EFFECTS OF INTEGRATED SOIL AND WATER MANAGEMENT ON LIVELIHOODS OF SMALLHOLDERS IN BUREGA SECTOR, RULINDO DISTRICT, NORTHERN PROVINCE, RWANDA

BY

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DECLARATION

Declaration by candidate

I Delphine MUTUYIMANA, declare that this research project is my own original work and it has never been presented for degree in any other institution.

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This research project has been submitted for examination with our approval as University Supervisors

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DEDICATION

- To my Parents: Thank you for your unconditional support with my studies. I am honored to have you as my parents. Thank you for everything you have done for me, especially to give me a chance to prove and improve myself through walking outside of the country. May Almighty God bless you.
- To my brothers and Sister: Thank you for your great supports and motivation during my studies.
- Thanks to everyone who supported me in one way or another.

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ABBREVIATIONS

CA: Conservation Agriculture

CIP: Crop Intensification Program

DFID: Department for International Development

DPSIR: Driving-Pressure-State-Impacts-Responses

EDPRS: Economic Development and Poverty Reduction Strategies

FAO: Food and Agriculture Organization

GovR: Government of Rwanda

IAASTD: The International Assessment of Agricultural Knowledge, Science and

IFAD: International Fund for Agricultural Development

IFPRI: International Food Policy Research Institute

ISWC: Integrated Soil and Water Conservation

LWH: Land Husbandry and Water Harvesting

MINAGRI: Ministry of Agriculture and Animal Resources

MINECOFIN: Ministry of Finance and Economic Planning

MINIRENA: Ministry of Natural Resource

MINITERE: Ministry of Lands, Environment, Forests, Water and Mines

NISR: National Institute of Statistics of Rwanda

REMA: Rwanda Environmental management Authority

SLM: Sustainable Land Management

SOFA: State of Food and Agriculture

SWC: Soil and Water Conservation Technology for Development

UN: United Nations

VUP: Vision Umurenge Program

WIEGO: Women in Informal Employment Globalization and Organizing

WOCAT: World Overview of Conservation Approaches and Technologies

N: Frequency

Ha: Hectare

%:Percentage

ABSTRACT

This study is an investigation of effects of integrated soil and water management on the livelihoods of smallholders of Burega Sectors, Rulindo District of Northern Province of Rwanda. The main aim was to investigate the effect of integrated soil and water management on the livelihood of smallholders. Specifically, the study aimed at determining the factors contributing to the use of the most SWC technologies, assessing the extent to which farmers have implemented soil and water conservation technologies, analyzing the effect of SWC technologies on the livelihoods of smallholders and also determining the benefits of soil and water conservation technologies in the study area. It was hypothesized that there is no relationship between factors contributing to the adoption of SWC technologies and a number of SWC technologies adopted, as well as there is no relationship between the number of SWC technologies used by farmers in Burega Sector and access to the livelihood assets. In order to address the objectives, both primary and secondary data were used for the study. Structured questionnaire was used to collect primary data from households to get their views on adoption of SWC technologies and their effects on the livelihoods of farmers as well as their benefits. The study applied a non-experimental design (explanatory) to collect primary data from a sample of 270 households drawn from the nine villages of Burega Sectors. Stratified random sampling technique was also used along with the simple random sampling technique in each stratum. Actually, data collection used a questionnaire to capture data from household heads and key informants. Secondary data were collected from official government reports, international reports as well as scientific publications. The data collected was then analyzed by inferential statistics such as chi-square and at the 95 % confidence level using SPSS computer package version 20 and Microsoft office Excel. Perceptions of respondents of factors influencing the adoption of SWC technologies, extent of using these SWC techniques, their effects on farmers' livelihoods as well as their benefits were analyzed. In addition, the relationship between the number of SWC technologies adopted and factors affecting their adoption as well as an access to the livelihood assets were analyzed with the aid of the Statistical Package for the Social Sciences (SPSS) software. Adoption extent of SWC technologies was analyzed by using descriptive statistics such as frequencies and percentages. The study found out that most adopted SWC technologies are crop rotation, ditches, agricultural inputs and radical terraces while the main factors influencing their adoption are farm size, having livestock, crop yield, farmers' perception of the soil erosion problem, access to extension services and experience, availability of inputs support and steep slope. It was found that 9.3% of respondents adopt at least one technique while 37.8% use the four identified SWC technologies. The results revealed that respondents have access to livelihood assets (natural, human, social, physical and financial assets) found in the area of study. Additionally, the findings showed that the adoption of SWC technologies has many benefits to the people in the area of study, including improvement of crop yield and soil fertility, control of soil erosion/runoff as well as the increase of availability of fodder for their livestock. The statistical test showed that farm size, crop yield, perception of soil erosion, availability of inputs supports and steep slope have a connection with adoption of SWC technologies, while on the other hand, raising livestock has no relationship with adoption of SWC technologies. In addition, it was observed that age, household size, education, access to extension services and knowledge dissemination have no connection with adoption of SWC technologies in the area. But, the availability of training and access on it as well as farmers' experience have a relationship with the adoption of SWC technologies. Natural and social assets were also found to have a relationship with adoption of SWC technologies in the study area. While access on financial assets in the form of livestock rearing has no connection with adoption, whereas farmers' cooperative in which members are able to access to credit and saving has found to have a relationship with adoption of SWC technologies. The study concluded that most of the participants were willing to maintain soil as a valuable resource and apply SWC technologies for maximizing their benefits, but expressed the need for the continuing support of the implementation. Further, it also brings to a close that conservation efforts ought to focus on areas where expected benefits are higher, especially on the steeper slopes, in order to encourage the use of the SWC technologies. The research also recommends further researches in the study area, including assessment of the impacts of the adoption of SWC technologies on climate change, women, final agricultural productivity, food security and market price changes as well as soil properties and long-term sustainability.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Current global developments call for more thoughtful management of the land. These developments include: the increased demand for land-based agricultural products for rapidly growing world population; the increasing scarcity of water, fuel, and minerals; the impacts of global climate change, increased commodity prices in the agricultural sector, and growing competition for land resources. Globally, large areas of land are being affected by land degradation, partly resulting from unsustainable land use. This is particularly the case in developing countries, which are especially vulnerable to overexploitation, inappropriate land use, and climate change. Bad land management, including overgrazing and inappropriate irrigation and deforestation practices often undermines productivity of land (WOCAT, 2012). In the context of productivity, land degradation results from a mismatch between land quality and land use (Beinroth et al., 1994). Land degradation as a result is a biophysical process driven by socioeconomic and political causes (Eswaran et al., 2001).

Land degradation is related to climate and soil characteristics, but mainly to deforestation and inappropriate use and management of the natural resources, soil and water. It leads both to a non-sustainable agricultural production and to increased risks of catastrophic flooding, sedimentation, landslides, etc, and the effects of global climatic changes (Pla, 2000). Hence, global climate change prediction, although still rather uncertain, will increase rainfall in some regions, while others might become drier, in a rather uneven spatial and time distribution. This may contribute to accelerated land degradation processes leading to larger runoff and erosion, and to increased risks of flooding, landslides, mass movements and mud-flows in tropical regions, and to higher risks of crop production in subtropical and temperate regions (Sentis, 2010).

The problems of soil and water degradation and derivative effects are increasing throughout the world, partially due to a lack of appropriate identification and evaluation of the degradation processes and of the relations causes-effects of soil degradation for each specific situation, and the generalized use of empirical approaches to select and apply soil and water conservation practices (Sentis, 2002 & 2010). It has shown that soil and land degradation are the main factors attempting against the sustainability of agricultural production. Although land degradation is affected by soil and climate characteristics, it is mainly due to inappropriate use and management of the natural resources, soil and water, generally imposed by social and economic pressures. In addition to the negative effects on plant growth and on productivity and crop production risks, soil and land degradation processes may contribute, directly or indirectly to the degradation of hydrological catchments, affecting negatively the quantity and quality of water for the population and for irrigation or other uses in the lower lands of the watershed (Sentis, 2010).

The productivity of some lands has declined by 50% due to soil erosion and desertification. Yield reduction in Africa due to past soil erosion may range from 2 to 40%, with a mean loss of 8.2% for the continent. In South Asia, the annual loss in productivity is estimated at 36 million tons of cereal equivalent valued at US$5, 400 million by water erosion, and US$1, 800 million due to wind erosion. It is also estimated that the total annual cost of erosion from agriculture in the USA is about US$44 billion per year, that is about US$247 per ha of cropland and pasture. On a global scale the annual loss of 75 billion tons of soil cost the world about US$400 billion per year, or approximately US$70 per person per year. Thus, land degradation will remain an important global issue of the 21st century because of its adverse impact on agronomic productivity, the environment and its effect on food security and the quality of life (Eswaran et al, 2001).

A study conducted in Rwanda showed the standard estimates of soil loss in the country which were made to examine some of the principal environmental conditions and conservation practices that contribute to soil erosion in this country (Lewis et al., 1988). Soil loss was estimated by using the universal soil loss equation calibrated from field data collected on more than 19,000 fields. Seasonal soil losses ranged from 1 t/ha (0.4 ton/acre) to 143 t/ha (63.8 tons/acre); the average seasonal soil loss was 5 t/ha (2.2 tons/acre). Soil loss in Rwanda showed a pattern of regional differences that closely followed variations in rainfall and topography. The development of regional strategies to minimize agricultural erosion is likely to be more effective than a single national policy (Lewis et al., 1988).

The study carried out in Zambia showed that the effects of soil degradation and water shortages on crop productivity have induced researchers to introduce some innovative practices such as mulching, bunding, contour ridging, ripping, minimum tillage and others check the downward spiral in agricultural production. Varied soil and water conservation practices requiring varied farmer inputs have been promoted among farmers for over a decade now (Mulenga, 2003; Haggblade & Tembo, 2003; Chelemu & Nindi, 1999).

Proper land use, soil and crop management practices may make soil resistant against the effects of climate changes and derived extreme events. Therefore**,** Sustainable Land Management (SLM) is required to minimize the issue of land degradation. Thus the SLM was defined by WOCAT (2012) as a form of land management that is targeted towards improving or stabilizing agricultural productivity, improving people's livelihoods and improving ecosystems.

1.2 Problem Statement

This study is an investigation of effects of integrated soil and water management on the livelihoods of smallholders. It was conducted in Burega Sector, Rulindo District in Northern Rwanda.

Land degradation has been recognized as a major problem in Rwanda many years ago. The country has very high rural population densities and characterized by steeply sloping highlands. Due to its topography and climate, land degradation and erosion have long been assumed to be severe and a major reason for the poverty and food insecurity in the country. This has been exacerbated by changes and variation of climate which again led to the decline of soil fertility and land productivity as whole.

As small-scale farming is the backbone of agriculture production in the country, farmers have to use available land either in marshland or hillsides in order to increase agricultural productivity as well as improve their living standards. To achieve this, however, farmers have to adopt many various technologies such as soil and water conservation technologies. In an effort to improve agricultural productivity, reducing poverty and at the same time reducing land and /or soil degradation, government, private institutions and NGOs have introduced and promoted the use of various soil and water conservation technologies and sustainable agriculture in different parts of the country including Burega Sector of Rulindo District. Despite the introduction and promotion of integrated soil and water conservation technologies, information about the effect of those technologies on the livelihoods of smallholders is still minimal. Filling this knowledge gap would help to be aware of the contribution of these SWC technologies to smallholders and reasons to convince other farmers to adopt those SWC technologies. The study addressed the following research questions:

1.3 Research Questions

1. What are factors contributing to the adoption of the most used SWC technologies in Burega Sector?
2. At which extent have farmers implemented SWC technologies in the study area?
3. What are the effects of soil and water conservation technologies on the livelihoods of smallholders and their benefits in the study area?

1.4. Research Objectives

The general objective of this study was to investigate the effect of integrated soil and water management on the livelihood of smallholders.

1.4.1. Specific Objectives

1. To determine the factors contributing to the use of soil and water conservation practices in the study area;
2. To assess the extent to which farmers have implemented soil and water conservation technologies in the study area;
3. To analyze the effect of SWC technologies on the livelihoods of smallholders and their benefits in the study area.

1.5 Hypotheses

Hypothesis One:

H_0: There is no relationship between factors affecting adoption of SWC technologies and number of SWC technologies adopted in the study area.

H_1: There is a relationship between factors affecting adoption of SWC technologies and number of SWC technologies adopted in the study area.

Hypothesis Two:

H_0: There is no significant relationship between the number of SWC technologies used by farmers in the study area and access to the livelihood assets.

H_1: There is a relationship between the number of SWC technologies used by farmers in the study area and access to the livelihood assets.

1.6 Justification

Although the close interaction between the conservation of the soil and water resources is increasingly being accepted, still in most of the cases they are evaluated separately, and consequently the prediction and prevention of the effects derived from their degradation are inadequate in many situations. This would become more important under the previewed effect of global climatic changes, which would mainly affect hydrological processes in the land surface, mostly related to the field water balance (Varallyay, 1990). Therefore the assessment of this combination of both soil and water conservation would play a great role in being aware of its contribution to the smallholders' live as well as mitigating climate change and its variation in the study area as well various part of the country. During this research, the factors contributing to the use of soil and water conservation, extent of using soil and water conservation measures were identified. The study once more would contribute a great role in providing the impact of combined soil and water management technologies in improving small farmers' living condition, environment and economic development. Though, the research would give the information on the impact of farming practices on soil degradation processes which is based on scientific literature, which mostly concerns observed effects under particular geo-climatic conditions and farming characteristics such as farming type.

Integrated soil and water management technologies are now widely used in the world of today in order to combat the global environmental issues which are mostly the main root cause of food insecurity, water shortage, land degradation, poverty, worsen climate change issue which in turn ruin the smallholder farmers whose capacity to get the food and success to some basic service is very hard to them. With regard to the protection of the environment and management of natural resources, the aim of the Government of the Republic of Rwanda is to transform the country into a middle-income country by the year 2020, with the a poverty rate of 30 percentage and increase of annual per capita income. Thus, as one of the pillars of the Vision 2020 is the human resource development and a knowledge based economy, this study would provide information regarding this pillar which is concentrated on improving living standards of households and protection of the environment as well as sustainable natural resource management. The findings of this research could make a contribution to these objectives of Rwandan Government as well as increasing farmers' awareness about their resource use and benefit from adoption soil and water conservation technologies and approaches. These make clear the level of household in achieving this aim and take full advantage of the opportunities for the use and adoption of practices of soil and water management simultaneously. Though there is still a lack of data on the impact of soil and water management on farmers' daily live standard; this research fills this gap and call for further research related to this study. The findings of this study revealed the role of these SWC technologies to vulnerable farmers living in rural areas, their development in term of socioeconomic and environmental aspects and the same as its role on women farmers' improvement who are mostly vulnerable to both land degradation and agricultural activities.

Though many studies such as Bizoza & Graaff (2012) and Bizimana (2011) have been carried out on soil and water conservation technologies in Rwanda and elsewhere, much effort has concentrated on dissemination of the SWC technologies, adoption of bench terraces technologies, financial cost-benefit analysis of bench terraces, as well as farm size, erosion and soil conservation investment. Little has been done on the effect of soil and water conservation technologies on the livelihoods of smallholders but none has been done in Burega Sector, Rulindo District. It is thus important to study the effect of integrated SWC technologies in Burega Sector. The present study fills an important gap in this field of research, not only in terms of covering a new geographical area but also to determine the effects of integrated SWC technologies and identify different soil and water conservation technologies farmers use mostly in the area of study.

1.7 Scope of the Study

The study was concentrated on the effects of soil and water conservation technologies on the livelihoods of smallholders in Burega Sector. It is one of Sectors made the Rulindo District, which is located in the Northern Province of Rwanda. Burega Sector was selected due to its environment which contains many mountains, high population density, high soil erosion as well as the efforts of SWC technologies, dissemination and implementation that occurred in the study area under supports from Government, including VUP, LWH project and promotion of sustainable agriculture. Before the implementation of various SWC technologies, people in this area were very vulnerable to disasters generated from lack of soil and water conservation measures. So this is the fact that Burega was selected for investigation of the effect of these integrated SWC technologies on the livelihoods of smallholders. During this study, the only most adopted SWC technologies in the area of the study were considered. Those include crop rotation, ditches, agricultural inputs and radical terraces. The study also determined the factors contributing to the adoption of these SWC technologies, such as farm size, livestock rearing, crop yield, availability of inputs, farmers' knowledge, soil erosion problem and high slope. Moreover, the study assessed the extent of adoption of those most SWC technologies used in the study area. Additionally, the study analyzed the effects of these integrated SWC technologies on the livelihoods of smallholders as well as their benefits in the area of the study.

These SWC technologies are those taken as approaches used to minimize the problem of land degradation and/or soil erosion in hillside and lowland farms. In concluding the study, the findings provide current situation of these SWC technologies and information showing the effects of these technologies on smallholders living in Burega Sector. Furthermore, the research would contribute to the objective of the Burega Sector as well as the Rulindo District which is to improve the quality of life and standard of living of the people of this District through economic and social empowerment and rural transformation. Due to the nature and objective of the study, the research did not investigate the variations in soil quality, soil loss and the impact of SWC technologies on the final agricultural production.

1.8 Operational definitions

Conservation agriculture: is a concept of resource-saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment.

Livelihood outcomes: are the achievements of livelihood strategies, such as more income, increased well-being, and reduced vulnerability, improved food security and a more sustainable use of natural resources

Livelihood strategies: are defined as the range and combination of activities and choices that people make in order to achieve their livelihood goals, including productive activities, investment strategies, reproductive choices.

Policies and institutions: policies and institutions are defined as those which influence rural household's access to livelihood assets

Smallholder: are marginal and sub-marginal farm households that own or/and cultivate less than two hectares of land

Soil and Water Conservation (SWC): activities at the local level, which maintain or enhance the productive capacity of the land in areas affected by, or prone to, degradation.

Sustainable Land Management (SLM): the use of land resources, including soils, water, animals, and plants, for the production of goods to meet changing human needs while simultaneously ensuring the long-term productive potential of these resources and ensuring their environmental functions.

Sustainable livelihood: A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks, maintain or enhance its capabilities and assets, while not undermining the natural resource base.

SWC Approaches: ways and means of support that help introduce, implement, adapt, and apply SWC technologies on the ground.

