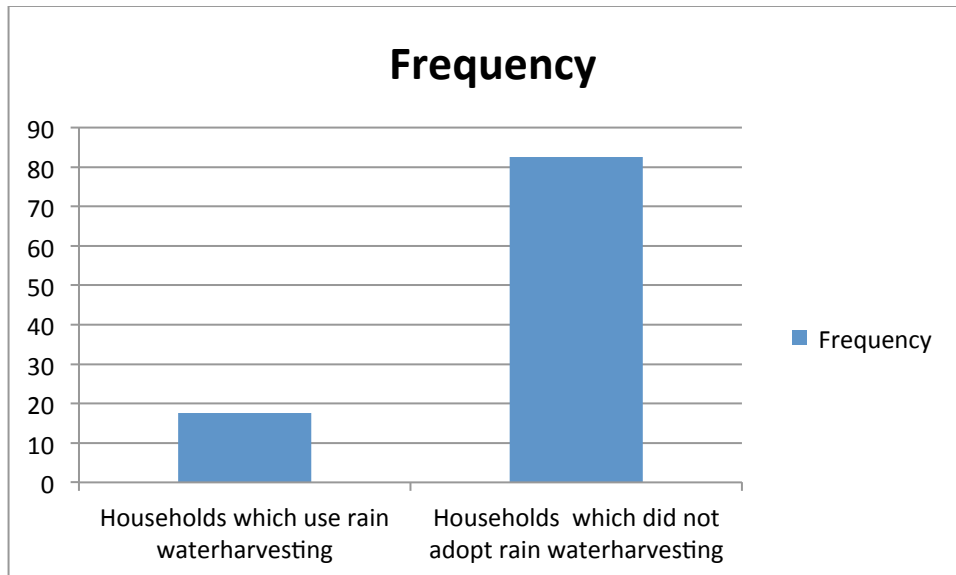


Figure show the people who use rain water harvesting system

The result show that the adoption and using water harvesting equipment is determined by different socioeconomic factors, in seventeen people who use rain water harvesting system all includes in 3 and 4 household categories (UBUDEHE Categories) and twelve people over seventeen who adopt water harvesting system all have finished at least secondary level, The Government of Rwanda though MINIRENA try to solve this problem by proving subsidies program for all people who want to buy water tank , where Government paid half cost and people paid half , this is adopted by different people in Ubudehe class 3 and 4 citizen in

Ubudehe class 1 and 2 they suffer for basic need like food, house, education they don't care on buying water harvesting tools.

NYUNDO Sector is located in Sebeya watershed with area of 31.7 km², household 6373 and population of 32410, the population density of NYUNDO Sector is 1022 per km² which greater than National level, this affect degradation of Sebeya River as we have seen that the rate of rain water harvesting is 17.53% and the remaining is conveyed into the River where it cause

4.2. *BENCH TERRACES*

Soil and water conservation strategies by making bench terraces is one way to improve soil fertility, erosion control and improving livelihood of farmers by getting more yield, fodder of their livestock in Sebeya watershed.

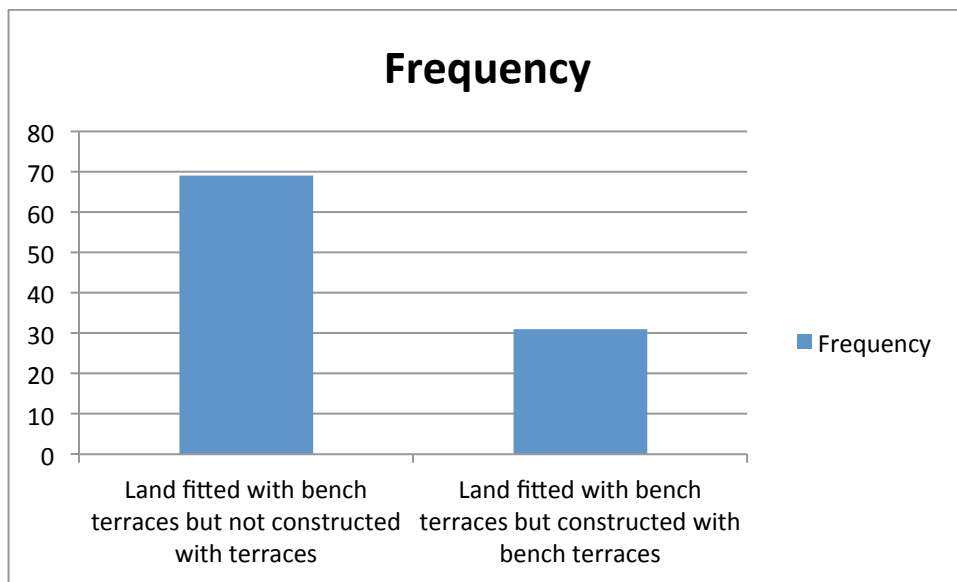


Figure 2 illustrate land occupied with bench terraces

As shown by table 4 and among 97 farmers from study area, the percentage of farm occupied by bench terraces is 30.93% correspond to 30 people and 69.07% respond that they did not have bench terraces even their site are suitable for bench terraces.

According to MINAGRI 2014, construction of bench terraces requires more fund where one hectare require between one million and one million half, this the reason why all site suited for bench terraces in Sebeya watershed are not protected with bench terraces.

4.3 Agroforestry

Sebeya watershed is dominated with different agroforestry system such as agro silviculture , silvopastural in Gishwati pasture, the study show that 68.04% of study area adopt agroforestry practices and alnus acuminate is dominated species.

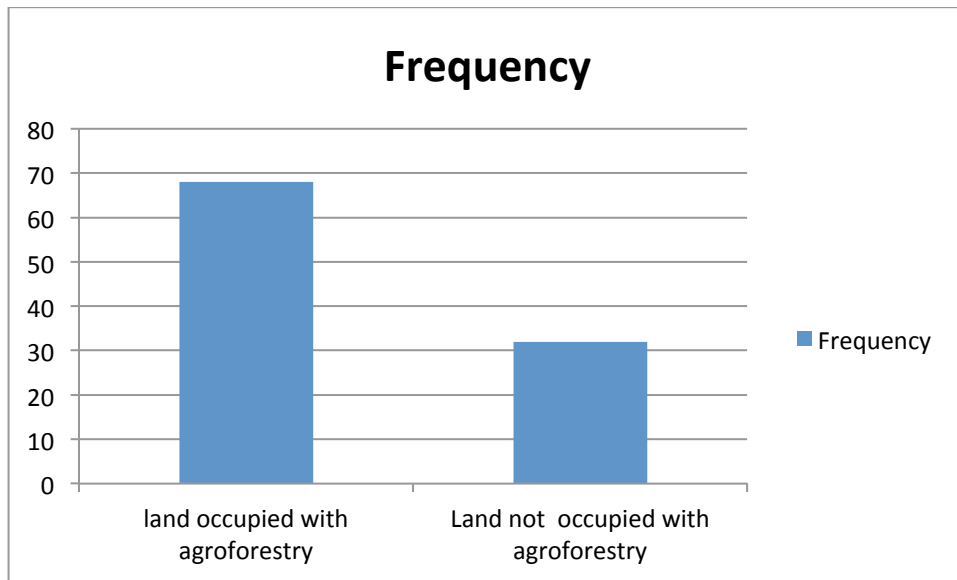


Figure show land occupied with agroforestry

Agroforestry is multipurpose in Sebeya watershed where farmers got more product such as fuel wood, fodder and fruit and those agroforestry product affect positively development of people where people earn money from those product, People told that erosion is reduced due to plantation of agroforestry trees.

4.4. Using improved cooking

Research show that 8.3% people use improved cook stoves and 91.7% did not use improved cook stoves they use traditional three stone open fire , many Rwandan households depends on biomass for cooking and heating(Water, 2012) .

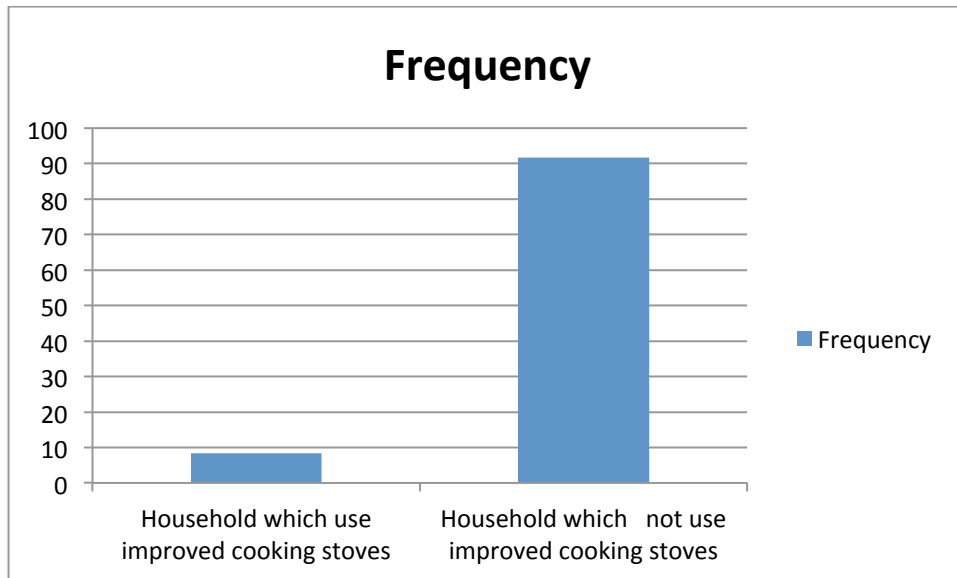


Figure 4 illustrate the level of household which use improved cooking stove

The use of traditional three stone open fire and unimproved stove is main cause of deforestation in Sebeya watershed and for getting 1 Kg of charcoal require 9 Kg of tree biomass with negative effect of different diseased caused by smoke .