SWC Technologies: agronomic, vegetative, structural and management measures that prevent and control land degradation and enhance productivity in the field.

Vulnerability context: refers to the seasonality, trends, and shocks that affect people's livelihoods.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter is an analysis of the previous research work. The themes of the literature are organized as follows; smallholder farmers, sustainable livelihood concept, land and soil degradation, soil and water conservation technologies. The chapter also provides the gaps in the literature that the current study intended to fill and also presents theoretical and conceptual framework related to the study.

2.2 Smallholder Farmers Overview

Approximately 2.5 billion people live directly from agricultural production systems, either as full or part-time farmers, or as members of farming households that support farming activities (FAO, 2008). In fact, there is no universally accepted definition of a small farm. According to IFAD, (2013) small farm may refer to the number of workers; capital invested, or amount of land worked. Land size is the criterion most commonly employed, but given the differing potential of land in soil quality and rainfall, a single measurement hardly captures the sense of limited resources or relative powerlessness characteristic of smallholders. Overall, smallholder farmers are characterized by marginalization, in terms of accessibility, resources, information, technology, capital and assets, but there is great variation in the degree to which each of these applies (Murphy 2010). With these qualifications, the Food and Agriculture Organization of the United Nations (FAO) adopted a two hectare threshold as a broad measure of a small farm which is not inclusive of fishers and other small-scale food producers. In addition, smallholder farmers defined as those marginal and sub-marginal farm households that own or/and cultivate less than two hectares of land (Singh et al., 2002). On the other hand, according to the (IAASTD, 2009) there are 1.5 billion men and women farmers working on 404 million small-scale farms of less than two ha. However, the two ha farm size is not a universal characteristic. Smallholding sizes vary across regions from an average of 0.5 to 10 ha and even 500 ha are considered a smallholding in Australia (IAASTD, 2009).

Moreover, the definitions of this group vary according to the crop and context, and there are a wide variety of models of how smallholder farmers are integrated into global value chains (WIEGO, 2014). The term "smallholder" is widely understood to include small farmers who do not own or control the land they farm and "out-growers" is used to refer to smallholders who are in a dependent managed relationship with an exporter (WIEGO, 2014). Smallholders include some 350 million indigenous peoples, who conserve many different crop varieties and livestock breeds. Their agricultural practices and techniques offer an important source of knowledge for the transition to sustainable agricultural intensification (IFAD, 2013). Women play a crucial role within the smallholder system and are commonly responsible for the production of food crops, especially where the farming system includes both food and cash crops (World Bank, FAO and IFAD, 2009) for an overview of gender in agricultural systems. According to Wiesmann (1998), they make up 75 percent of the rural population, and thus also have a large influence on resource use and degradation. The farm sizes vary between one and 22 acres, with an average size of 5 acres what approximates 2 hectares (Lewis and Ndungu, 2006).

2.3 Smallholder farmers perspective in Africa

In Africa, according to the study conducted by Dixon et al (2003), smallholder farmers are categorized on the basis of the agro-ecological zones in which they operate; the type and composition of their farm portfolio and landholding; and/or on the basis of annual revenue they generate from farming activities. In areas with high population densities, smallholder farmers usually cultivate less than one hectare of land, which may increase up to10 ha or more in sparsely populated semi-arid areas, sometimes in combination with livestock of up to 10 animals (Dixon et al, 2003). Moreover, smallholder farmers are defined in various ways depending on the context, country and even ecological zone and in addition the term smallholder is interchangeably used with small-scale, resource poor and sometimes peasant farmer. Additionally, the term "smallholder farmers" has been defined by Adeleke et al. (2010) as those farmers owning small-based plots of land on which they grow subsistence crops and one or two cash crops relying almost exclusively on family labour. And also, most smallholder operations occur in farming systems in the family at the center of planning, decision-making and implementation, operating within a network of relations at the community level. In fact, most African smallholder farmers defined on the basis of land and livestock holdings, cultivate less than 2 hectares of land and own only a few heads of livestock (Adeleke et al., 2010). Therefore, in most cases the terms of smallholder only refer to their limited resource endowment relative to other farmers in the sector.

And as indicated by the Republic of South Africa (2012) at www.nda.agric.za, additionally, smallholder farmers are the drivers of many economies in Africa even though their potential is often not brought forward. One of the main characteristics of production systems of smallholder farmers are of simple, outdated technologies, low returns, high seasonal labour fluctuations and women playing a vital role in the production. Smallholder farmers play an important role in livelihood creation amongst the rural poor. Even though smallholder production is important for household food security, the productivity of this sub-sector is quite low. There is therefore a need to significantly increase the productivity of smallholder farmers to ensure long term food security. This can be achieved by among others, encouraging smallholder farmers to pursue sustainable intensification of production through improved inputs.

2.3.1 Smallholders farmers and Agriculture in Rwanda

In case of Rwanda, most land in Rwanda is formed by very small holdings, primarily for household subsistence. More than 60 percent of households cultivate less than 0.7 ha, 50 percent cultivate less than 0.5 ha and about 30 percent cultivates less than 0.2 ha (www.ifad.org). The average size of small holdings is little more than half a hectare and relatively low yields are major concerns for Rwandan agriculture. Small farming system that relies mainly on family labor is the backbone of agriculture production in Rwanda. Over 70 percent of the land in the country is under agricultural use and the Ministry of Agriculture and Animal Resources (MINAGRI) notes that land is exploited to the limits of agricultural possibilities and often beyond. The sector remains largely subsistence in nature, with 90 percent of output being food crops, with 66 percent of this production consumed in the household. Statistics produced by the GovR suggest that the most widely grown food crops include beans, bananas, sorghum, Irish potatoes, cassava and maize (Willoughby & Forsythe, 2011). Although, agricultural producers face a large number of both human and environmental challenges in Rwanda as well as small land holdings and population pressures represent a serious challenge to agricultural cultivation, the small-scale agriculture still plays a great role in Rwandan economy. In fact, smallholder agriculture represents the key livelihood activity for the majority of the Rwandan population, and is a significant driver for economic growth in the country. Agriculture occupies 79.8 percent of the labour force and crops such as tea and coffee account for 70-90 percent of total export revenues. The World Bank estimates that the sector contributes around 36 percent of overall GDP in the country (Willoughby & Forsythe, 2011).

2.3.2 Role of smallholder farming in agricultural production

Smallholder agriculture often shows an impressive productivity and is strategically contributing to food security. Many high-value crops, for example, rubber, and fruit and vegetables that require labour-intensive farming, perform best in well-developed smallholder agriculture than in other types of farming (HLPE, 2011) because of the favorable incentive structure in self-employed farming and the significant transaction and monitoring costs of hiring labour.

Many several studies have shown that smallholder agriculture has a greater role in global agricultural production. For example: China, has close to 200 million smallholdings, and according to Dan (2006), it has at least 250 million small family farms (Dan, 2006); they cover only 10 percent of the total amount of agricultural land that is globally available, and they produce 20 percent of all food in the world (Dan, 2006). This is an important indication of the productivity that might be achieved in smallholder agriculture. In Brazil, 58 percent of all milk is produced by household agriculture (www.saladeimprensa.ibge.gov.br), for chicken and pork this is respectively 50 percent and 59 percent. For coffee, the contribution of smallholders is 38 percent, for maize 46 percent, for beans, the contribution of smallholders reaches 70 percent and for cassava this is as high as 87 percent (www.ibge.gov.br). In Benin, the traditional sector, consisting of small-scale family-run units, provides 80 percent of the production of palm oil. This craft industry has always been able to adapt to changes in the upstream sector (variations in the volumes of raw materials offered by planters) and downstream (changes in demand), and covers most of the local market. New techniques have secured the stability of the sector. For palm oil, similar situations can be found in Nigeria and other West and Central African countries. Other products can also be mentioned, in so many ways, by craft industries often run by women: making *farinha* out of cassava in Brazil, or *tempe* from soybeans in Indonesia (CGPRT, 1988), with tens of thousands of production units. Smallholder agriculture plays a major role in the national economy of many countries, particularly in least developed countries. This has been shown by Delgado, (1997) who affirms that smallholding farming in sub-Saharan Africa (SSA) is thought at present to account for 70 percent of total employment, 40 percent of total merchandise exports, and 33 percent of GDP on average, although the shares are much higher in many countries of the region. One-third to two-thirds of value added in manufacturing depend on the supply of agricultural raw material, mostly from smallholders. Furthermore, primary agricultural commodities account for large shares of total merchandise exports in the region, again, mostly from smallholders despite these achievements, economic conditions for smallholders in SSA have been especially tough.

One study done in Rwanda has found that farmers who sell coffee cherries to wash stations increase their annual expenditures by 17 percent compared with farmers who sell lower-quality parchment coffee (Murekezi & Scott, 2009). The same study indicates that since the reform, coffee farmers have increased their food consumption and their overall household expenditures, leading to improved food security and to generally improve economic conditions for coffee smallholder farmers. Again, in a survey of 239 farmers and coffee-washing station workers, (Tobias & Boudreaux, 2011) asked farmers to identify the benefits they received as a result of being a member of a coffee cooperative. Farmers listed a number of direct financial benefits, such as increased prices received for their cherries, employment opportunities and better and easier access to loans, particularly access to credit to purchase inputs such as fertilizers. Farmers also noted that their families are now better fed, that they are able to hire laborers, that they have helped with marketing and sales, and that they receive some medicines for free. And they stated that they benefit from socializing with and learning from others, this means they have increased or improved their experiences.

2.4 Land and Soil Degradation

2.4.1 Globally

Land degradation remains a major threat to the world's ability to meet the growing demand for food and other environmental services. It is complex and involves the interaction of changes in the physical, chemical and biological properties of the soil and vegetation (NRC, 1994). The complexity of land degradation means that its definition differs from area to area, depending on the subject to be emphasized. A review of the literature reveals a wide range of definitions of land degradation (GLASOD, 1988; UNCCD, 1994; Hill et al., 1995; Bai et al., 2008). All these definitions point to a state of the land losing its capacity to provide the services intended. This study adopted the defining of land degradation as presented by Reynolds (2001) which states that: land degradation is a persistent reduction in the biological and economic productivity of terrestrial ecosystems, including soils, vegetation, other biota, and the ecological, biogeochemical and hydrological processes that operate therein.

Land degradation is a gradual negative environmental process which can be accelerated by human activities. The negative effects generally touch on food security, economic well being, and environmental conditions; thus explaining the reason behind much attention given to land degradation worldwide (IFPRI, 1997). Forms of degradation vary with the causative factors: loss of topsoil, terrain deformation mass movement or water and wind erosion, loss of nutrient and organic matter, salinization, alkalinization, acidification, pollution (chemical deforestation, compacting, crusting waterlogging substance of organic soils (physical deterioration) of the total degraded area, overgrazing, agricultural mismanagement, deforestation and over exploitation of natural resources are said to account respectively for 49,24,14, and 13 percent (Oldman et al 1991; Batjes, 2001 and IFPRI, 1997). Farmland degradation can also have important negative effects of the farm, including deposition of eroded soil in streams or behind dams, contaminations of drinking water by agrochemicals and loss of habitat (IFPRI, 1997).

Various sources suggest that 5 to10 million hectares are being lost annually to severe degradation. If this trend continues, 1.4 to 2.8 percent of total cropland, pasture and forest land will have been lost by 2020 (IFPRI, 1997). And as stated once more by IFPRI (1997) that, by the year 2020, land degradation may pose a serious threat to food production and rural livelihoods, particularly in poor and densely populated areas of the developing world. Research done by IFAD, (2002) highlighted some figures showing soil degradation. Human induced soil degradation affects around 1.035 million hectares. Of this total: 45 percent is affected by water erosion, 42 percent by wind erosion, 10 percent by chemical deterioration and 3 percent by physical deterioration of the soil structure. As shown by these percentages, water erosion is the most dominant form of degradation and wind erosion in the developing world. The later one is dominant in arid zones. The largest area affected is in Asia and Pacific, with about 550 million hectares. In Africa, an estimated 500 million hectares of land have undergone soil degradation since 1950, including 65% of the regions agricultural land. The main direct drivers (pressures) contributing to land degradation in sub Saharan Africa (SSA) are non-sustainable agriculture, overgrazing by livestock, and overexploitation of forests and woodlands. The need to produce more food for the rapidly increasing human population has led to the rapid expansion of agricultural land and the shortening of the fallow periods in traditional, extensive land-use systems, which have reduced the regeneration of soil fertility through natural processes (Finegan & Nasi, 2004). Today, close to 33% of the earth's land surface is devoted to pasture or cropland (de Sherbinin, 2002). Land degradation affects about 300 million hectares of land in Latin America while in North America; about 95 million hectares are affected as well as in Europe, 157 million hectares affected by water and wind erosion alone. The research again shows that the land degradation is a global issue that the world of today is facing with. For example, in China alone, between 1917 and 1990, the area of arable land was reduced by an area equal to all the crop land in Denmark, France, Germany and The Netherlands combined mainly because of land degradation. Much of the recent increase in area under agricultural land continues to occur mostly in developing countries, mainly Africa and Latin America (Houghton, 1994).

2.4.2 The Status of Land degradation in Africa

Nearly one thousand million hectares of vegetated land in developing countries are subjected to various forms of degradation, resulting in moderate or severe decline in productivity. About 490 million hectares in Africa are affected by different types of degradation from the approximately 2976 million hectare total land area in Africa. Of this total land, 72 percent are problem of soil with different production constraints such as soil acidity, low fertility, saline and poorly drained soils. Poor and inappropriate soil management is the main cause of physical and chemical degradation of cultivated land (Nabhan et al, 1997)**.** Sub-Saharan Africa is particularly vulnerable to threats of natural resource degradation and poverty. This is due to various factors, including a high population growth rate and increasing population pressure, the reliance on agriculture that is vulnerable to environmental change, fragile natural resources and ecosystems, high rates of erosion and land degradation, and both low yields and high post-harvest yield losses. On top of this can be added sensitivity to climate variability and long-term climate change (TERRAFRICA, 2011).

High population growth and migration in response to the shortage of land resources are important factors contributing to the degradation of agricultural land in SSA population continue to grow at higher rates than any other region of the world (3 percent per year) (Diagana, 2003). FAO estimates of the actual supporting capacity of land range from 10 to 500 persons per square kilometers. Reviewing data from 37 countries in SSA, Drechsel et al. (2001) confirmed a significant relationship between population pressure, reduced fallows and soil nutrient depletion. This indicates a generally unsustainable nexus between population, agriculture and environment that leads through a downward spiral into a poverty trap (Diagana, 2003). Degradation was found to be increasing in most sites, primarily caused by inappropriate soil management.

In some way, land degradation appeared to be caused most frequently by population pressure, insecure land tenure, and poverty in combination with aspects of governance, institutional functioning, and politics (WOCAT, 2012). For example, in Somalia, land degradation is under three groups of types: soil degradation, biological degradation and water degradation. Soil degradation occurs when the soil chemicals or physical conditions have been altered. While biological degradation includes: loss of biomass, biodiversity and loss of soil life. The most common types in Somalia, loss of vegetation cover, loss of vegetation species, loss of habitat and reduction of biomass (IFPRI, 1997). In Kenya, classification of Landsat imagery for the period 1973, 1988 and 2003 showed that there were significant changes in land use, land cover (LULC) in the western Kenya districts in the area under agricultural activities, increasing from 28 percent in 1973 to 70 percent in 2003 while those under wooded grassland decreasing from 51 percent to 11percent over the same period. Detailed field observation and measurements showed that over 55 percent of the farms sampled lacked any form of soil and water conservation technologies. Sheet erosion was the most dominant form of soil loss observed in over 70 percent of the farms. There was a wide variability in soil chemical properties across the study area with values of most major properties being below the critical thresholds needed to support crop production. Notable was the high proportion, 90 percent of farms with slightly acidic to strongly acidic (pH 5.5) soils. Over 55% of the farms had less than 2 percent soil organic carbon. In SSA concerted efforts to deal with land degradation through SLM must address water scarcity, soil fertility, organic matter and biodiversity. SLM seeks to increase production through both traditional and innovative systems, and to improve resilience to the various environmental threats (TERRAFRICA, 2011).

2.4.3 The case of Land Degradation and Land Use Consolidation in Rwanda

The increase in degradation processes acting on hill slopes eventually lead to excessive deposition in the valley bottoms, conditions which, over time, can precipitate flood damage and the destruction of lowland crops. Decreasing soil fertility, for example, reduces vegetation cover which, in turn, increases the potential for soil loss and even lower fertility. The study conducted by Clay & Lewis (1996) showed that farmers themselves said that the productivity of the land is declining and that often this is due to soil erosion. Farmers have observed a decline over time in the productivity of a full 50 percent of their holdings. Two reasons for the declining productivity of the farmers' farms focus on: over-cultivation and soil erosion. This study also stated that near half 48.7 percent of the fields identified as declining in productivity are believed by their operators to be over-cultivated- undoubtedly, to the gradually disappearing use of fallow periods in the crop rotation cycle. Secondly, only to over- cultivation as a perceived cause of declining productivity is soil erosion.

The conservation of scarce land resource is essential to the long-term viability of agriculture in Rwanda. High population density, steep slope abundant rainfalls prevail in the highland portions of this country, making the task of erosion control uncommonly difficult for the farmers. And over 90 percent of all households draw their livelihood from agriculture. Population pressure in Rwanda has pushed farmers onto increasingly fragile lands. Without proper attention, the downward spiral of environmental deterioration in affected areas will be inevitable. In the northwest region, where the potential for agricultural productivity is high, the expansion of agriculture onto marginal lands is already resulting in serious slope failures (slumps and landslides) (Nyamulinda, 1988).

A UN Food and Agriculture Organization (FAO) study in 2006 noted that the country faces moderate to severe soil erosion on 50 percent of its land surface. MINAGRI has attempted to address this problem through a program of soil erosion protection. Similar to other countries in

East Africa, unpredictable rainy seasons, prolonged droughts, flood and landslides create added challenges (Willoughby & Forsythe, 2011).