The people doesn't take care on using improved cooking stoves as 8.3% in whole population they us it and those is not their initiative is due to different Government project give support of improved cooking stoves to people who is in Ubudehe categories

4.5.SEBEYA RIVER BANK PROTECTION

The water from mountain of Rutsiro District are shaded in Sebeya river which its outlet is Kivu lake , the result shown that 77.32% of river length is protect by bamboo (*bambusa Vulgalis*) , *Alnus acuminata*, *Pennisetum purpureum* and protective wall as river bank erosion control while 22.68% is not well protected. This protection has the aim of reducing sediment and siltation caused by erosion from hillside and flooding mitigation. The vegetation across the river increases soil the stability through the soil structure improvement.

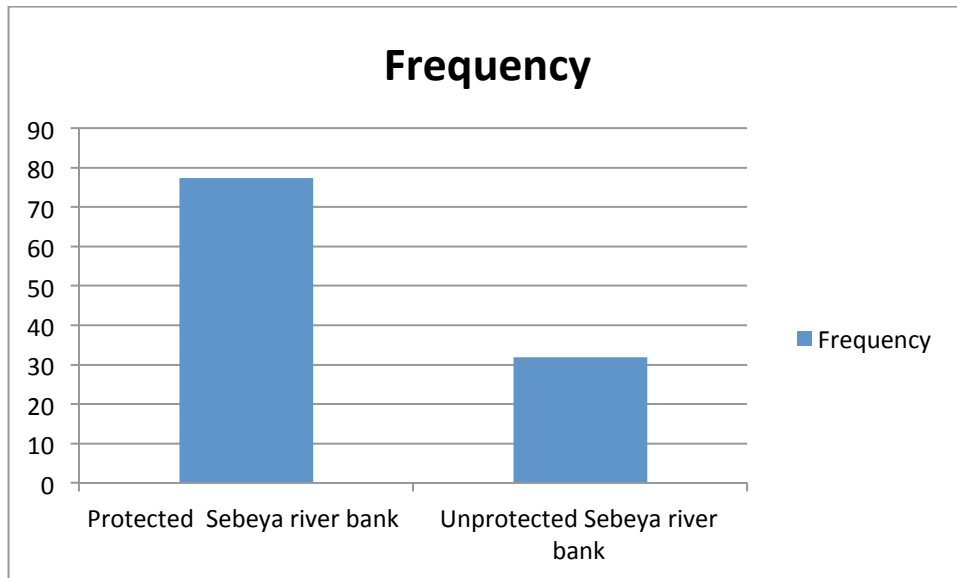


Figure 6 illustrate the protecting level of Sebeya river bank

Recently, the unprotected area which is 22.68% of river length, have been protected but due to human activities like grazing and sand mining accompanied with destruction of planted bamboo and agroforestry tree by domestic animals. In addition the mining activities and cultivation by farmer destroy coastal of river which cause sliding into the river. The sliding increase the sediment and siltation in the Sebeya river and this reduce its flow capacity to hold water from upland and this result in deviation of water flow from its original way. Lastly that water induces the destruction of different infrastructure in Rubavu District.

4.6. *Illegal Mining*

The result shown that the illegal mining is main cause of pollution of sebeya river at the rate 98.97%. The illegal mining activities done in upland of Sebeya watershed in Nyabirasi, Murunda and Ruhango sector induce the siltation and sedimentation in the river. Rutsiro District is dominated with cassiterite, wolfram and Colton those mineral are available in farm of people , the illegal mining is done with local people with low skill in mining which cause the siltation and sedimentation of sebeya river.

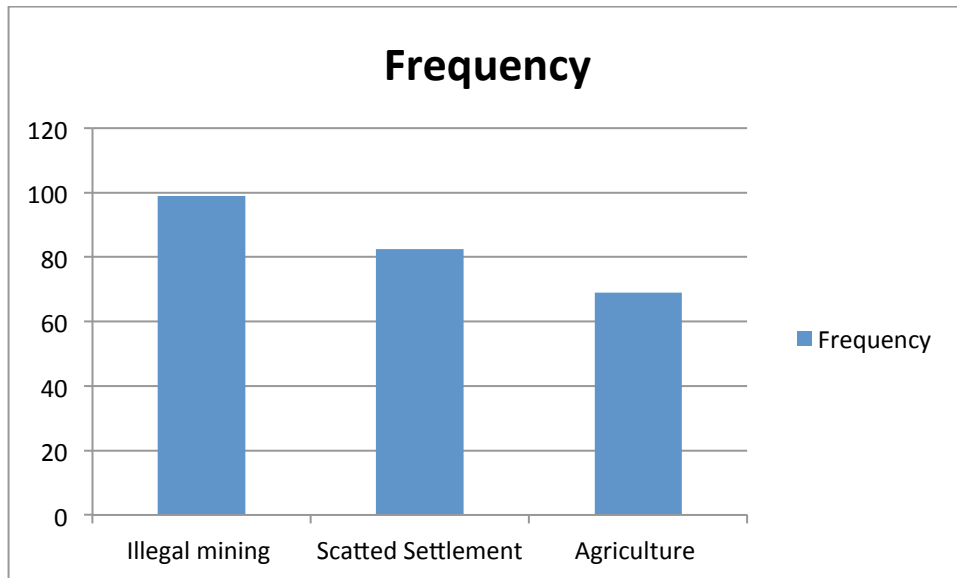


Figure 6 show main factor cause degradation of Sebeya watershed

Different companies and cooperatives have been trained on best practices for mining and environmental protection but some of them they did not respect rule and regulation for sustainable watershed management.

4.7 Effect of Settlement on Degradation of Sebeya watershed

The result show that the contribution of improper settlement in degradation of Sebeya watershed is 82.47%. According to(REMA, 2014) those sectors Nyakiliba, Kanama, Nyundo and Rugerero have population density between (1100 to 4480 people/Km²) which is high than Nation level but sector in upland have the population density between (260 to 600 person/Km²) and 47% live in informal settlement or dispersed house. There is change in land use where area reserved for agricultural is change to settlement and farmers try to cultivated at very steep slope for getting food.

The cause the degradation of sebeya watershed is induced by increasing in settlement as shawn in table 3 where 82.47% of total house did not adopt rain water harvesting .un harvested water cause erosion , land slide and flooding in lowland which affect negatively the livelihood of people.

4.8 Local people participation in Sebeya watershed Management

Participation of local people in watershed management is essential criteria for achieving sustainable integrated watershed management. The result shown that 20.62% of local people participate in planning ,implementation of different activities for managing Sebeya watershed while 79.38% did not join in any activities related to managing Sebeya watershed.

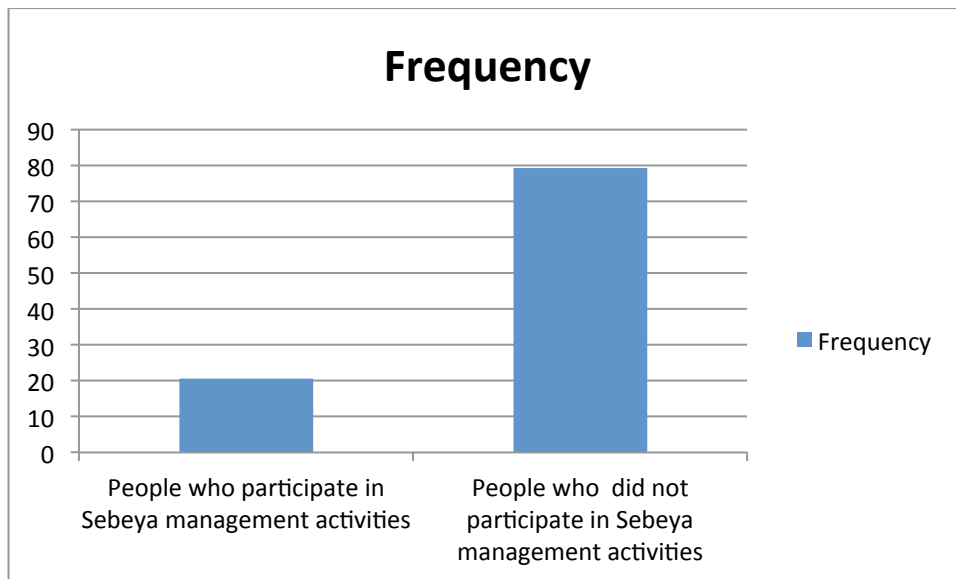


Figure 7 show local people participation in Sebeya watershed practices

Local people is the one of the main stakeholders in watershed management as different activities to conserved watershed was implemented in their field like agroforestry , terraces , etc..., they really know the historical background of different factors affect watershed degradation and tradition ways to manager those circumstance.

4.9. Contribution of agricultural activities in degradation of Sebeya watershed

Agriculture is based on both staple crop and exports of tea and coffee and Horticulture is common in all four districts in the catchment as the fertile soils in the area lead to high production levels and they have market in RDC.