With these challenges occur in Rwandan agriculture, the government has introduced the program of Land Consolidation. Land consolidation, however, is generally considered as putting together small plots with the aim of making them viable and more productive per unit of investment, through economies of scale. These need not change the amount of land controlled by individuals, and is therefore not necessarily an instrument for social justice (Zhou, 1999). Land consolidation is not a new concept, and has been implemented in different a number of countries. One study has shown that it is believed that land consolidation was practiced around 1060 B.C.in China and 300 B.C. during the Roman Empire. And land consolidation was in practice in Europe since the Middle Ages and the current practices date back to the 19th and 20th centuries (Vitikainen, 2004). Practices of land consolidation are found today in Germany, the Netherlands, France, Belgium, Luxembourg, Austria and Switzerland, as well as Finland, Norway, and Sweden. There has been considerable land consolidation in Eastern European countries after the reform of socialist production systems that had resulted in fragmented property rights. In the whole of Western Europe by early 1990s land consolidation involved a quarter of all cultivated land, which is in excess of 38 million hectares of agricultural land (Vitikainen 2004).

The land use consolidation policy was implemented for the first time in 2008 by the Government of Rwanda, through the Ministry of Agriculture, as part of the Crop Intensification Program (CIP). The CIP was initiated by the same Ministry in September 2007 with a goal to increase agricultural productivity of high potential food crops and to provide Rwanda with greater food security and self-sufficiency. The implementation of this program involves various components, including Land Use Consolidation as the main pillar, the proximity advisory services to farmers, inputs (seeds and fertilizers) distribution and post-harvest technologies (e.g. driers and storage facilities).

2.4.4 Impact of global land degradation on agricultural production

Globally, there are few studies of the impacts of degradation on agricultural production. An analysis of results of GLASOD (IFPRI, 1997), has shown that there has been a 17 percent cumulative productivity less over 45 years as a result of degradation. During that same period, growth in global food production and long-term declines in grain prices were unprecedented, clearly other factors offset the effects of degradation on aggregate performance. A study of the impact in Africa based on field data estimated that yield reductions due to past erosion may range from 2 percent to 40 percent with a means of 8.2 percent for the continent and 6.2 percent for sub Saharan Africa. If the accelerated erosion continues unabated, yield reduction by the year 2020 may be 16.5 percent for the continent and 14.5 percent for sub Saharan Africa. Evidence from four Southeast Asians and three Middle Eastern countries indicates a degradation induced decline in productivity, greater than 20 percent (IFPRI, 1997). Removal of a 5 cm layer of topsoil has a greater impact on a poor shallow soil than on a deep fertile soil. Therefore, relative changes of the soil properties are better indicators of soil degradation: the percentage of the total topsoil lost, the percentage of total nutrients and organic matter lost, the relative decrease in soil moisture holding capacity, changes in buffering capacity, etc (van Lynden & Oldeman, 1997).

2.5 Sustainable Livelihoods

The sustainable livelihoods idea was first introduced by the Brundtland Commission on Environment and Development, and the 1992 United Nations Conference on Environment and Development expanded the concept, advocating for the achievement of sustainable livelihoods as a broad goal for poverty eradication. Of the various components of a livelihood, the most complex is the portfolio of assets out of which people construct their living, which includes both tangible assets and resources, and intangible assets such as claims and access.

According to different organizations, DFID (1999) and FAO (2006) as well as various authors, including Chambers & Conway (1992); (Krantz, 2001) and Scoones (1998), Sustainable livelihood was defined as: a livelihood which comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks, maintain or enhance its capabilities and assets, while not undermining the natural resource base. Further, livelihood is also sustainable when it contributes to net benefits to others livelihoods at the local and global levels and in the short and long term (Chambers & Gordon, 1992). Besides, the important activities required for a means of living may include crop and livestock production, fishing, hunting, gathering, bartering, and other endeavors and income generating activities (including off-farm work).

So far, Morse et al., (2009) stated that SLA is an example of the multiple capital approach where sustainability is considered in terms of available capital (natural, human, social, physical and financial) and an examination of the vulnerability context (trends, shocks and stresses) in which these assets exist. The framework also offers a way of assessing how organizations, policies, institutions, cultural norms shape livelihoods, both by determining who gains access to which type of asset, and defining what range of livelihood strategies are open and attractive to people (Carney, 1998). On the word of DFID (1999), Sustainable Livelihood has three main elements: Livelihood resources, Livelihood strategies, and Institutional processes and organizational structures. And it is better to note that livelihoods vary significantly within a country, from rural to urban areas, and across countries (FAO, 2006).

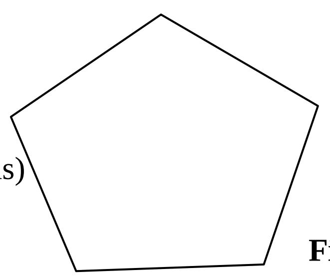
Vulnerability Context

Vulnerability context refers to the seasonality, trends, and shocks that affect people's livelihoods. The key attributes of these factors are that they are not susceptible to control by local people themselves, at least in the short and medium term (DFID, 2000).

In the livelihoods approach, resources are referred to as 'assets' or 'capitals. However, five principal assets (or capitals) are recommended as important to the livelihood and they are presented as a pentagon in Figure 2.1.

Natural capital
(Natural resources, including land, water, air etc and environmental services)

Social Capital
(Network, social relations, associations)



Human capital
(Ages, labour, skills, knowledge, etc.)

Physical Capital
(Equipment, buildings, roads)

Financial capital (income, credit/savings, other economic assets)

Figure 2.1: The five capitals of sustainable livelihood (Scoones 1998)

Policies and institutions

As defined by DFID (2000) policies and institutions are those which influence rural household's access to livelihood assets and are also important aspects of livelihood framework. Institutions are the social cement which link stakeholders to access to capital of different kinds to the means of exercising power and so define the gateways through which they pass on the route to positive or negative livelihood adaptation (Scoones, 1998).

Livelihood strategies

According to (DFID, 1999) the term livelihood strategies are defined as the range and combination of activities and choices that people make in order to achieve their livelihood goals, including productive activities, investment strategies, reproductive choices, etc. Livelihood strategies are composed of activities that generate the means of household survival and are the planned activities that men and women undertake to build their livelihoods (Ellis, 2000).

Livelihood outcomes

Livelihood outcomes are the achievements of livelihood strategies, such as more income (e.g. cash), increased well-being (e.g. non material goods, like self-esteem, health status, access to services, sense of inclusion), and reduced vulnerability (e.g. better resilience through increase in asset status), improved food security (e.g. increase in financial capital in order to buy food) and a more sustainable use of natural resources (e.g. appropriate property rights) (Scoones, 1998)

2.6 Soil and Water Conservation Technologies

2.6.1 Definitions and classification of soil and water conservation

i.Sustainable Land Management

Like other composite approaches to agricultural development, soil and water conservation (SWC) has numerous definitions. Over time the conception of SWC has changed from an initial emphasis on structures to reverse soil erosion to an important part of sustainable land management. UN Summit (1992) and WOCAT have defined Sustainable Land Management (SLM) as the use of land resources, including soils, water, animals and plants, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions. At the same time as, TerrAfrica partnership (2005) has further defined sustainable land management as the adoption of land use systems that, through appropriate management practices, enables land users to maximize the economic and social benefits from the land while maintaining or enhancing the ecological support functions of the land resources (FAO, 2009). Sustainable Land Management (SLM) is crucial to minimizing land degradation, rehabilitating degraded areas and ensuring the optimal use of land resources for the benefit of present and future generations.

Sustainable Land Management has also an objective of promoting human coexistence with nature with a long-term perspective so that the provisioning, regulating, cultural and supporting services of ecosystems are ensured. SLM is an essential prerequisite to sustainable development; progress should be made simultaneously at all levels. In terms of such concerns as food security, poverty alleviation, livelihood improvements, water conflicts and ecosystem services, SLM are an important local issue that is also a global concern (WOCAT, 2010).

ii.Sustainable Land Management Technologies

The study done by (WOCAT, 2012) found that combinations of SLM measures appeared to perform better than applying one type of measure by itself. The study highlighted thirty-eight SLM measures including; thirty for SLM technologies and eight for SLM approaches. The physical practices used in the field to control land degradation and enhance productivity. The SLM technologies, in other words could be divided into five groups: cropping management, water management, cross-slope barriers, grazing land management, and forest management. They addressed all the main types of land degradation and depending on the kind of degradation addressed, agronomic, vegetative, structural, or management measures were used, or some combination of these (WOCAT, 2012). Most of the technologies aimed to prevent or mitigate degradation; only a few were described as intended for rehabilitation. These are the physical practices in the field that control land degradation and enhance productivity in the field.

They are:

Agronomic (e.g. intercropping, contour cultivation, mulching),

Vegetative (e.g. tree planting, hedge barriers, grass strips),

Structural (e.g. graded banks or bunds, level bench terrace),

Management measures (e.g. land use change, area closure, rotational grazing).

Combinations of above measures which are complementary and thus enhance each other are part of a technology.

According to WOCAT (2007), four different conservation measures types exist: Agronomic, vegetative, structural and management measures. Agronomic measures include soil management, such as contour cultivation, direct planting, soil cover, crop mixtures and rotations. These measures are normally cheap but very effective. Manuring and composting also belong to these measures and have a big influence on soil fertility. Agronomic measures are normally linked with annual crops and repeated every year or cropping season. Usually, they are not permanent and do not change the slope profile. Vegetative measures such as grass strips, hedges, windbreakers or agro-forestry help to protect the ground and reduce the wind speed. These measures are of long duration and often causing a change in slope. Water competition between crops and the plants of the vegetative measures can cause problems if water is short. Special management is needed to reduce this competition. Terraces, bunds and banks are the structural measures. In most of the cases, they are built to prevent movement of eroded soil. The construction of such measures is related to earth movement and leads thereby to changes in slope profile. Structural measures require a considerable input for implementation and maintenance in terms of money and labor. Management measures involve a fundamental change in land management. They are often applied where degradation is much advanced and other conservation measures would not be useful until a land use change is accomplished. Such changes can take place, for example, in overgrazed areas. Uncontrolled grazing is stopped and the vegetation gets the possibility to recover. These changes in management are often not related to great costs, but in certain circumstances, the conservation of one part can increase the pressure in other areas. A combination of the measures described above is often applied by land users.

iii.Conservation Agriculture

Conservation agriculture (CA) is not just one simple approach, but a combination of different principles. After the FAO (2007), Conservation agriculture is a concept of resource-saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment. CA is based on enhancing natural biological processes above and below the ground. Interventions such as mechanical soil tillage are reduced to an absolute minimum, and the use of external inputs such as agrochemicals and nutrients of mineral or organic origin are applied at an optimum level and in a way and quantity that does not interfere with, or dispute, the biological processes. CA is characterized by three principles which are linked to each other, namely: (i) Continuous minimum mechanical soil disturbance, (ii) Permanent organic soil cover, (iii) Diversified crop rotations in the case of annual crops or plant associations in the case of perennial crops. To achieve the full advantage of CA, all three principles have to be applied. If one is neglected, it becomes more difficult to practice CA. As an example, more fertilizers or pesticides are needed. As a result, the whole system becomes less sustainable (Bwalya and Friedrich, 2002).

iv. Soil and Water Conservation Technologies used in Rwanda

As described by REMA (2010), the soil and water conservation measures used are for sloping land in order to sustain agriculture and Agroforestry production. There are various measures and application of soil and water conservation used in the whole country. However, with population pressure on mountain areas showing no signs of diminishing, it is becoming increasingly clear that watershed protection is vital to increase upland production while providing the necessary protection. Watershed rehabilitation generally requires land use adjustment measures which contribute to a reduction in soil erosion rates, and at the same time increase rural employment and income. The three main techniques considered are agronomic or biological measures, soil management strategies and mechanical or physical methods. Suggested measures in these on-farm erosion control strategies are: Agronomic or biological measures utilize the role of vegetation in helping to minimize erosion. Soil management is concerned with ways of preparing the soil to promote dense vegetation growth and improve its structure so that it is more resistant to erosion. Mechanical or physical methods depend upon manipulating the surface topography, for example, by installing terraces to control the flow of water. Mechanical measures are largely ineffective on their own because they cannot prevent detachment of soil particles. Their main role is in supplementing agronomic measures, being used to control the flow of any excess water that arises (REMA, 2010). Mechanical methods, including bunds, terraces, waterways, and structures such as vegetative barriers or stone lines installed on farm also can break the force of winds or decrease the velocity of runoff to reduce soil erosion.

In general, when deciding what conservation measures to employ, preference is always given to agronomic treatment. These are usually less expensive and deal directly with reducing raindrop impact, increasing infiltration, reducing runoff volumes and decreasing water velocities while mechanical measures are effective soil conservation technologies as they reduce soil loss (REMA, 2010). The most soils and water conservation used in Rwanda are presented in Table 2.1.

Table 2.1: Major soil and water conservation measures used in Rwanda

Agronomic or biological measures	**Soil management strategies**	**Mechanical or Physical Methods**
Mulching Crop Management -Cover crops -Improved fallows -Intercropping -Planting Pattern/Time -Crop rotation Agroforestry	Conservation Tillage -Minimum tillage -Improved tillage -No-till Contour Tillage Strip farming	Terracing Contour Bunds Infiltration Galleries Waterways Gully Controls -Stabilization structures -Stone check dam -Gabion Baskets -Reno Mattresses -Stone lining

Source: REMA, 2010**.**

Various studies done in Rwanda are based on dissemination of soil and water conservation technologies, cost-benefits of terraces and the role of the Agroforestry system in improving soil properties especially on steep slopes of the country. One research conducted in Rwanda has shown that the use of living hedges has greatly improved the soil properties where after 2 years, living hedges reduced runoff to less than 2 percent and erosion, they produced fire wood and high quality leguminous forage and returns to the soil as much as 80 to 120 kg/ha/year of nitrogen, 3kg/ha/year of phosphorus, 30 to 60 kg/ha/year of calcium and potassium, 10 to 20 kg/ha/year of magnesium (Eric & Francois, 1997). Again, findings of a study based on soil and water conservation investments in Rwanda showed that 76.2 percent of farm holdings have received investments in the form of radical terraces, hedgerows, grass strips, or anti-erosion ditches, and that such investments are concentrated on the steeper slopes (Clay & Reardon, 1994)**.**

v. SWC technologies in Burega Sector of Rulindo District

The land in the study area is very hilly and susceptible to high soil erosion. They are using organic fertilizers, terraces, normally, the LWH and government have helped the farmers by providing them training on how to make the land more productive by shifting from substance farming system to the agricultural market oriented system, which will help farmers to develop themselves and getting high yields of agricultural productivity.

2.6.2 Different studies done on SLM and CA

Various studies have been done on Sustainable Land Management. The study carried out in Laikipia and Meru Districts, Kenya showed that farmers highlighted some reasons for adopting Conservation Agriculture, including: economic factors such as crop protection, human factors such labor and natural factors such as soil conditions. Furthermore, in this study, farmers have also given other reasons indicating that there are two important elements for adoption of CA; first of all, farmers have to be aware of their situation and recognize that runoff, soil erosion, high evaporation losses and other factors reduce the productivity of their farms. Secondly, farmers have to be informed about the possibilities of CA and experience the advantages of the technologies on their own, for example on field visits. And also farmers have said that CA is cheap and less labor intensive. Additionally, according to the research conducted by Simon et al., (2012) and Alufah et al., (2012) household size, perception of the soil erosion problem, training in soil erosion control, land ownership and access to institutional credit had significant effects on the adoption of SWC technologies. A research conducted by Toborn (2011) showed that size of farm holding is a surrogate for a large number of potentially important factors such as access to credit, capacity to bear risk, access to scarce inputs (water, seeds, fertilizers, insecticides), wealth, access to information, and so on. Since the influence of these factors varies in different areas and over time, so does the relationship between holding size and adoption behavior. One more study revealed that age, distance of farm, slope of cultivated land and membership of an organization or group has a positive influence on the adoption of SWC technologies. On other hand the analysis of the interviews during the research indicated that factors that have to take into consideration in order to increase the rate of adoption: first, non-CA farmers have to realize that runoff, soil erosion and high evaporation losses reduce the productivity of the farms, secondly, farmers have to be aware of the advantages related to CA technologies and third, farmers have to be attended and supported during the phase of adoption (Natalie, 2008) while according to Simon et al., (2012) and Alufah et al., (2012); education, distance of farm from homestead and number of farm parcels have negative effect on adoption of SWC technologies in the catchment.

It was clear from the study findings that farmers consider personal characteristics, socio-economic, institutional, technology attributes and other exogenous factors before adopting SWC technologies in the catchment. The findings of the study reinforce the fact that in order to achieve sustainable watershed management, institutional and economic factors should be given special attention (Simon et al., 2012). As revealed by Toborn (2011) FAO has published the criteria used to explain adoption of SWC technologies, including i) farmer and farm household characteristics, ii) farmer biophysical characteristics, iii) farm financial/ management characteristics, and iv) exogenous factors.

During the study conducted in Kenya by Alufah et al., (2012) terracing, tree planting, agroforestry, cover cropping, mixed cropping and contour vegetation strip were major SWC technologies in the area. An important point found during one research conducted by (Waga & Jermias, 2013), is that a mixed picture where plots without SWC generally have higher yield values per hectare. These plots with SWC however, are significantly steeper and more eroded than plots without SWC. And also an additional research has shown that comparing SWC technologies to plots without SWC indicated that SWC increased the returns from degraded plots and sometimes from other inputs (Nyangena & Köhlin, 2008). Soil erosion and shortage of drinking water have been identified as serious problems of the community and farmers lose more than 2 hours per day to fetch water (Waga & Jermias, 2013).

And according to the findings of a research done by Gebreselassie et al (2009), showed that the cause of soil erosion were identified as the nature of the topography, high and erratic rainfall patterns, extensive deforestation, continuous cultivation and complete removal of crop residues from the field, overgrazing and free-grazing, improper farming practices and development efforts, overpopulation and poverty, socioeconomic problems, lack of awareness on the effect of erosion, and poor land use policy enforcement. Further, these findings of Gebreselassie et al (2009) also confirmed that soil bunds stabilized with vegetative measures are better held the soil in-situ and improve inter-terrace soil physical and chemical properties compared to the non-conserved fields. Additionally, the results of the experiment in this study indicated that organic carbon (OC), total nitrogen (N), bulk density, infiltration rate, bund height, and inter-terrace slope are significantly affected by soil conservation measures. The non-conserved fields had a significantly lower organic carbon, total nitrogen, and infiltration rate; whereas higher bulk density as compared to the conserved fields with different conservation measures. However, no significant differences in bulk density were observed among the conservation methods (Gebreselassie et al., 2009).