Unsmarts agricultural practices affect negatively watershed management as show in table 9 where agriculture contribute 69.07% of Sebeya watershed degradation. Sebeya watershed belong in Congo Nile watershed Divide it characterized with high altitude and with high population density ,the agricultural practices done even above 50% of slope which cause permanent erosion and landslides as result of soil fertility declines.

The intensive agricultural in Sebeya watershed cause water pollution in river due to the leaching of inorganic fertilizes, disposal of plastic bags contain pesticides which cause more cost for water treatment in WASAC as all water used in RUBAVU City is treated on Sebeya River at the end cause eutrophication in Kivu lake.

CHAPTER V: CONCLUSION AND RECOMMENDATION

5.1. *CONCLUSION*

The study assessed the sustainable integrated watershed management approach in Sebeya watershed located Nyabihu, Rubavu, Rutsiro and Ngororero of western province. It is found that all catchment is not protected where Bench terraces occupied 30.93% of total land fitted for constructing bench terraces, Progressive terraces take 26.80% of all area trim for it, Rain water harvesting was done at low rate where 17.53% households only use rain water harvesting equipment, the protection of Sebeya river bank is at 77.32% it means 22.68% is not protected, agroforestry practices was applied at 68.04% the remaining is 31.96%, the using improved cooking stove is at low rate 8.3% and 91.7% did not adopt improved cooking stove, the participation of local people in different activities related Sebeya watershed management was at low rate 20.62% it means 79.38% did not participate in management of Sebeya watershed. The main causes of degradation of Sebeya watershed is illegal mining, intensive agriculture, unproper settlement respectively.

Therefore, policies that target promotion of watershed management and farmers development should be pursued together with the promotion of RWH, improved cooking stoves, terraces. In addition, there is a need for policies and strategies that target on various ways of reducing the cost of adopting different technology required for sustainable watershed management so as to include the poorer peoples.

5.2. *Recommendation*

Integrated watershed management approach is used as a strategies for solving food insecurity issue by increasing ground water availability, vegetation caver, reducing erosion and flooding. IWR need to be understand by all stakeholders within watershed at the same level it means from village to National level (bottom -up and up-down visa-versa) and the stakeholders must participate at each stage of watershed management.

- ✓ We recommend to Government of Rwanda before setting different activities to be implemented in watershed for managing it, must focus on study related socio-economic aspect, for example Rain water harvesting by using Tanks this require high cost, it means peoples has different social class cannot afford at the same level, Governmental must introduce subsidies program for the people who are in First and Second categories of

ubudehe at least 75% of total cost to be share of Government and remaining 25% must be paid by people in different phase.

- ✓ Integrated watershed management need to take into account all Socio-economics ,bio-physical components for improving livelihood of people and as result shown that all catchment in Sebeya watershed did not protected , and all catchment drain at same River ,unprotected catchment destroy all activities done in lowland by flooding and all catchment must be protected from upland to lowland and management practices respect soil capabilities and suitability.
- ✓ Illegal mining activities done in Rutsiro is driving factor cause degradation of Sebeya watershed , Rutsiro district must take measure for solving issue of illegal mining by training different company engaged in mining on proper mining strategies by respecting environmental impact assessment rule and creating off-mining activities for the local people.
- ✓ Informal settlement in Sebeya watershed it causes different problems that lead to degradation of Watershed , Government must take measure for those informal settlement , those who live in High Risk Zone must be integrated in model villages and 25% population of Sebeya watershed live in KANAMA sector, NYUNDO, NYAKILIBA nad RUGERERO those sector have population density more than 1000 person /km² and the new building in MAHOGO is observed as cities accompanied Rubavu. Before giving construction permit , each house must have at least two rain water harvesting tanks .
- ✓ Improved cooking stove is one way for reducing deforestation and climate change mitigation , this practices must integrate in District performance contract and make sure that institutional like schools, prison , hotel and Restaurant use improved cooking stoves and other source of energy instead of using biomass energy.

REFERENCES

- Bizoza A. R., and de Graff, J. (2012). Financial cost-benefit analysis of bench terraces in Rwanda. *Land Degradation & Development*, 23(2), 103-115.
- Akbar, S., Barnes, D., Eil, A., & Gnezditskaia, A. (2011). Household Cookstoves, Environment, Health, and Climate Change: A New Look at an Old Problem. *World Bank*, (May), 94.
- Asumadu-Sarkodie, S. (2015). Situational Analysis of Flood and Drought in Rwanda. *International Journal of Scientific and Engineering Research*, 6(8), 960–970.
<https://doi.org/10.14299/ijser.2015.08.013>
- Das, T. K., Haldar, S. K., Gupta, I. Das, & Sen, S. (2014). River bank erosion induced human displacement and its consequences. *Living Reviews in Landscape Research*, 8(1), 1–35.
<https://doi.org/10.12942/lrlr-2014-3>
- Dyszynski, J., & Hogarth, R. (2011). Forests and Tree-based Systems Sector Working Paper. *Smith School of Enterprise and the Environment, University of Oxford*, (June). Retrieved from <http://www.rema.gov.rw/climateportal/IMG/pdf/forestry-swp-final.pdf>
- FAO, A. (2004). Sustainable Practices in Watershed Management : Global Experiences Sudha Menon, 1–15.
- Fazli, B., Shafie, A., E.M. Yahaya, N. K., Awang, S., Mat Jusoh, A., Noordin, N., & Abdul Ghani, P. H. (2016). Lake and Watershed Management: Issues and Challenges in Managing Lake Water Quality. *Proceedings of the 2nd World Congress on New Technologies*, (July).
<https://doi.org/10.11159/icepr16.169>
- Geelani, M., Geelani, S. H., Haq, S. S., Mir, N. A., Qazi, G., & Wani, S. (2016). Mining and Its Impacts on Environment With Special Reference To Review Article Mining and Its Impacts on Environment With Special Reference To India. *International Journal of Current Research*, 5(12), 3586–3590.

- Germain, R. H., Floyd, D. W., & Stehman, S. V. (2001). Public perceptions of the USDA Forest Service public participation process. *Forest Policy and Economics*, 3(3–4), 113–124. [https://doi.org/10.1016/S1389-9341\(01\)00065-X](https://doi.org/10.1016/S1389-9341(01)00065-X)
- Karpuzcu, M., & Delipinar, S. (2014). INTEGRATED WATERSHED MANAGEMENT : SOCIO-ECONOMIC PERSPECTIVE INTEGRATED WATERSHED MANAGEMENT : SOCIO-, (January 2011).
- Luyet, V., Schlaepfer, R., Parlange, M. B., & Buttler, A. (2012). A framework to implement Stakeholder participation in environmental projects. *Journal of Environmental Management*, 111, 213–219. <https://doi.org/10.1016/j.jenvman.2012.06.026>
- Mekonnen, G. T., & Fekadu, A. (2015). Experiences and challenges of integrated watershed management in central zones of southern Ethiopia. *International Journal of Current Research*, 7(10), 20973–20979.
- Mena, M. M., Madalcho, A. B., & Dana, D. (2017). Integrated Watershed Management for Ecosystem Balance & Climate Change: Ethiopia. *Civil and Environmental Research*, 9(9), 1-12–12.
- MINILAF. (2017). Forest Investment Program for Rwanda. *Minilaf*, (November), 162.
- MINIRENA. (2016). REPUBLIC OF RWANDA Rwanda Natural Resources Authority NATIONAL RAINWATER HARVESTING STRATEGY November 2016, (November).
- Muhinda, J. J. M. (2014). Integrated Management of Critical Ecosystems in RWANDA. *Journal of China and International Relations*, 2(2). <https://doi.org/10.5278/ojs.jcir.v2i2.941>
- Munyaneza, O., Majoro, F., Hagenimana, E., & Usabyisa, W. (2016). Impact Assessment of Hillside Rainwater Harvesting Ponds on Agriculture Income: Case Study of Ntarama Sector in Rwanda. *Journal of Water Resource and Protection*, 08(09), 844–854. <https://doi.org/10.4236/jwarp.2016.89069>
- Murthy, I. K., Dutta, S., Varghese, V., Joshi, P. P., & Kumar, P. (2016). Impact of Agroforestry Systems on Ecological. *Global Journal of Science Frontier Research*, 16(5), 15–28.

- Pascal, G. (2014). BENCH TERRACES FOR FOOD AVAILABILITY IN A VULNERABLE COMMUNITY ., (September).
- RAB. (2017). Girinka Programme transforms livelihoods, reconciles communities, 1.
- REMA. (2018). *Sebeya Catchment Management Plan (2018-2024)*.
- Sample, D., & Barlow, S. (2013). What Is Soil Restoration? Where Can SR Be Used?, 1–4. <https://doi.org/10.1007/978-1-4612-2820-2>
- Samra, J. S., & Sikka, a K. (1998). Participatory watershed management in India. *Towards Sustainable Land Use Vols I Ii*, 31, 1145–1150.
- SEPA. (2016). Reducing river bank erosion: A best practice guide for farmers and other land managers.
- VINCENT, K. (2014). Program and Poverty Alleviation in Rwanda.
- Wallmo, K., & Jacobson, S. K. (1998). A social and environmental evaluation of fuel-efficient cook-stoves and conservation in Uganda. *Environmental Conservation*, 25(2), 99–108. <https://doi.org/10.1017/S0376892998000150>
- Wang, G., Mang, S., Cai, H., Liu, S., Zhang, Z., Wang, L., & Innes, J. L. (2016). Integrated watershed management : evolution , development and emerging trends. *Journal of Forestry Research*, 27(5), 967–994. <https://doi.org/10.1007/s11676-016-0293-3>
- Wani, S. P., & Garg, K. K. (2009). Watershed Management Concept and Principles. *Icrisat*, (January), 1–11. <https://doi.org/10.1016/B978-84-8086-474-9.50110-X>
- Water, E. (2012). Africa energy services group, (11).
- Water for Growth, R. Sebeya Catchment Plan Summary Integrating Land and Water Resources Management through joint performance contracts , Dufatanye mu mihigo A catchment plan for Sebeya (2017).
- Xiaoyan, L., & Ruiling, Z. (2002). Effects of Rainwater Harvesting on the Regional Development and Environmental Conservation in the Semiarid Loess Region of Northwest