Furthermore, another research conducted in Ethiopia by Yenealem et al. (2013) indicates that on average participant households earned 8.3 percent more crop production value per hectare and 21.2 percent more gross household income than their matches. Therefore, in agricultural dependent countries, soil and water conservation is crucial in improving the livelihoods of the rural farm households The appraisal study by Keyser & Mwanza (1996) conducted in Mumbwa, Zambia, noted differential income for the user of conservation farming techniques in the order of 45-60 percent over and above the users of conventional farming. The article, reviews of adoption of conservation technologies in Sub-Saharan Africa undertaken by Haggblade et al., (2004) also recognize the likely potential in financial incentives of soil conservation practices. Smallholder farmers in the micro-catchment who adopts SWC technologies attain higher productivity. Knowler & Bradshaw (2007) draw interesting conclusions from a review and synthesis of recent research on conservation agriculture. Based on 130 financial analyses of conservation agriculture and other soil and water conservation in Sub-Saharan Africa and Latin America/Caribbean, the authors conclude that the former produced positive net present value in 90 percent of the cases, the latter in 58 percent of the cases. Since the adoption of CA is still low with some notable exceptions, what other factors are at play when farm finance impact seems positive.

2.7 Gaps from Literature Review

A lot has been done on factors of adoption of soil and water conservation technologies, dissemination of soil and water conservation technologies. In Rwanda, the studies on SWC technologies deals mainly with dissemination of soil and water conservation technologies, factors of adoption of soil and water conservation technologies, cost-benefits of terraces and the role of the Agroforestry system in improving soil properties and the impact of soil erosion and land degradation on agricultural productivity. The dissemination and assessment of cost of technologies are not enough to get the benefit from the SWC technologies in the country and it is necessary to assess whether they conduct various environmental impacts. Despite of these previous studies, the country still remains need more effort to conserve natural resource and minimize the high erosion occurring in the country. This is exacerbated by the high and many hills which are susceptible to the severe high erosion as well as the lack of fallow period because of land fragmentation. This particular study was conducted in a new geographical area where such study has not been carried out before. From literature, the economic, human and environmental factors do not contribute to the adoption equally and the adopted SWC technologies are different; some are highly adopted than others, but WOCAT showed that the combination of many various technologies has great effect on natural resource management. So, as it has shown in literature, adoption is caused by many various factors. This study tried to fill the gap by determining the factors which contribute to the adoption of various SWC technologies, their effects on the livelihoods of smallholders and their benefits as well as the environmental impact of ISWC technologies in the study area. This is based on three theories.

2.8 Theoretical and Conceptual Framework

2.8.1 Theoretical Framework

Soil and water conservation technologies have always occupied a central role in solutions to land degradation problems. This started as early as the 1930s, when colonial governments became concerned with land degradation issues (Anderson 1984; Stocking 1985; Swift 1996). More recently, as rapidly growing populations in Africa have become a concern in the international arena, soil and water conservation technologies are seen as the means through which to obtain the necessary increase in agricultural production without degrading the land (Valentina & David, 2000). Some theories have been used to explain the focus of using ISWC technologies. Ecosystem services theory, land use theory and Esther Boserup (1965) on the relationship between population growth and agricultural change are used.

Theory of ecosystem services:

According to Millennium Ecosystem Assessment (2003), ecosystem services have been defined as the benefits people obtain from ecosystems. These include provisioning, regulating, and cultural services that directly affect people and supporting services needed to maintain the other services. With this model, humans may affect the ecosystem services by anthropogenic activities while also human intervention can increase some services, though often at the expense of other ones. Thus, human interventions have dramatically increased food provisioning services through the spread of agricultural technologies, although this has resulted in changes to other services such as water regulation. As an ecosystem is typically composed of a number of different regions, such as forest, agriculture, and urban areas, each of which produces a different bundle of services. In an ecosystem, both the production of services from each area and the flows of materials between areas must be assessed. Any change in an ecosystem may affect the all ecosystem services. Agricultural production, for example, can be maintained through the addition of fertilizers and through new crop varieties, new advanced agricultural technologies even while the productive potential of the ecosystem is degraded through soil erosion. These include provisioning services such as food and water; regaling services such as flood and disease control; cultural services such as spiritual, recreational, and cultural benefits; and supporting services, such as nutrient cycling, that maintain the conditions for life on Earth.

Land use theory:

According to Wood et al., (2000), habitat destruction and plant species diversity loss stem from a complex combination of direct and indirect driving forces. Direct driving forces are those associated with the exploitation of natural resources at a local scale. These include changing land use of a particular niche as replacement of natural vegetation by cultivating land; expansion of agriculture in areas used for grazing, settlement expansion at the expense of natural vegetation and changes in cropping systems. Preparation of agricultural land, for example, involves clearing of vegetation, which in turn may reduce vegetation cover and either change or lead to a complete loss of primary vegetation. Similarly, settlement expansion at the expense of agricultural and grazing land is encroached for agriculture, the grazing area is reduced; the carrying capacity of the land is decreased instigating pressure on the pastureland and alteration of species composition. According to Wood et al., (2000), the underlying factors for changing resources use patterns include cultural perception of the local communities on forests and biodiversity, adopted or existing forest and land policies, change in forest management responsibilities, demographic changes, macro-economic policies and structure, and poverty and inequality. These responses may result into either improved natural resources use and management or negative impacts with such results as the degradation of a natural ecosystem and biodiversity loss. Demographics and socioeconomic change have a consequence on land use. Human population affects land use through production, recreation and consumption behaviors. In order to meet the food security and protect the environment, various technologies are introduced and promoted through various smallholders farming systems. And because of the rapid population growth and high population density per square kilometer, farming in hillside and marshland have been promoted which in turn result in land use in order to satisfy high food demand for population. The use of these SWC technologies will lead to agricultural productivity, soil erosion decrease and environmental protection.

Esther Boserup theory of agricultural transformation (1965):

This was one of the first development economists to theorize the relationship between population growth and agricultural change. In this theory, technologies play a central role in allowing the food production to grow along with the population. Boserup (1965) analyzed different trends of technological development of countries and continents over centuries and concludes that population growth provides the impetus for technological change. Boserup showed that the increased need for food and land scarcity caused by population growth was commonly countered by an intensified use of technologies in which more labor was used in conjunction with land improvement technologies. She showed that agricultural variability was simple and schematic. Its main point being that population density was the prime engine driving change in methods and technology in primitive agriculture. Land would be cultivated more intensively if more investments were made in permanent land improvement structures, as well as more careful husbandry could be practiced. Thus more people provide both the stimulus as well as the means to new kinds of land management and this rapid population growth induces greater frequency of cropping to meet food security. Because the maintenance of yields on land that is most frequently cultivated requires more labor inputs not only in farming but also into farm improvements such as soil conservation, irrigation, terracing, etc. With more frequent cropping and more labor investments, land tenure will shift from being tribal or feudal based on private property based. With a higher population density, the per capita cost of communication infrastructure is reduced. This will lead to cheap transport, which in turn creates local specialization between towns, thus raising demand for food and increasing farm-gate prices.

Farmers will earn higher incomes and they will be inclined to invest more labor and capital into farming. Increase in population results in greater consumption of natural resources, including land and water which lead to the use of all available land resources. This land scarcity has promoted the adoption of hillside and the marshland farming system in order to satisfy the increased population.

Due to the shortage of the land resources in the country as well as in the area of the study, have led to the land use change in order to get land for agriculture. Therefore, every single available land is being used in order to produce more crops to satisfy high population growth. This has led to the transformation of agriculture sector where have changed from traditional to modern agriculture. This transformation and pressures of agricultural activities resulted in serious changes of environment, including high soil loss, water resource pollution, soil fertility depletion, loss of vegetation cover as well as biodiversity, which in turn affect the ecosystem services and livelihoods of smallholders. In order to meet the demand of the growing population and reducing the negative impacts of agricultural development, various soil and water conservation technologies were introduced in the country and in the study area as well. The use of these SWC technologies could be presented in the DPSIR relationship framework along with ecosystem services and sustainable livelihood. Rising population pressure on resources within a constrained area frequently does force farmers to alter their production tactics, often demanding greater inputs in the process.

2.8.2 Conceptual Framework

In this study, DPSIR Framework (Figure 2.2.) in association with Sustainable Livelihoods and Ecosystem Services is used to help carrying out an integrated analysis of Soil and Water Management technologies in Burega Sector.

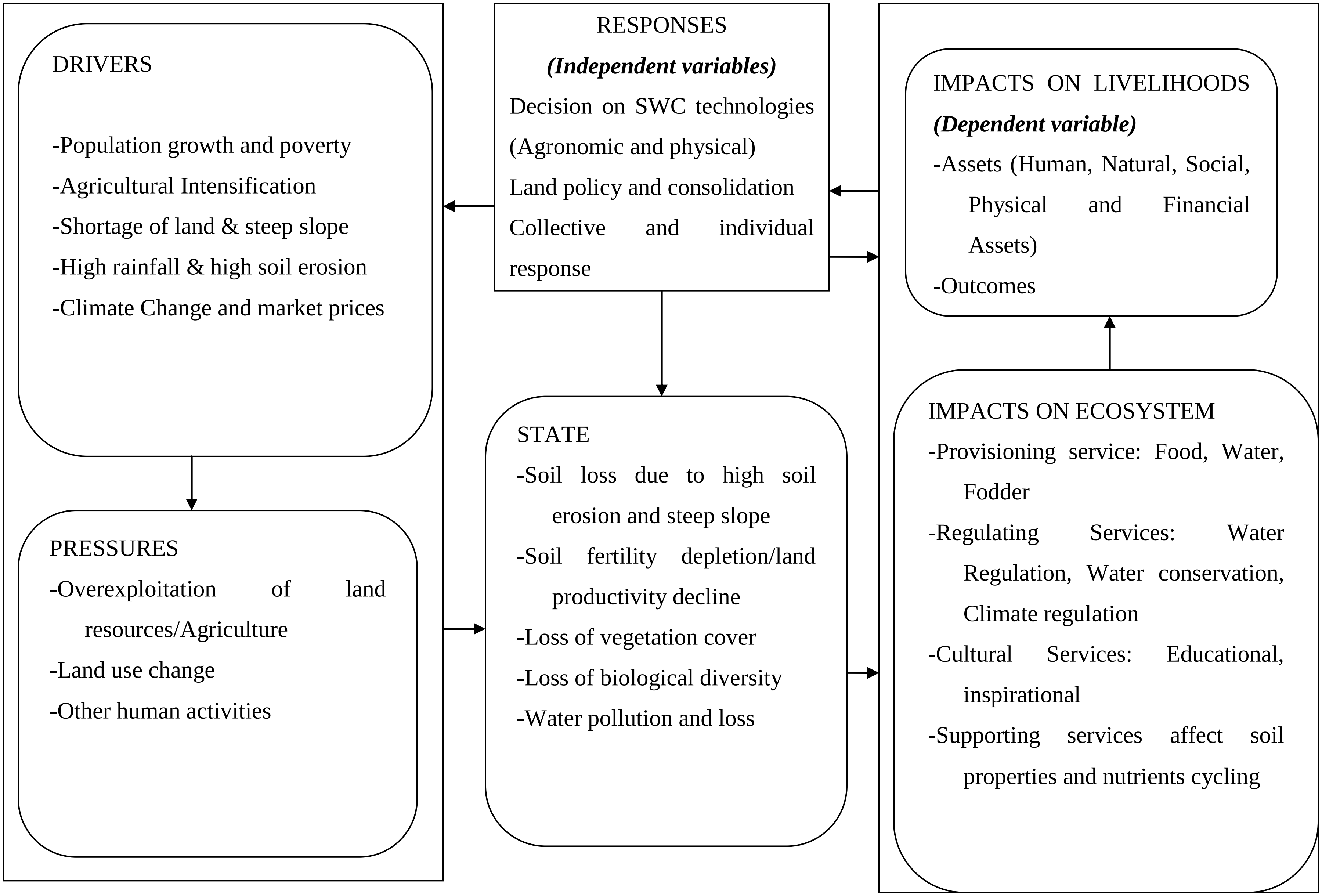


Figure 2.2 DPSIR Framework (Adapted and modified from (LADA, 2009))

In this study, drivers are the crucial factors promoting environmental change in Burega Sector. These driving forces are human activities which lead to the environmental changes. They comprise of agricultural intensification, rapid population growth, a shortage of land which is very hilly and excessive high rainfall along with soil erosion. These driving forces in this case produce different pressures, including overexploitation of land resources, water, changes in land use and other human activities related to the development of agriculture. Pressures are due to changes in the state of ecosystems in both the supply of ecosystem services and livelihoods of smallholders. As a result of the perception of sustainable livelihoods, government and society perform different responses to control the state as well as promoting the impacts of the adoption of these actions (responses). Therefore, the impacts can be understood as changes in the quality and functioning of the ecosystem service delivery to the society. And also, depending on the social perception of sustainable livelihood of people, government and society perform different actions (responses) to control or maintain the effects of these responses to the state of the environment as well as to the drivers.

CHAPTER THREE

THE STUDY AREA

3.1 Introduction

This chapter describes the area in which the research carried out. It provides the geographical description of Rwanda in general, location of the study area, population, climate, hydrology and vegetation characteristics.

3.2 Rwanda Description

Rwanda is a small and landlocked country. It is located in East Africa between latitudes 1°04' and 2°51' south and longitudes 28°45' and 31°15' east. Its surface area is 26.338 km^2. It is bordered by the Republic Democratic of Congo in the Western; Uganda in the Northern, Tanzania in the East and in the Southern is bordered by Burundi. The Rwandan relief is hilly and mountainous with an altitude averaging 1700 meters. The highest point on Mount Karisimbi is 4507 meters above sea level. Rwanda has volcanic mountains at the northern fringe and undulating hills in most of the central plateau. However, the eastern part of the country is relatively flat with altitudes well below (REMA, 2009).

The country is divided into three distinct regions according to the altitude: (i) the lowlands of the east lying between1000 m and1500 m, with annual rainfalls between 700 mm and 1000 mm, (ii) the central plateau with the altitude between 1500 m and 2000 m and annual rainfalls between 1500 mm and 2000 mm and (iii) the Congo-Nile River divide in the west, at altitudes between 2000 m and 3000 m and annual rainfalls between 1,500 mm and over 2000 mm. Soils in Rwanda vary widely according to the parent materials from which they are derived; most are acidic and are derived from alterations from granites and schists. Richer soils, derived from volcanic ash, prevail in the North. Soils in the rainfall, rich high mountains of the Congo-Nile divide and those in the hilly central plateau are particularly susceptible to erosion and are generally older, acidic and less fertile than the rest of the country (GovR, 2007). About 50 percent of all soils in Rwanda have a low aptitude for highly nutrient demanding crops, mainly due to their advanced level of erosion and acidity (MINAGRI, 2005). These combinations of altitude, rainfall and soil type determine the Agro-Ecological Zones of Rwanda (GovR, 2007).

There are four main vegetation types: closed evergreen mountain forests on the higher mountains to the north and south (virtually all within National Parks), savanna woodland to the drier east, mainly within an Akagera National Park, a variety of wetland types of shallow lakes to extensive papyrus swamps to ephemeral wetland patches floodplains. The fourth type is the man-modified cultivation landscape, which has lost most natural vegetation, but has a growing tree cover, mainly of exotic and fruit trees (GovR, 2007).

The population density has more than doubled since 1978 from 183 inhabitants per square kilometer (km^2) to 415 inhabitants per km^2 in 2012. Population density in the country is the highest in Africa. More than 80 percent of the Rwanda's projected population of 10.5 million depends on farming (IFAD, 2014).

Rwanda's economy is largely agrarian. The agriculture is the backbone of Rwandan economy; the country has the aim of transforming agriculture from substance farming to market oriented modern farming; with the vision which seeks to fundamentally transform Rwanda into a middle-income country by the year 2020. According to FAO (2007), Agriculture in Rwanda is dominated by small-scale, subsistence oriented family farming units. Approximately 1.4 million rural households depend on agriculture as their main livelihood source. These households produce a range of food crops (cereals, roots and tubers, bananas, fruits and vegetables), with approximately 66 percent of production destined for home consumption. The remaining 34 percent of production finds its way to local markets. Crops are produced mainly under rain-fed conditions using mostly family labor and little or no purchased inputs such as improved seed, fertilizer, and crop protection chemicals (MINAGRI, 2013).

Additionally, approximately 60 percent of households also keep animals for milk, eggs, and meat. These animals, are mainly local breeds, are raised using traditional low-input extensive grazing methods, although in the case of cattle the declining availability of pasture land is causing a shift to confined feeding with cut fodder supplemented by grain and/or roots and tubers. A minority of rural households also produces export crops, the most important of which are coffee (cultivated by approximately a one third percent of all rural households) and tea (cultivated by less than 1 percent of all rural households). Due to the small average farm size in

Rwanda, of less than 0.7 ha, it is essential to raise the economic productivity of existing farmland. This means increasing physical productivity through better technologies and input usage that generates higher yields and moving to a higher-value mix of outputs (including livestock as well as crops). It is paramount, though, that these changes take place without compromising future productivity and the incomes of future generations (MINAGRI, 2013).

Through Second Economic Development and Poverty Reduction Strategy (EDPRS II), Rwanda in general needs to achieve at least 11.5 per cent average GDP growth per annum, and also aims to reduce poverty to below 30 per cent. It is focused on ensuring that poverty is reduced from 44.9% to below 30% by 2018. This will be achieved through focus on increased productivity of agriculture, which engages the vast majority of the population and ensures sustainable poverty reduction (GovR, 2013).

3.3 Study Area Location and Description

The study was conducted in Burega Sector which is located in Rulindo District; Northern Province of Rwanda. The Rulindo District is one of five Districts which made Northern Province; the others are Gakenke, Burera, Gicumbi and Musanze. The District has 17 administrative Sectors, 71 Cells and 494 Villages with an estimated total population of 288,452 of which 136,058 are males while 152,394 are females according to the provisional population census results 2012. It is around one hour drive from Kigali City. Burega Sector is one of seventeen Sectors of Rulindo District and is located in the western part of this District. And it is composed by three cells Karengeri, Butangampundu and Taba. Rwanda is organized into 4 Provinces and Kigali city, thirty Districts, 416 Sectors, 2148 cells and 14837 villages (NISR, 2012).