China. *12th ISCO* Retrieved from

<http://www.tucson.ars.ag.gov/isco/isco12/VolumeII/EffectsofRainwaterHarvesting.pdf>

ANNEX

Questionnaire

SECTION A: GENERAL IDENTIFICATION OF A RESPONDENT

Please tick (✓) in the space provided that most accurately describes your relationship

1. Name (Optional):-----

2. Age class

✓ Below 20 years

✓ 21-30 years

✓ 31-50 years

✓ Above 50 years

3. Sex: (a) Male [] (b) Female []

4. Marital Status: Married [] Unmarried [] Divorced/ Widower []

5. Size of Household Members: -----

6. Educational attainment:

(a) Non formal education []

(b) Primary school education []

(c) Secondary school Education []

(d) Post-Secondary School education []

7. Approximate your income from your farm produce in a year: -----

8. Source of Farm labour:

- (a) Family labour [] (b) Hired labour []
- (c) Both family and hired labour [] (d) other (specify) -----

9. Do you have any off-farm employment?

- (a) Yes [] (b) No []

10.a) If yes above, what type of work do you do? -----

b) Before doing off farm activity which kind of job have you done?

.....

SECTION B: Activity done for sustainable managing Sebeya watershed

In the previous activities indicates the activities done in your area for managing sebeya watershed?

- a. Bench terraces []
- b. Progressive Terraces []
- c. Plantation of agroforestry trees []
- d. Afforestation []
- e. Waterharvesting system by digging ditches []
- f. Waterharvesting system by using tank
- g. Cleaning and maintaining waterways []
- h. Protection of Sebeya River bank by bambo and trees []

2. For the identified activities have participate in implementation plan ?

(a) We have raised idea related to managing Sebeya watershed and our idea local people and NGO come for solving our questions []

(b) The implementer have use meeting with us before start activities to manager Sebeya watershed []

c. They implement without communicate us []

3. What is advantages of different activities done to manage Sebeya Watershd ?

a. Reduction of Soil erosion reduction []

b. Reduction of flooding and siltation in downstream of Sebeya []

c.. Increase of agricultural productivity compared to the past .

d. . Fodder of domestic animals []

e. Forestry product (fire wood, Timber) []

f. Water from waterharvesting system (tanks) we use it for irrigating kitchen garden []

4. Does any off farm activities created and unrelated mining activities ??

a. Yes [] which one

b. No []

5. Does all catchment of Sebeya watershed managed in your district?

a. Yes []

b. No []

6. Does different activities implemented for managing SEBEYA Watershed based on slop requirement?

a. [0-6] 1. Agroforestry , contour ploughing, Alley cropping grass strip []

2. Perennial crops, Tea, Banana, fruit trees []

b. [6-16] 1. Progressive terraces []

2. Perennial crop []

3. Forestation where soil is limited and unsuitable for crop []

c. [16-40] 1. Bench terraces []

2. Progressive []

3. Perennial crops []

4. Forestation for soil unsuitable for crop []

[40-60] 1. Narrow terraces []

2. Progressive terraces []

3. Forestation (Biological measure) []

4. Perennial crops []

[>60] 1. Forestation (Ditches) []

2. Perennial crops []

PART : Recommendation

1. What is your suggestion for sustainable SEBEYA watershed management?

.....
.....

2. Which challenge have you meet in the implementation of different activities for managing SEBEYA Watershed ?

We highly thank you for your idea and advice that will help us for sustainable Sebeya watershed management. Prepared by IRATUZI Jean Claude; student in Masters program Agroforestry and soil Management from University of Rwanda, College of Agriculture ,Animal and Veterinary Medecine .

DATA

The survey indicated that 45.26 %, 38.95%, 8.42% and 7.37% of households were classified in 1, 2, 3 and 4 of ubudehe categories

Ubudehe category	Frequency	Percentage
1	43	45.26
2	37	38.95
3	8	8.42
4	7	7.37

Table 1: household categories

The table below shows the education level of respondent and indicates that 43.3 % had no education, 41.24% had attended primary education, 5.15% had attended secondary school and 10.31 % had university studies

Ubudehe category	Frequency	Percentage
Illiteracy	42	43.3
Primary	40	41.24
Secondary	5	5.15
University	10	10.31

Table 2: Education level of household

The table below represents the status of water harvesting practices across interviewed households and shows that 82.47% had no implemented any water harvesting practices whereas 17.53% had implemented water harvesting practice. Water harvesting was a dummy variable where 0 stand for No and 1 represents Yes.