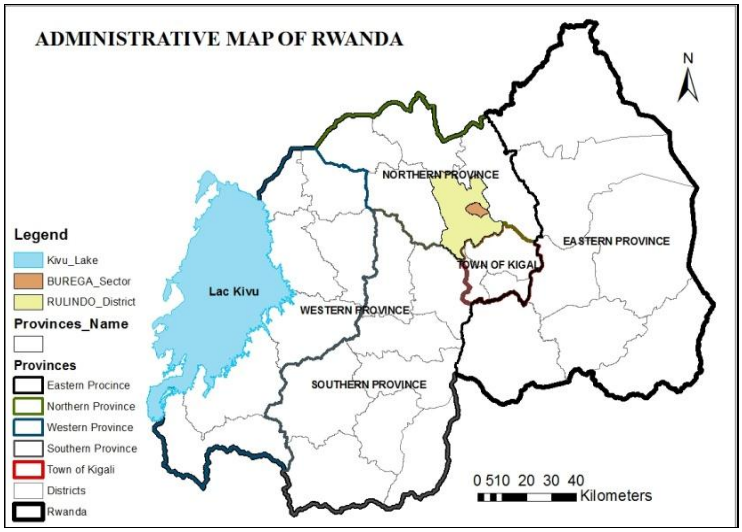


Figure 3.1*: Map showing Burega Sector as the area of the study* (NISR, 2006)

The Figure1 shows the administrative map of Rwanda. It shows the five Provinces, and thirty Districts. This map indicates also the study area which is located in the Northern Province, District of Rulindo; Burega Sector. As shown above, the District has seventeen Sectors and Burega Sector is one of them. The following figure indicates the Sectors included in Rulindo District.

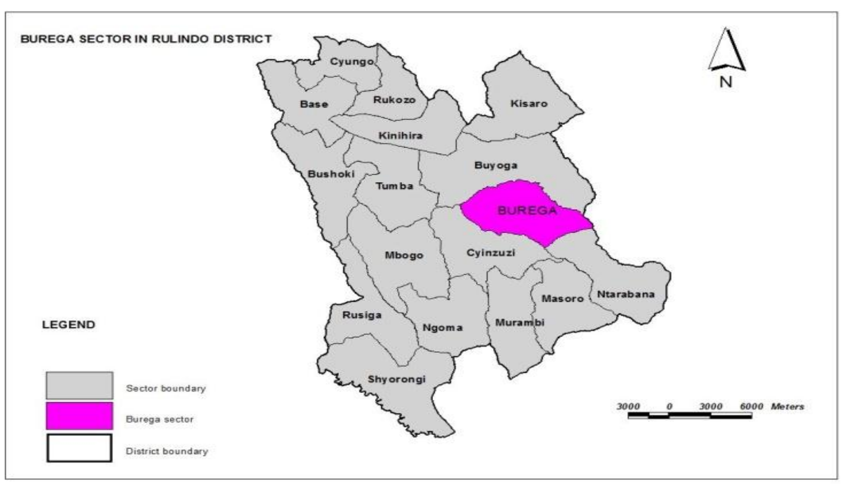


Figure 3.2: Map indicates Burega Sector in Rulindo District (NISR, 2006)

The figure below shows the administrative map of Burega Sector. It is made of three cells named Taba, Karengeri and Butangampundu. Its total area is 32.3130km^2. It's bordered by Buyoga, Cyinzuzi, Ntarabana Sectors and Mutete Sector which is in another District of Gicumbi.

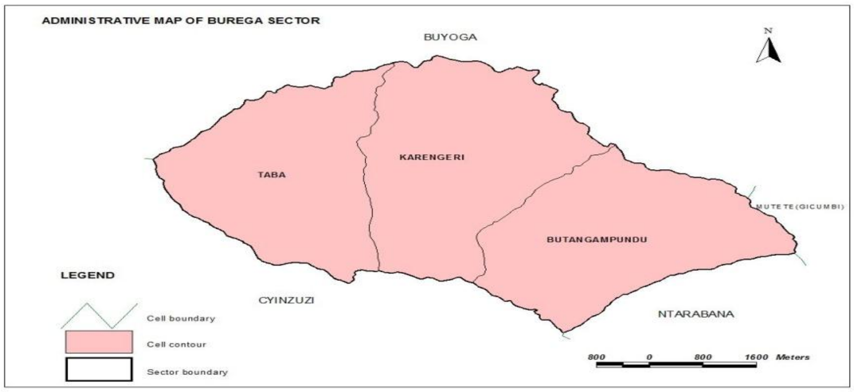


Figure 3.3: Administrative map of Burega Sector (NISR, 2006)

3.3.1 Population

The total number of people living in this Sector is 12730, where males are 5992 and females are 6738 (NISR, 2012). The women are abundant in the area. In general, people are smallholders and rely on agricultural activity. Smallholder farmers living in this Sector are 4650 and some are grouped into cooperatives, where each cooperative contains at least twenty farmers. The income and livelihood of the population are based on agricultural production. Their source of income is agricultural productivity. The most cultivate crops are maize, beans, vegetables, Irish and sweet potatoes, etc, while the main livestock found in the area are cattle, goats, sheep, poultry, rabbits and pigs

3.3.2 Climate

This Sector has a tropical climate, which is characterized by a succession of rainy seasons and droughts. The long dry season usually extends from June to August and a short dry season starts in January to February while the rainy season normally stretches from September to December and in March to May. The average annual temperature is 19 °C. High temperatures are observed in August where they reach 28°C in the middle of the day. During the rainy seasons, the District encounters concentrations of mists in the valleys in the morning and on the hilltops in the late morning. Rainfall normally reaches 1,243.3 mm per year on average. The Latitude of Burega Sector is relied between 499553 - 4809322 East, 509127- 4807319 West, 503744 - 4811584 North and 505661 - 4805463 South and the altitude is ranging from 1900 to 2300 m with average of 2000m.

3.3.3 Relief, Soil and Agro-ecological zone

Burega Sector, the rugged terrain comprises eroded hills (high altitude region) subject to severe water erosion. It has mountain ranges, separated by relatively low-lying valleys.

The soil in Burega Sector is mostly laterite, rich in iron and aluminum oxides and heavily eroded and additionally is silty clay. It is located in Agro-Ecological zone of Buberula Highlands with an average altitude of 2000 m.

3.3.4 Land tenure

In Rwanda as well as in the area of the study, land resource is either public or held by individuals under customary land rights. Customary land is acquired through inheritance, through allocation by the village government, or by purchase from others with customary land rights. Additionally, according to this principle, women, married or not, should not be excluded from the process of land access, land acquisition and land control, and also female descendants should not be excluded from the process of family land inheritance (MINITERE, 2004).

3.3.5. Hydrology

Burega Sector has only one main river which is called Kove River. It flows from South West to North East of the Sector. On the border of Burega are Muyanza River on the North West, Rusiro in the South and Kerera in West. These rivers have a great role to the farmers of this area. They provide water for irrigation farming and livestock.

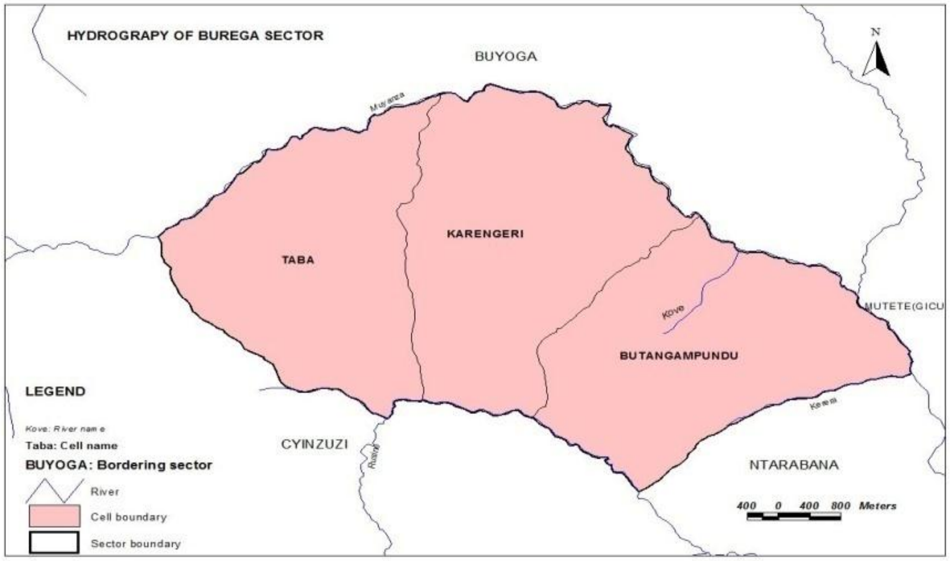


Figure 3.4: Hydrology map of Burega Sector (NISR, 2006)

3.3.6. Flora and Fauna

Natural forests in Burega Sector have taken a decreasing due to many factors, including human settlement and its related impact such as expanding land for agriculture, use of wood for cooking, etc. However, there is no remaining natural vegetation in the study area; the vegetation is generally dominated by artificial affortation (*Grevillea robusta* and *Cupressus lusitanica*) as well as food and cash crops. The main food crops are maize, beans, Irish and sweet potatoes, banana, while cash crop is coffee.

The Sector is also home to the ordinary domestic animal species, including, although wildlife has gradually been depleted due to land clearing and forest destruction. Animal species include amphibians (lizards and toads), reptiles, butterflies and birds (swallows, cranes, crowned eagles, crows, partridges, pigeons) wildlife is on a lower scale (GovR, 2013).

3.3.7 SWC Technologies in the study area

Due to the topography of the study area, various SWC technologies have been adopted in order to prevent excwessive soil loss. Various SWC technologies are being used such as application of fertilizers, cro rotation, ditches, radical terraces, agroforestry and forest where the slope is very steep.

CHAPTER FOUR

RESEARCH METHODOLOGY

4.1 Introduction

This chapter presents the research methodology used in the study, including study design, study population, source of data, sample size and sampling technique, methods and instrument of data collection, methods of data analysis and limitations of the study.

4.2. Study Design, Study Population, Sample Size and Sampling procedure

4.2.1. Study design

Research design is a mapping strategy. It is essentially a statement of the object of the inquiry and the strategies for collecting the evidences, analyzing the evidences and reporting the findings. In fact, the research applied a non-experimental design (explanatory) to collect primary data. The reason for the choice of this method is to describe the nature of the situation as it exists at the time of the survey. Descriptive statistics of farmers' characteristics, socioeconomic and environmental characteristics, geographical characteristics, factors of adoption of SWC technologies and their benefit were analyzed. These statistics included descriptive and chi-square statistics.

This helped to outline the influence of farm characteristics and socioeconomic and environmental characteristics as well as their expected outcomes from adoption of SWC technologies in their farms located either on hillsides or marshland.

4.2.2. Study Population

The study targeted smallholder-farmers whose farms were located in marshland and hillslopes farms and applied soil and water conservation technologies in their farms. The total number of these smallholder farmers was 4650. The smallholders were organized in 235 cooperatives.

4.2.3 Sample Size

The sample size of this study was determined largely from the following factors: (i) the total number of population living in the study area, (ii) the desired level of confidence, (iii) the acceptable margin of error. The sample size of this study was calculated based on the following formula Krejcie & Morgan (1970):

$$n = (\frac{X^2 N.P(1-P)}{ME^2(N-1)) + (X^2.P(1-P))}$$

Where:

n: required sample size

X: Z value (confidence level – standard value of 1.96)

N: total number of farmers living in the study area: 4650

P: Standard deviation (standard value of 0.5)

ME: Margin error at 5% (standard value of 0.05)

$$n = \frac{1.96^2 \times 4650 \times 0.5(1-0.5)}{0.05^2(4650-1) + 1.96^2 \times 0.5(1-0.5)}$$

$= 354.91 \approx 355$

The sample was reduced to two hundred and seventy (270) due to three reasons: to reduce high variability among participants, high financial resources as well as time.

4.2.4 Sampling Procedure

Stratified random sampling was used during the data collection. It was stratified according to the farm location; hillside or marshland. In fact, due to the topography of the study area, some farms are located in hillside while others are in marshland.

4.3. Sources of Data

For the study purpose, both primary and secondary data were used. The primary data were collected from small-farmers themselves, agronomists in the three cells of Burega Sector and data from Land Husbandry and Water Harvesting Project. The secondary data were collected from reports of the agricultural activities and soil and water conservation service in Burega Sector, LWH and VUP. LWH and VUP are project and program, respectively, which aims at improving the agricultural productivity by promoting marshland and hillside farming as well as soil and water conservation technologies in the whole country. The primary and secondary data were collected in order to cover every aspect of the study. The primary data are related to the farmers' characteristics (socioeconomic factors), factors contributing to the adoption of SWC technologies, various SWC technologies adopted and their impact on the farmers' livelihood as well as benefits from SWC technologies. The secondary data shows all small-farmers available, and taken their activities in the study area.

4.4. Sampling Techniques

The stratified random sampling technique was used. The research covered all three cells of Burega Sectors (Taba, Karengeri and Butangampundu). In each cell, three villages were chosen in each cell and finally in each village thirty households was selected which was equal to two hundred and seventy households. This was classified into three stages: (i) stage of cells, (iii) stage of villages and (iii) households. Two hundred and seventy households were drawn from the sample size determined above. All the cells were chosen and in each cell, three villages were taken which in turn thirty households in each village were chosen, this means in one village ninety households were chosen which is equal to two hundred and seventy in nine villages. And the simple random sampling technique was used in each stratum.

4.5. Instrument of Data Collection

The method which used during the research was a questionnaire. In fact, the questionnaire is a set of questions that have been prepared to ask a number of questions and collect answers from respondents relating to the research topic. A questionnaire is a series of questions asked to individuals to obtain statistically useful information about a given topic. The questionnaire had an open-ended questions and the questionnaire was under two forms: one for the households and the other one for key informants.

4.5.1. Method of data collection

For collection of primary data for this research work, interview and observation methods were used.

(i)Interview

The interview is a method of data collection, information or opinion gathering that specifically involves asking a series of questions. The interview method of research is a conversation with a purpose and is non-experimental in design. The interviewer in one-to-one conservation collects detailed personal information from individuals using oral questions. The interview is used widely to supplement and extend the knowledge about the individual (s) thought and feelings. The interview can give both quantitative and qualitative data about participants' thought and feelings. Both households and key informant interviews were done. The interview with household head was used to capture general characteristics of the household as well as information regarding SWC technologies and farm size. The interview with key informant was also used to capture data from them on one-on-one conversation. This allowed the researcher to collect reliable and accurate data needed in order to achieve the specific objective of the research. These include information regarding the SWC technologies used in the area, the factors influencing adoption of these SWC technologies, their effects on the livelihoods of smallholder farmers as well as their benefits.

(ii) Observation Method

Observation is a complex research method because it often requires the researcher to play a number of roles and to use a number of techniques; including the human five senses, to collect data. The observer puts herself in the actual situation and watch carefully. On the basis of her knowledge, skills, experience and the purpose of the research, the observer collected the data without contacting the respondents. Observation methods have been developed with the objective of observing people in their natural setting as they go about their everyday lives. An addition to the survey method used for collecting primary data, observation method was also suitable for the topic study. Observation employed an observation schedule to collect data related to the types of SWC technologies used, type of crops, livestock and type of soil erosion, including gully erosion and the location of the farm and its size.

4.6. Methods of Data Analysis

The purpose of data analysis is to determine whether some hypothesis is extremely unlikely given observed data. Descriptive statistics were used in the data analysis and Chi-square was also used in hypothesis testing. Application of the appropriate statistic helps a researcher to decide if the difference between the two groups' scores is big enough to represent a true rather than a chance difference. Choice of appropriate statistical techniques is determined to a great extent by the research design, hypothesis, and the kind of data that was collected. In fact, after data collection, the data were editing and coding and subsequently, the data was entered into SPSS.

The descriptive statistics permit the researcher to meaningfully describe many pieces of data with a few indices. The major types of statistics are measures of central tendency, percentages, pie charts and bar graphs were used in the data analysis. Additionally, all hypotheses were tested by Chi square. The Chi-square (x^2) was computed using the following formula:

$$\chi^2 = \Sigma(O-E)^2/E$$

Where: O – Observed frequency

E – Expected frequency

$\Sigma (O-E)^2$ – Sum of the squares of the differences between Observed and Expected frequencies.

The χ^2calculated was compared with χ^2critical at a significance level of 0.05 and degrees of freedom which was determined as follows:

Degrees of freedom (df) = (r – 1) (c – 1)

Where r: number of rows

c: number of columns

The Null hypothesis (H_0) was rejected where χ^2calculated was greater than χ^2critical and the alternative hypothesis (H_1) adopted.

4.7. Limitations of the Study

To carry out the research study, the following limitations were faced during the research study:

(a) Some household did not know the precise size of their farms and level of application of agricultural inputs;

(b)Some head of the family did not share their views on the topic because of the lack of information;

(c) Time, cost and location factors were major difficulties in completion of research

However, to overcome the limitations and maintain the effectiveness of research work sincere effort would be put.

To overcome the limitations, some alternatives were used. Some of them are:

(i) Methods of documentary were used to deal with limitations of size of the farms through the program of Land Consolidation as well as MINAGRI reports.

(ii)Interview methods were used to deal with the limitation of information from some head of the house where the family member would help him/her;

(iii)The motorcycle was used in order to overcome limitations of time, cost and location, so that I would save the time, cost and reach the place on time.

CHAPTER FIVE

RESULTS AND DISCUSSION

5.1 Introduction

This chapter presents the data and interpretation of the analytical findings. This chapter presents the results on household and area characteristics, factors contributing to the adoption of SWC technologies and the extent of using those SWC practices, effects of SWC technologies on farmers' livelihoods as well as benefits of SWC technologies.

5.2.CHARACTERISTICS OF RESPONDENTS AND SWC TECHNOLOGIES

The study was conducted to the farmers whose farms are located on hillsides, marshland and both locations (hillside and marshland). It was found that 61.85% (n=167) cultivate in hillsides, 1.85% (n=5) in marshland while 36.3% (n=98) cultivate in both locations (hillside and marshland). The farming system is still substance where farming system is more a livestock based mixed farming system by using mainly hoe and other traditional materials. Additionally, the farming system in Rwanda as well as in the study area is characterized by rotating crops according to the agricultural seasons. The main crops grown in the study area are maize, beans, vegetables, Irish and sweet potatoes, coffee, sorghum, banana, cassava while the most abundant domestic animals are: cattle, goats, sheep, pigs, rabbits, poultry.