Water harvesting practices	Frequency	Percentage
0	80	82.47
1	17	17.53

Table 3: Water harvesting practices and household

DATA

The table below summarizes the status of bench terraces and farm of household and shows that only 30.93% of respondents in their farm had terraced whereas 69.07% had not terraced. A bench terrace was a dummy variable where 0 stand for No and 1 represents Yes.

Bench terraces	Frequency	Percentage
0	67	69.07
1	30	30.93

Table 4: Farm management using terraces

The table below summarizes the status of progressive terraces and farm of household and shows that only 26.80 % of respondents in their farm had progressive terraced whereas 73.80 % had not progress terraced. A progressive terrace was a dummy variable where 0 stand for No and 1 represents Yes.

Progressive terraces	Frequency	Percentage
0	71	73.20
1	26	26.80

Table 5: Farm management using progressive terraces

The table below represents the status of agroforestry implemented by household across Sebeya watershed .Thirty one percent of household had no implemented agroforestry whereas 68 had implemented agroforestry practices. An Agroforestry practice was a dummy variable where 0 stand for No and 1 represents Yes.

Agroforestry practices	Frequency	Percentage
0	31	31.96
1	76	68.04

Table 6: Farm management using agroforestry

The table below illustrates the status of sebeya river bank protection using Bambus vulgaris and agroforestry tree species

Sebeya river bank protection	Frequency	Percentage
0	22	22.68
1	75	77.32

Table 7: Sebeya river bank protection

The table below represents the use of improve strove among households. Its show that

Use of improved strove	Frequency	Percentage
0	53	54.64
1	44	46.36

Table 8: use of improved strove across household

The table below indicates the household views on the effect of intensive agriculture and Sebeya watershed degradation

Intensive agriculture	Frequency	Percentage
0	67	69.07
1	30	30.93

Table 9: household perception on intensive agriculture

The table below depict the effect of urbanization on Sebeya watershed degradation and shows that 21.65 % of household

Urbanization	Frequency	Percentage
0	21	21.65
1	76	79.35

Table 10: Urbanizations of sebeya watershed degradation

The table below illustrates the household point of view on illegal mining to cause Sebeja watershed degradation

Illegal mining	Frequency	Percentage
0	1	1.03
1	96	98.97

Table 11: Household view on illegal mining

The table below summarizes household participation in watershed management and shows that a big number of households didn't participate for Sebeja watershed management interventions implemented

Household participation	Frequency	Percentage
0	77	79.38
1	20	20.62

Table 12 .Household participation in Sebeja watershed management

1. MODELING OF FACTOR CONTRIBUTING TO SEBEJA WATERSHED DEGRADATION

The following tables represent the factors contributing to the degradation of Sebeja watershed and show that

Driving variables	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]
Illegal mining	.141055	.153767	1.04	0.039	.0105511 .2505217
Intensive agriculture	.5624215	.22456	1.21	0.100	-.1644749 1.591418
Rain water	1.008854	1.478547	0.68	0.001	-3.906752 1.889044
House water	.8316055	1.736994	0.48	0.0062	-4.236052 2.572841
Weak household parti	0.2603526	1.467725	0.18	0.0859	-2.616335 3.13704

Urbanizations	0.764202	1.243681	0.61	0.05	-1.673368	3.201772
Constant	1.035071	1.492792	0.69	0.001	-1.890747	3.960889

2. MODELING THE POTENTIALITIES OF PRACTICES IMPLIMENTATED IN SEBEYA WATERSHED MANAGEMENT

Potential of practices	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
Rain water harvesting	.7473773	1.580546	2.04	0.043	-2.350435	3.84519
Agroforestry	1.32184	.42843	1.34	0.005	.3120276	1.4271
Reforestation	0.5213	0.3883	3.11	0.001	.54226	1.57143
Digging ditches	0.4622	0.04038	1.32	0.000	.16526	.661131
Water ways	0.42139	0.02573	2.33	0.000	.388213	1.0217732
River bank protection	0.231863	0.018078	1.34	0.003	.0688125	.4862872
Improve strove	0.6681803	0.224325	1.22	0.010	1.227403	2.01143
Bench terraces	0.7285	0.31181	0.88	0.024	1.4213	2.01278
Progressive terraces	0.58071	0.1115403	2.03	0.004	.152143	1.01874
Constant	2.43827	.8323520	2.60	0.000	4.240568	4.60758