5.2.1 Respondents' Occupation

All 270 samples of respondents were all farmers and relied on natural resources for their basic needs. The study results indicated that 87 % (n=234) are smallholder farmers with farm size below two hectares, while only 13 % (n=36) respondents have farms with size of greater than or equal to two hectares. With this problem of land shortage; smallholders are applying their activities both in marshland and hillside areas, where this latter requires many attentions. This means that many diverse soil and water conservation practices are undertaken in the study area in order to be enabled to control soil erosion and water management.

5.2.2 Respondents' Age

Demographic characteristics may be directly or indirectly related to the adoption of soil and water conservation practices due to high demand and supply conditions for basic human needs, including food, health insurances; educational facilities which in turn directly or indirectly influence the extreme use of natural resources such as land.

Four age groups of respondents were identified: below or equal to 20, between 21 and 40, between 41 and 60 and then greater or equal to 61 years old. The findings indicate that only 1.5% (n=4) are below or equal to 20 years old, 46.3% (n=125) are between 21-40 years old, 37.4 % (n=101) are between 41 – 60 years old and 14.8% (n=40) are over or equal to 61 years old. Most of the respondents (83.7%, n=226) are in the age vary from 21 to 60 years (Table 5.1). The average age is 44.17 years for all respondents, max=63 and min=18 years. Additionally, the average age for women is 42.5 years and 45.8 years for men.

Table 5.1: Ages distribution of Respondents

Ages in Years	Frequency	Percentage
≤ 20	4	1.5
21 – 40	125	46.3
41 – 60	101	37.4
≥ 61	40	14.8
Total	**270**	**100**

Source: Primary data, 2015

The results showed that all interviewed respondents are using at least one SWC technology. The findings indicate that respondents aged below or equal to 20 years adopt the less SWC practice while those with age between 21 and greater than or equal to 61 years are using various SWC technologies. This may be linked to their experience in soil erosion and may be their livelihoods are based on agricultural activities while those who are under 21 years old may have other off-farm activities for their livelihoods (Figure 5.1).

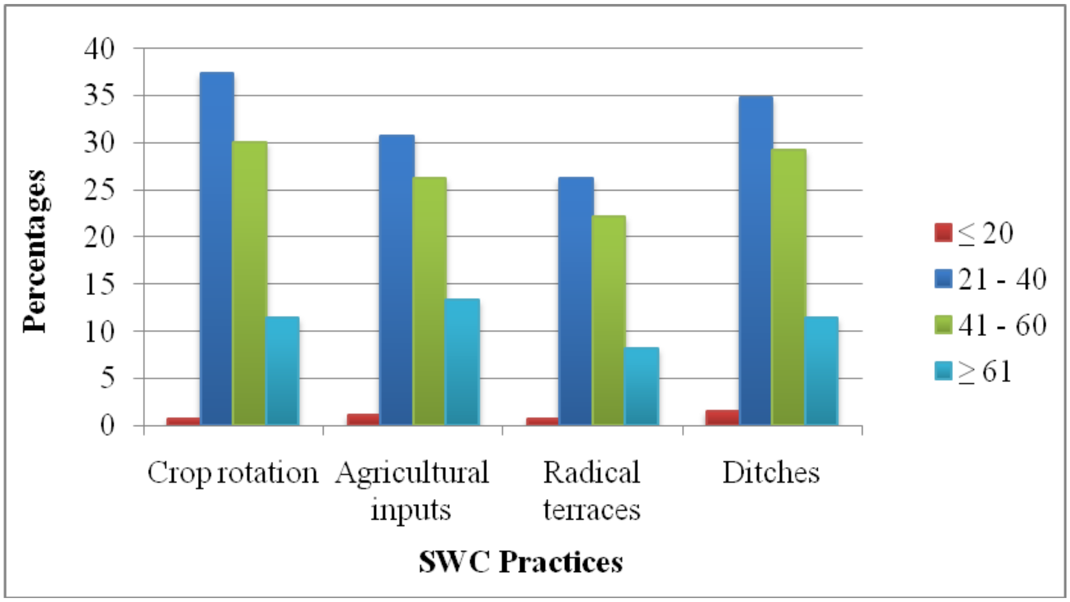


Figure 5.1: Respondents' Age and SWC technologies (Field Survey, 2015)

The findings indicate that the majority of respondents (83.7%) who engaged in SWC activities are aged between 21 and 60 years, while the elderly farmers were 14.8% and a small number of younger farmers engaged in SWC activities were only 1.5% (Table 5.1and Figure 5.1). The results also showed that the number of elder and younger farmers engaged in SWC activities in the study area is still small (16.3%=44). Therefore, the elderly age which is characterized by labor shortage could be an impediment to practicing soil and water management measures. But on the other hand, farmers in this age group are assumed to have a good understanding of the problem of soil erosion due to farming experience and information they have. And although the number of young farmers who engaged in SWC practices is still low, it has shown that younger people play a great role in sustainable land management; this is shown by innovations and labor put in soil and water management activities by those younger farmers. According to the findings of a study carried out in Spain by Calatrava Leyva et al, (2007) showed that farm profitability, the presence of young farmers and continuity of the farming activity by relatives and the use of family labor influence the adoption of soil conservation practices.

5.2.3 Respondents' Gender

The distribution of the percentages showed that females are 53% (n=142) while males are 47% (n=128) (Table 5.2). High number of female engaged in SWC activities could be explained by high number of females found in the area of the study and it is quite known that women play a crucial role in agriculture sector as well as in soil and water conservation activities.

Table 5.2: Gender of Respondents

Gender	Frequency	Percentages of Gender
Female	142	**53**
Male	128	**47**
Total	**270**	**100**

Source: Primary data, 2015

The findings revealed that females are more practicing SWC technologies than males except where males (29.63%) adopt radical terraces than female (28.15%) (Figure 5.2). And it is quite known that the percentage of men engaged in soil and water management activities are less than women. The women are both the first environmental preservers as well as agricultural producers. The important contribution of women in soil and water conservation activities is usually recognized by the various agencies involved (IFAD, 1992). Additionally, women's growing contribution to soil and water conservation activities tends to increase their already heavy workload. But, on the other hand, an analysis of the role of women in desertification control activities in the West African Sahel has shown that although they play a major role in these activities, they derive only limited benefits from them (Monimart, 1989).

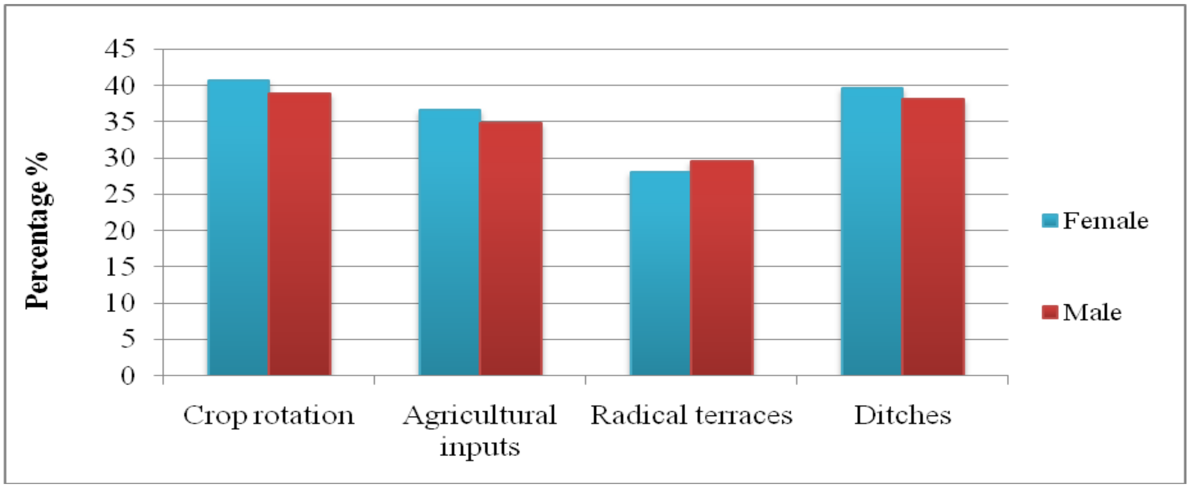


Figure 5.2: Gender and SWC technologies (Field Survey, 2015)

5.2.4. Education level of Respondents

In Rwanda the education system is composed of four main levels: Pre-primary, Primary, Secondary, and Higher Education. Pre-primary Education is organized in nursery schools and for a period of three years for children between the age of 4 and 6. Primary Education lasts six years with the official school age at this level being from 7 years to 12 years. This stage focuses on core literacy and numeracy skills, as well as preparation for secondary studies. Primary education ends with national examinations which determine eligibility for proceeding to Lower Secondary school. Secondary Education also lasts for six years with the official age for this level being from 13 years to 18 years of age. It is subdivided into lower secondary (the first three years) and upper secondary (the last three years), both culminating in national examinations which respectively determine eligibility for upper secondary, and secondary graduation or entry to higher education. However, compulsory education lasts the nine years from age 7 to age 15, covering primary and lower secondary education, and is commonly known as the Nine Years Basic Education (9YBE) while the combination of primary (six years) and secondary schools (six years) is known as Twelve Years Basic Education (12YBE) and it is not compulsory. At tertiary level students can pursue their studies in a range of academic directions or opt to enter an array of technical or vocational fields. Undergraduate degrees currently require four years to complete (MINEDUC, 2013).

During the study, four education levels were identified: illiterate, primary, lower secondary and Upper Secondary school. The results indicate that 20.74% (n=56) are illiterate, and among them 11.48 % (n=31) are females while 9.26% (n=25) are males. Additionally, 7.78% (n=21) are aged over 61 years, 5.18% (n=14) are aged between 21 and 40 years old and then7.78% (n=21) are aged between 41 and 60 years old (Table 5.3).

The study pointed out that 73.7% (n=199) have finished primary school, and among them 37.41% (n=101) are female while 36.3% (n=98) are male. Respondents who have finished primary school, the findings indicate that 1.1% (n=3) are aged below or equal to 21 years old, 37.4% (n=101) are aged between 21 and 40 years old and 28.5% (n=77) are in age varying from 41 to 60 years old while those who are aged over or equal to 61 years old are 6.7% (n=18).

Furthermore, the study results revealed that 3% (n=9) have finished lower secondary school (this means nine years basic education), among them 2.96% (n=8) are females while 0.37% (n=1) are males. At this phase, the study also shows that 0.37% (n=1) are aged below or equal to 21 years old, 2.2% (n=6) are aged between 21 and 40 years while 0.37% (n=1) are aged between 41 and 60 years as well as over 61 years for each (Table 5.3).

Lastly, 2% (n=6) have finished Upper Secondary school (this means twelve years basic education). Among them, 2.96% are female while 0.37% (n=1) and it has found that at this phase, 1.48% (n=4) are aged between 21 and 40 years while 0.74% (n=2) are aged between 41 and 60 years old (Table 5.3).

Table 5.3: Respondents' Education level with their gender

		EDUCATION LEVEL								**TOTAL**	
		Illiterate		**Primary**		**Lower Secondary**		**Upper Secondary**			
		N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Gender	**Female**	31	11.48	101	37.41	8	2.96	2	0.74	142	52.59
	Male	25	9.26	98	36.3	1	0.37	4	1.48	128	47.41
Total		**56**	**20.74**	**199**	**73.71**	**9**	**3.33**	**6**	**2.22**	**270**	**100**

Source: Primary Data, 2015

It was also found that the number of females (41.11%, n=111) who are educated is higher than that of the males (38.15%, n=103). This high number of educated women in the study area could be associated with a politics launched in 2007 by the Government of Rwanda which aims at promoting gender equality in schools. As a result, this politic is called education for all.

The study results showed that farmers with primary education and those who did not attend schools adopt SWC technologies higher than those with education beyond primary level (Figure 5.3). This is contrary to the findings of a study done by Bandara & Thiruchelvam (2008) showed that the probability of good level of soil conservation is seen to increase with the education level of farmers. This reflects the fact that formal education supports the farmers' decision to manage the soil better. When education moves from lower to higher level, probability of adoption of poor level of soil conservation is decreasing. Additionally, the findings of Derajew et al., (2013) also pointed out that the educational level of the household head; extension contact; and slope of the plot positively and significantly affect farmers' conservation decision and the extent of use of improved soil conservation technologies.

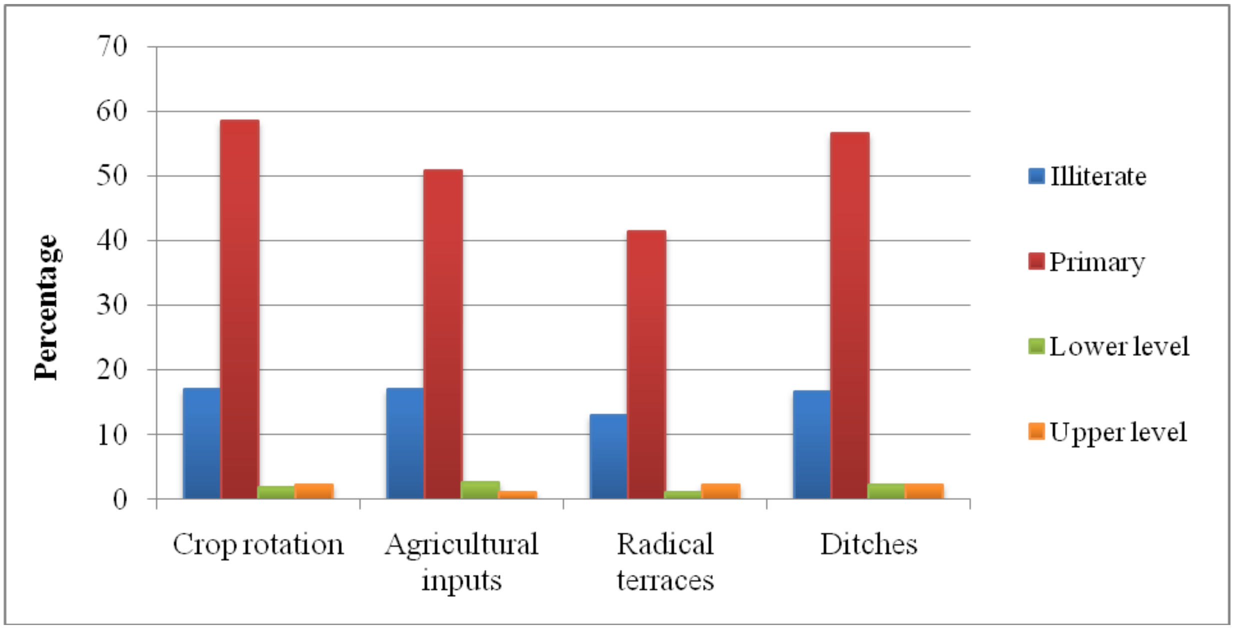


Figure 5.3: Education level and SWC technologies used in the area (Field Survey, 2015)

5.2.5 Marital Status of Respondents

Four marital status types have been identified; single, married, divorced and widowed. The marital status varies a lot by age, sex and in less extent by area of residence along with living conditions. The respondents aged below 21 years are all single 4.8% (n=13), married are 83% (n=224), widowed are 11.5% (n=31) and divorced are 0.7% (n=2) (Table 5.4).

Table 5.4: Marital Status of Respondents

Marital Status	Frequency	Percentages %
Single	13	4.8
Married	224	83
Widowed	31	11.5
Divorced	2	0.7
Total	270	100

Source: Primary data. 2015

5.2.6 Household size

Family size in the study is considered as the number of individuals who reside in the respondent's household. Large family assumed as an indicator of labor availability in the family. Three categories of household size were identified: family with members from one to three persons, from four to six persons and from seven to nine persons. The results show that households with members ranging from one to three persons are 20.7% (n=56), households with members ranging from four to six persons are 75.2% (n=203), family size ranging from seven to nine, are 4.1% (n=11). The average family size is 4.48, min=1 person while max= 8 persons and the standard deviation is 1.156 (Table 5.5).

Table 5.5: Household size

Household Size	N	Percentage
1 to 3 persons	56	20.7
4 to 6 persons	203	75.2
7 to 9 persons	11	4.1
Total	270	100

Source: Primary Data, 2015

It was found that households with family size ranging from four to six persons (75.2%) tend to adopt SWC technologies than other households (Figure 5.4). This high adoption of SWC technologies by families with household size vary between 4 to 6 members can be explained by the high availability of labor in these families. This may be explained by the fact that those with family size ranging from one to three and those with family size are greater or equal to seven people may their livelihoods are less dependent to agricultural activities while those with family size ranging from four to six persons may have sufficient labor putting in adopting SWC technique because they are much more relying on agricultural activities.

The findings of Simon et al., (2012) and Alufah et al., (2012) showed that household size, perception of the soil erosion problem, training in soil erosion control, land ownership and access to institutional credit had significant effects on the adoption of SWC technologies.

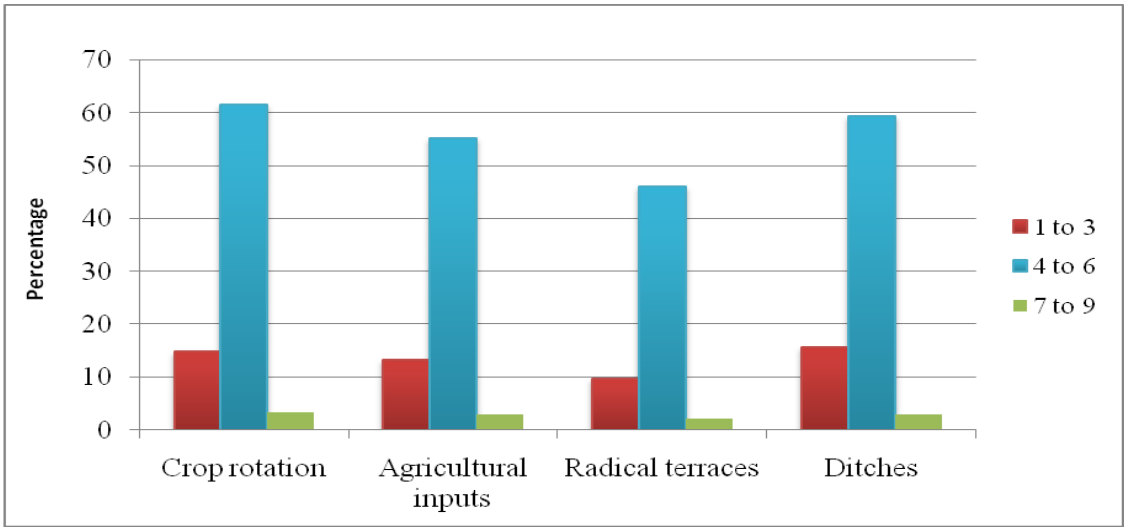


Figure 5.4: Household size and SWC technologies (Field Survey, 2015)

5.2.7. Farm size

The results showed that the majority of respondents owns a very small portion of land. As a result, five groups of farm size of respondents are identified (Table 5.6): below 0.3 ha, 0.3-0.9 ha, 0.9 – 1.5 ha, 1.5 – 2.0 ha and over 2 ha. The results of the study showed that a great number of farmers are smallholders; therefore their farms are less than 2 hectares. The study indicates that 34.44 % (n=93) owns the farm with size less than 0.3 hectares, 22.59 % (n=61) have farms vary between 0.3 – 0.9 hectare, 17.41 % (n=47) have farms with size vary between 0.9 – 1.5 hectares, 12.22 % (n=33) have farms with size vary between 1.5 – 2.0 hectares while the farmers with land greater than or equal to 2 hectares are only 13.33% (n=36). The average size of respondents' farms is 1.23 ha. The majority of farmers' land size varies from 0.3 to 0.8 ha (Table 5.6).

Table 5.6: Farm size

Farm size (ha)	Frequency	Percentage
< 0.3	93	34.44
0.3 - 0.9	61	22.59
0.9 - 1.5	47	17.41
1.5 - 2.0	33	12.22
≥ 2	36	13.33
Total	**270**	**100**

Source: Primary data, 2015

It was found that farmers with farm size below two hectares adopt SWC technologies than those with farm size greater than or equal to two hectares (Figure 5.5). This may be explained by high dependence on the land, along with a shortage of land found in the study area as well as the whole country. In point of fact, high population density has stimulated a shortage of arable land, led to decreasing farm size, shortage of arable land and the adoption of intensive agricultural practices on marginal land which in return accelerate declining soil fertility by high soil erosion.

This is different to other studies, where most farmers with large farms are likely to adopt SWC measures than those with small farms. The findings of a study done by Clay and Reardon (1994) and Tadesse & Belay (2004) stated that farm size positively influence land conservation practices (investment in anti-erosion ditches). The same as the findings a study carried out in Nigeria by Amanze et al., (2010) proved that the output of the crop, level of education, farm size and price of fertilizer were important factors influencing farmers' use of fertilizer in arable crop production and also farm size were shown generally to have a positive impact on a household's decision to adopt and use a new technology such as fertilizer. Furthermore, various the studies have shown the influence of farm size on adoption of soil conservation measures. For example, Mulugeta, (2000), Milliona & Belay (2004) and Yishak (2005) pointed out a positive relationship between farm size and number of plots owned on the adoption of SWC practices.

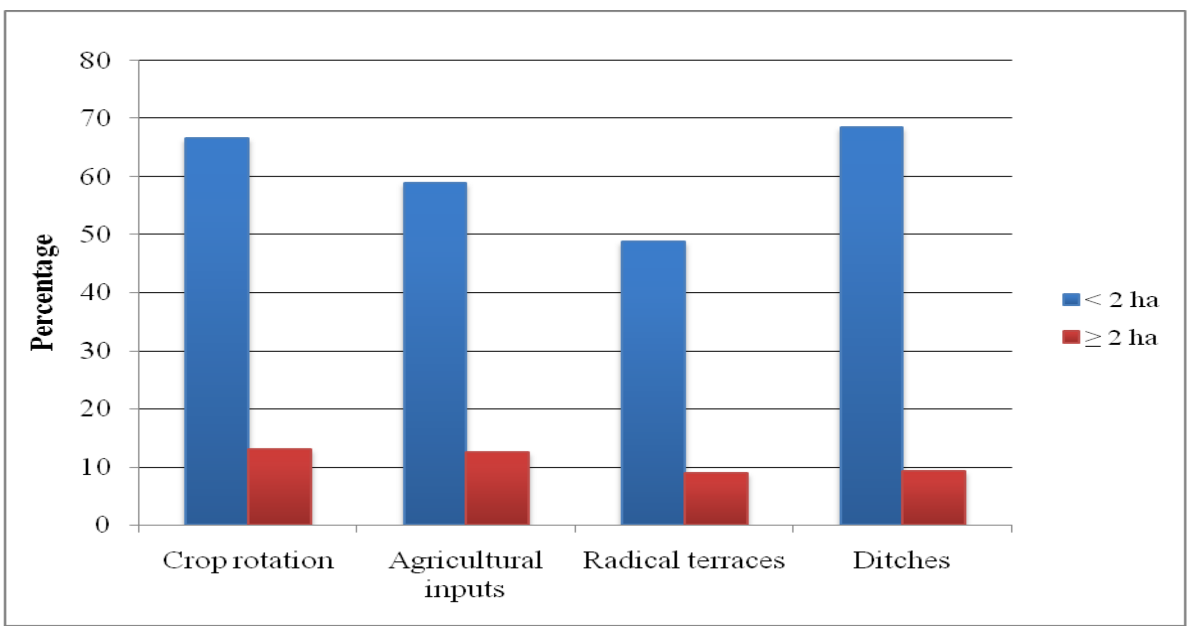


Figure 5.5: Farm size and SWC technologies (Field Survey, 2015)

5.2.8 Type of land use

According to the topography of the study area, land use type is determined according to the location of the farm as well as slope. Farms located in marshland are used for only farming, while for those located on hillsides are used either for farming annual crops, coffee plantation and forest to the very steep slope. According to the study results, the land use were identified into three groups: 74.8% (n=202) are engaged in farming only, 22.6 % (n=61) are in farming combined with farm, forest, and the remaining 2.6% (n=7) are combining three land use (farming, coffee and forest) (Figure 5.6).

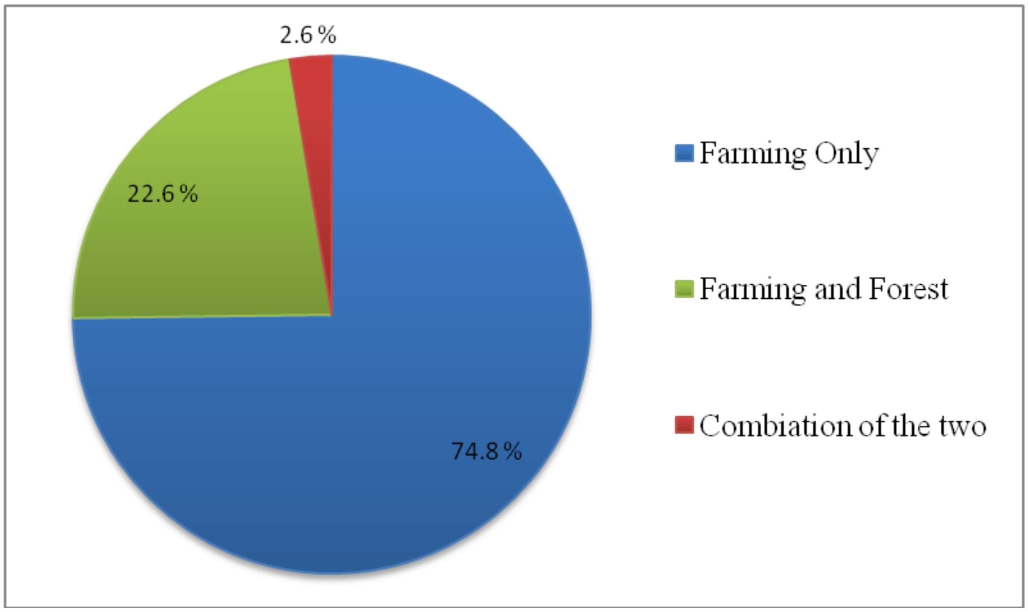


Figure 5.6: Types of Land use (Field Survey, 2015)

5.2.9 Types of Crops

Farming system which is overwhelmingly smallholder in nature is characterized by intensive organic systems and involved the combination of food, fodder and tree crop. Crop rotation and use of some soil and water conservation techniques are typically practiced. Number of crops cultivated in the study area ranges from one to four, according to the farm location and priority of crops, including maize, beans, Irish and sweet potatoes, vegetables, and others (cassava, banana, sorghum and coffee). The most grown crops are as follows: maize (*Zea mays*) with a proportion of 92.2 % (n=249), followed by beans (*Phaseolus vulgaris*) with a proportion of 88.5

% (n=239), vegetations 27.4 % (n=74), Irish potatoes are 10.4 % (n=28), sweet potatoes 7 % (n=19), Coffee is 5.9 (n=16) and others (Cassava Banana and Sorghum) are 4.4 % (n=12) (Table 5.7).

Table 5.7: Types of Crops

Type of crop	Frequency	Percentage %
Maize	249	92.2
Bean	239	88.5
Vegetables	74	27.4
Irish potatoes	28	10.4
Sweet Potatoes	19	7
Coffee	16	5.9
Others (Cassava, Banana, Sorghum)	12	4.4

Source: Primary Data, 2015

In fact, the Government of Rwanda through MINAGRI has launched a program called the Crop Intensification Program (CIP), which aims at increasing agricultural productivity of high potential food crops and to provide the country with greater food security and self-sufficiency. So as a result, at the National level, eight priority crops have been selected through Land Use Consolidation (LUC) as a part of CIP, according to the agro-ecological zone. In the study area the selected crops under LUC are maize and beans, while other crops are still grown on land where has not yet been consolidated, or grown in marshland, kitchen farms or where the land is very steep or small.

This is similar to the findings of a study done by Amanze et al., (2010) where they proved that output of the crop, level of education, farm size and price of fertilizer were important factors influencing farmers' use of fertilizer in arable crop production.

Plate 5.1: Somes crops grown in the study area (Maize and Cabbage)

5.2.10 Types of livestock

The findings revealed that some of the respondents do not hold any livestock while others have at least one type of livestock. The results indicate that 4.4 % do not own any type of livestock while those who own at least one type of livestock are 95.6 %. The major domestic animals raised in the study area are cattle, goats, sheep, pigs, chickens and rabbits. According to the study findings, cows 89.6 % are very dominant, followed by goats 61.1 %, sheep 9.3 %, pigs 5.9 %, rabbit 4.8 % and finally chicken 9.3%with and respectively (Table 5.8).

It has also found that respondents who have at least one cow are 23.7 % (n=64) while those who have at least two different livestock are 84.44%. Thus, this may have a positive impact on respondents' livelihoods where the increase of livestock has contributed to a significant increase of milk production, meat and per capita as well as manure. High availability of cattle in the study area, could be explained by the fact that, Rwanda Government has launched a politics called One Cow per Poor Family Program in 2006 and aims to increase crop production by using manure' income and improve nutrition conditions at the household level and countrywide as well. It has contributed to a significant increase in milk production and subsequently increase in average consumption of milk. Additionally, this program improves the livelihoods of those most in need and institutes lost pride through the recovery of a traditional symbol of wealth. In addition, due to the land shortage, these domestic animals must be raised under zero-grazing system. Furthermore, the rise of chicken has also increased the availability of eggs, even if the demand is still high by comparing with the number of chickens found in the study area. This may help farmers to improve their food security conditions and income generation. According to Shiferaw & Holden (1998) livestock are generally considered as assets that could be used in the production of process or be exchanged for cash or other productive assets. Livestock may reduce the economic impact of soil erosion and thus lower the need for soil conservation.

Table 5.8: Type of livestock

Type of Livestock	Frequency	Percentage %
Cows	242	89.6
Goats	165	61.1
Chicken	25	9.3
Sheep	25	9.3
Pigs	16	5.9
Rabbits	13	4.8
No Livestock	12	4.4

Source: Primary data. 2015

Plate 5.2: Cattle

5.2.11 Status of Soil erosion

Soil erosion is worldwide known as a major problem, especially in developing countries, where many tons of soils are washed away due to unsustainable land use. According to the research findings, 44 % (n=120) respondents confirmed having a problem of soil erosion while 56 % (n=150) pointed out that there is no soil erosion on their farms. Soil erosion may occur due to various drivers, including direct and indirect causes. And once soil erosion occurs, it reduces the capacity of land productivity as well as the increase of vulnerabilities. During the study, it was found that; soil erosion 23 % (n=62) and soil fertility depletion 21 % (n=58) are serious trends in the study area (Figure 5.7).

Respondents acknowledged the soil erosion as a serious environmental issue in the study area, followed by the soil fertility depletion in-situ. This latter could be exacerbated by the excessive loss of topsoil due to high soil erosion and lead to the decrease of crop productivity. This is due to the topography, heavy seasonal rainfall, and unsustainable use for agricultural purpose. In addition, the study results present soil erosion and soil fertility depletion problem, according to the farm location. Respondents indicated that soil erosion in marshland is 0.74% (n=2), hillside 17.41 % (n=47) and 4.81 % (n=13) in both locations while soil fertility decline is 1.11 % (n=3) in marshland, 13.3 % (n=36) in hillsides and 7.04 % (n=19) in upland and marshland respectively (Figure 5.7). High land use pressure and shortage of arable land along with unsustainable land use on marginal land may accelerate soil erosion which in turn could lead to the decline of land productivity. A study done in Rwanda by FAO (2006) noted that the country faces moderate to severe soil erosion on 50 percent of its land surface.

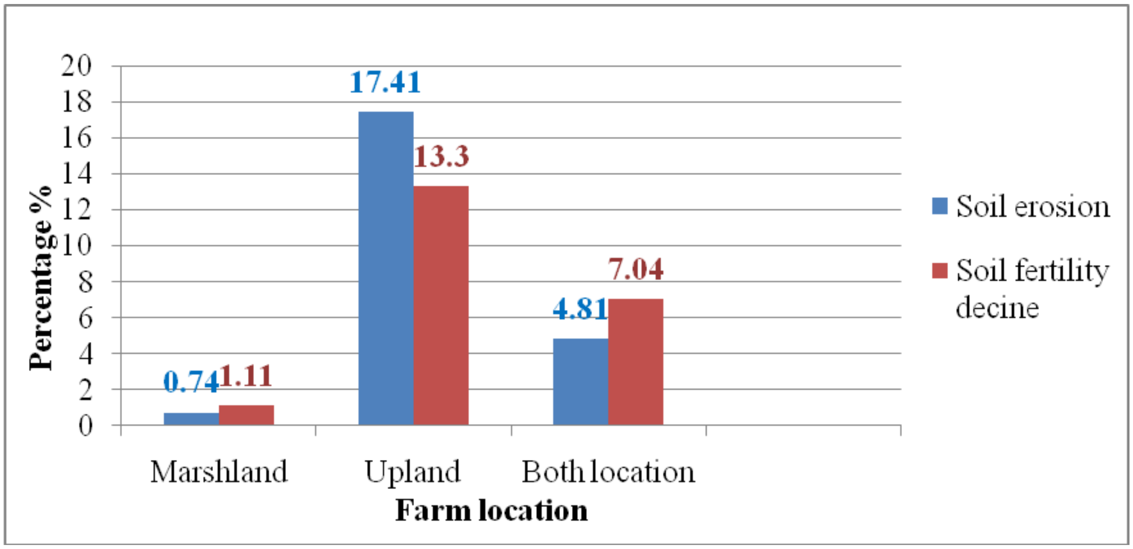


Figure 5.7: Soil erosion, soil fertility and farm location (Field Survey, 2015)

5.2.12 Extent of Soil erosion, Soil fertility decline

The extent of soil erosion in the study area have been identified into three categories; extent into low, moderate and high while the level of soil fertility was identified as low, medium and high. According to the findings, respondents mentioned the extent as well as degree according to their perception. Farmers have classified soil erosion into two categories; soil erosion by water and soil fertility decline and into different degree according to category. Out of 120 respondents, have mentioned the soil erosion, according to the degree as follows: 17.5 % (n=21), 26.7 % (n=32) and 7.5 % (n=9) low, medium and high soil erosion respectively in their farms. While, at the other hand, the results indicate that the state of soil fertility depletion is: 14.2 % (n=17), 25 % (n=30) and 9.2 % (n=11) classified as low, medium and high soil fertility depletion respectively in this area (Table 5.9).

Table 5.9: Extent of soil erosion and soil fertility in the study area

	Description	Frequency	Percentage
Degree of Soil Erosion	Low	21	17.5
	Medium	32	26.7
	High	9	7.5
Level of soil fertility	Low	17	14.2
	Medium	30	25
	High	11	9.2
Total		**120**	**100**

Source: Primary data, 2015

5.2.13 Soil and Water Conservation Technologies

During the research respondents were asked to mention the SWC technologies they use in their farm. A number of SWC technologies were identified. The most SWC technologies are crop rotation, agricultural inputs (organic and mineral fertilizers), radical terraces and ditches while the least used are rainwater harvesting, check dam, Agroforestry/tree planting and grass strip.

According to the research, it was found that crop rotation, agricultural inputs, radical terraces and ditches are the most used SWC technologies. The study results indicate that crop rotation is one of the most adopted by respondents (79.6%), followed by ditches (77.8%) and application of agricultural inputs (organic and mineral fertilizers) as well as radical terraces with proportions of 71.5% and 57.8% respectively (Figure 5.8). High adoption of crop rotation and agricultural inputs may be associated with the fact that is a simple technique and as well as availability of seeds through governmental support while ditches are the technique that are very easy to implement even at the household level. But on the other hand, radical terraces require much means, including financial, technical and labor means. Moreover, radical terraces are new technologies that are being implemented in the study area.

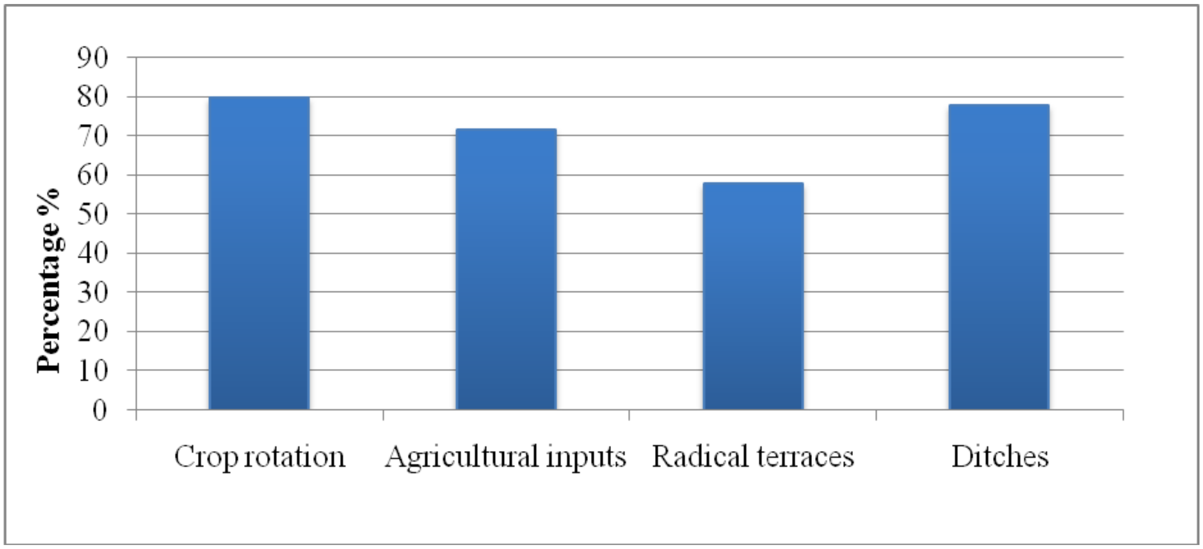


Figure 5.8: The most adopted SWC technologies in the study area (Field Survey, 2015)

On the other hand, the research findings indicate that the least SWC technologies are rainwater harvesting, grass strip, forest/ tree planting and Agroforestry. The results show that tree planting is one of the most adopted in the least used techniques (23.3%), followed by Agroforestry (19.63), grass strip and rainwater harvesting with proportions of 8.52% and 0.74% respectively (Figure 5.9).

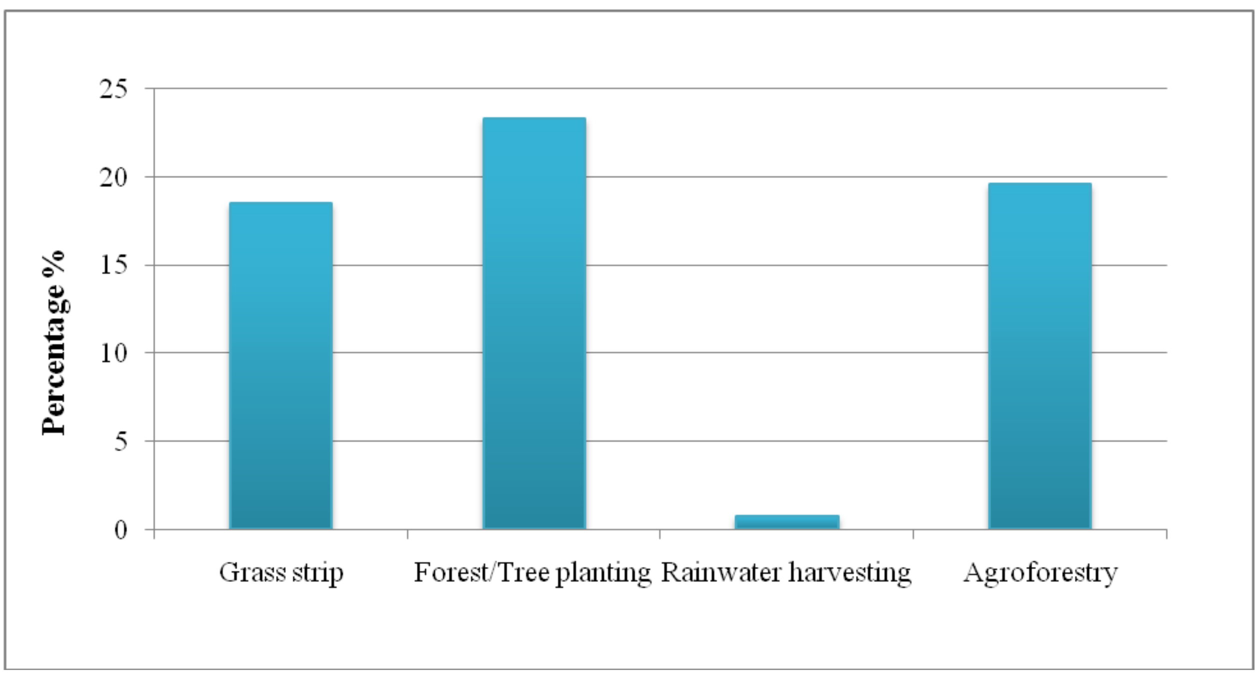


Figure 5.9: The least used SWC technologies in the study area

Plate 5.3: Radical terraces

5.3 FACTORS CONTRIBUTING TO THE ADOPTION OF SWC TECHNOLOGIES

The study has identified the most used SWC technologies in the area; therefore the factors contributing to the adoption of these techniques would not be ignored. However, this part describes the main factors contributing to the adoption of these SWC technologies. Throughout the study, respondents were asked to mention the key factors contributing to the adoption of these SWC technologies. For convenience, "soil and water conservation technologies" is used in the text to refer to the above most used SWC technologies.

5.3.1. Farm size

The study findings indicate that the majority of the respondents (34.44 %) have farms with size less than 0.3 hectares (Table5.6). Farm size may influence adoption of SWC technologies directly or indirectly and vary from household to household. The results of study showed that adoption of SWC techniques is highly in farms with size less than two hectares than those with size greater or equal to two hectares (Table 5.10).

Table 5.10: Farm size and SWC technologies

Farm Size	CR	AI	RT	Ditches
	% of respondents			
None	20.4	28.5	42.2	22.2
< 2 ha	66.6	58.9	48.9	68.5
≥ 2 ha	13.0	12.6	8.9	9.3
Total	100	100	100	100

Source: Primary Data, 2015

CR: crop rotation, AI: agricultural inputs, RT: radical terraces

The chi square results indicated that at significant level of 0.05; farm size has a relationship (p=14. 315, Appendix 4.7) with the number of SWC technologies adopted in the area. This relationship may be explained by the fact that smaller farms are associated with land shortage and insufficient wealth which make worse the problem of soil erosion in their farms; however this increases the probability of investment in soil conservation measures. This association is similar to the findings of various studies. For example the study findings of Tadesse & Belay (2004) stated that farm size has a positive and significant influence on the farmers' decision to adopt physical soil conservation measures. The same as the findings of a study carried out in

Nigeria by (Amanze et al., (2010) proved that the output of the crop, level of education, farm size and price of fertilizer were important factors influencing farmers' use of fertilizer in arable crop production and also farm size were shown generally to have a positive impact on a household's decision to adopt and use a new technology such as fertilizer. Additionally, the studies done by Mulugeta (2000), Tadesse & Belay (2004) and Yishak (2005) indicated a positive relationship between farm size and adoption. Farm size and number of plots owned have a positive influence on the adoption of SWC practices. But, on the other hand, the findings of studies carried out in Cameroun and Ethiopia by Gockowski & Ndoumbe (2004) and Degnet, et al., (2001) revealed that there is negative relationship between farm size and adoption of mono-crop horticulture as well as between farm size and adoption of high yielding maize varieties.

5.3.2. Livestock rearing

The study results showed that 95.6% have at least one livestock while 4.4% have no livestock. It was also revealed that respondents who have at least one livestock have adopted at least one SWC technology (Table 5.11).

Table 5.11: Influence of livestock rearing on adoption of SWC technologies

Livestock rearing	**CR**	**AI**	**RT**	**Ditches**
	% of respondents			
None	20.4	28.5	42.2	22.2
± one livestock	77.4	68.1	56.3	74.1
No livestock	2.2	3.3	1.5	3.7
Total	100	100	100	100

Source: Primary Data, 2015

CR: crop rotation, AI: agricultural inputs, RT: radical terraces

It was found that having livestock is an important asset that could influence adoption of SWC technologies in one way or another. This could be explained by the fact that most respondents reported a shortage of feed for their livestock, especially during the dry season. Therefore, they adopt different SWC technologies in order to get sufficient fodder and water for their domestic animals. Actually, the grazing system used and accepted in Rwanda, is zero grazing system. With this system, is not easier to feed livestock without using various techniques including SWC technologies. In fact, according to Shiferaw & Holden (1998) livestock are generally considered as assets that could be used in the production of process or be exchanged for cash or other productive assets. Livestock may reduce the economic impact of soil erosion and thus lower the need for soil conservation.

Statistically, the chi square results indicate that there is no relationship (p=3. 348, Appendix 4.8) between raising livestock and the number of SWC technologies adopted in the study area. This is similar to the findings of the study done in Ethiopia by (Derajew et al., (2013) indicated that distance of the plot from residence, livestock holding and the fertility of the farm plot affect negatively and significantly farmers' conservation decision and the extent of use of improved soil conservation technologies**.** But on the other hand, those farmers who have a large number of livestock may have more capital to invest in soil conservation practices. This affects soil conservation positively. Furthermore, this is was also proved by the findings of Tesfaye (2003) indicating that land size, livestock ownership, family size, risk perception, land tenure on non-arable lands, labor organization, characteristics of technology, indigenous institution and physical factors are significant determinants of SWC.

5.3.3. Crop yield

Respondents reported crop yield as a major factor influencing the adoption of SWC technologies. The study findings indicate that the majority of respondents (71.1%) reported to adopt crop rotation due to the need of increasing crop yield in their farms, followed by those who adopt ditches with a proportion of 69.6%, and then followed by 65.2% and 52.2% for those who adopt agricultural inputs and radical terraces respectively (Table 5.12).

Table 5.12: Influence of crop yield on adoption of SWC technologies

Crop yield	CR	AI	RT	Ditches
	% of respondents			
None	20.4	28.5	42.2	22.2
Reported	71.1	65.2	52.2	69.6
Not reported	8.5	6.3	5.6	8.1
Total	100	100	100	100

Source: Primary Data, 2015

During the study, crop yield was identified as one of the factors contributing to the adoption of SWC technologies. Many farmers in the region were facing declining of crop yields due to high soil erosion, which in turn lead to soil fertility depletion. And the latter itself has negative impact on crop yield. This has adverse effects on the region's economic growth. Therefore, the findings from farmers and key informant interview indicated that the perceptions of farmers on crop yield decline are a major reason for adopting different SWC technologies. Thus, the decline in crop yield is attributed to land degradation, which is a result of various factors, among others soil erosion, nutrient mining, and the inability of smallholder farmers to adopt technologies that enhance soil conservation and soil fertility (Bojö, 1996; Mbaga-Semgalawe & Folmer, 2000).

As the results of low crop production in the area of study as well as in Rwanda, the Ministry of Agriculture and Animal Resources (MINAGRI) has developed a Crop Intensification Program (CIP) in 2008 for increasing agricultural productivity and food security which therefore requires replication of such adoption of modern inputs by the smallholder farmers. However, with the introduction and adoption of these improved inputs, the farmers were able to significantly increase their crop production levels by several folds. The increased yields provided food security and stability, which in turn triggered an array of social and economic transformation.

According to the chi square results, the study results showed that farmers' perceptions on low crop yield has a relationship (p=9. 869; Appendix 4.10) with the adoption of SWC technologies in the study area. This is similar to the findings of a study done by Amanze et al., (2010) where they proved that the output of the crop, level of education, farm size and price of fertilizer were important factors influencing farmers' use of fertilizer in arable crop production.

5.3.4. Inputs

The study results show that 55.2% of respondents reported to adopt crop rotation due to the subsidizing of agricultural inputs while 51.5% using agricultural inputs (manure and fertilizers) due to the fact that they get subside of organic and mineral fertilizers at low cost (Table 5.13).

Table 5.13: Influence of input (support) on adoption of SWC technologies

Inputs	CR	AI	RT	Ditches
	% of respondents			
None	20.4	28.5	42.2	22.2
Reported	55.2	51.5	34.1	47.4
Not reported	24.4	20.0	23.7	30.4
Total	100	100	100	100

Source: Primary Data, 2015

CR: crop rotation, AI: agricultural inputs, RT: radical terraces

The study results indicate that most of farmers adopt crop rotation and agricultural inputs due to the subsidies of organic and mineral fertilizers as well as improved seeds.

The subsidizing of organic and mineral fertilizers as well as improved seeds may influence the adoption of SWC technologies directly or indirectly. Actually, MINAGRI through a crop intensification program distribute vouchers to farmers through service providers. And the farmers buy fertilizers from the distributors by presenting the vouchers. The Government subsidizes inputs to the farmers at 50% of all costs, covering transportation and administration costs. It estimates that as a result of these efforts, the national average fertilizer use per year has increased from 8 Kg/Ha to 23 Kg/Ha in 2010 (MINAGRI, 2010).

Statistically, the chi square results showed that having access to support (inputs) is associated (p=39. 916; Appendix 4.13) with number of adopted SWC technologies in the study area. This is alike to the study done by Tewodros & Melesse (2010) where their findings revealed that households with large farm size, better socioeconomic status, endowed with labor, access to institutional supports and a number of monthly contacts with development agents were more likely to adopt and this is confirmed by a positive elasticity.

5.3.5. Knowledge and their Source (access to extension services) and Farmers' Experience

Extension plays a great role in promoting SWC technologies. During the interview, it was clear that farmers in the area got assistance from extension services. The access to the extension services may influence the adoption of SWC technologies in one way or another. The study found that most respondents have reported to adopt SWC technologies due to the access to extension services. The results also indicated that due to the access to extension services; 76.7% and 76.6% of respondents adopt ditches and crop rotation respectively, while 70.7% and 57.8% farmers adopt the application of agricultural inputs (organic and mineral fertilizers) and radical terraces respectively (Table 5.14).

According to the respondents' experience, the results indicated that the majority of farmers adopted SWC technologies below fifteen years, while only few of them adopted SWC technologies more than sixteen years (Table 5.14).

Table 5.14: Knowledge from extension services and SWC technologies

Extension service	CR	AI	RT	Ditches
	% of respondents			
None	20.4	28.5	42.2	22.2
Have knowledge	76.6	70.7	57.8	76.7
Do not have knowledge	0.0	0.7	0.0	1.1
Total	100	100	100	100
Respondents' Experience				
None	20.4	28.5	42.2	22.2
Below 15 years	57.0	37.8	57.0	56.7
More than 16 years	22.6	33.7	0.7	21.1
Total	100	100	100	100

Source: Primary Data, 2015

CR: crop rotation, AI: agricultural inputs, RT: radical terraces

The results from farmers and key informant interview indicate that farmers get assistance provided by extension services and this assistance has a great role in adoption of SWC technologies. Access to agricultural extension services was reported to increase the development and awareness of smallholder farmers. However, the access to extension service in Rwanda was promoted by Ministry of Animal and Agriculture (MINAGRI) through decentralized governmental extension services and non-governmental agencies.

The chi square results indicated that there is no relationship (p=4. 744; Appendix 4.4) between access to the extension service and the number of SWC technologies adopted in the study area. Contrary, findings of a study carried out in Burkina Faso by Basga (1992) proved that governmental extension services exhibit positive correlation coefficients for both the traditional and new soil conservation practices. And additionally, according to the findings from the study done by Derajew et al., (2013) pointed out that the educational level of the household head; extension contact; and slope of the plot positively and significantly affect farmers' conservation decision and the extent of use of improved soil conservation technologies. Furthermore, it was also revealed by Senait, 2005) on the determinants of choice of land management practices in Ankober District, the findings showed that land ownership type, distance of the farm plot from homestead, resource availability and contact with extension agents were found to be the most important factors affecting choice of land management practices such as the use of commercial fertilizer, manure, stone/soil bonds or a combination of them.

Furthermore, the statistical results showed that there is a connection (p=250. 829; Appendix 4. 14) between farmers' experience and a number of SWC technologies adopted. This is similar to the findings of Adeola (2010) revealed that education, contact with extension agents, farming experience and farm size significantly influenced the adoption of soil conservation measures among farmers. Further, the finding of Belay (2014) also asserted that farmers with experiences of one or more of the soil conservation practices (e.g. Terracing, check dam, diversion ditches, contour plowing and crop rotation, etc.) already had the experience and they were more aware of the soil erosion problem than farmers who did not have any experience of doing soil and water conservation practices. Therefore, through experience, farmers may perceive and analyze the problem of soil erosion and opt to use soil conserving measures (Derajew et al., 2013).

5.3.6. Perception of soil erosion

The perception of soil erosion as a serious problem was one of the physical factors which influence the adoption of the SWC technologies. Table 5.15 indicates the study findings indicating the percentages of respondents who reported to adopt such technique due to the problem of soil erosion. The results indicate that the majority of respondents (64.1%) adopts crop rotation due to the soil erosion problem, followed by those who adopt ditches (56.3%), agricultural inputs and radical terraces with proportions of 53.3 % and 46.7% respectively.

Table 5.15: Farmers who experience soil erosion and adoption of SWC technologies

Perception on Soil erosion	CR	AI	RT	Ditches
	% of respondents			
None	20.4	28.5	42.2	22.2
Experience S.E	64.1	53.3	46.7	56.3
Do not experience S.E	15.6	18.1	11.1	21.5
Total	100	100	100	100

Source: Primary Data, 2015

S.E : Soil erosion

CR: crop rotation, AI: agricultural inputs, RT: radical terraces

Perception of soil erosion as a hazard to agricultural production and sustainable agriculture is the most important determinant of effort at adoption of conservation measures. Forty-four percent of respondents stated to have the problem of soil erosion on their farms. And among them, 23% stated to have soil erosion as a serious problem while 21% said to have a problem of soil fertility depletion. In addition, it was found that soil erosion and soil fertility depletion is higher in hillside areas than in marshland (Figure 5.7). Surprisingly, it was found that all farmers (including those who reported to not have a problem of soil erosion) have adopted one or more SWC technology.

Furthermore, the results showed a relationship (p=8. 936; Appendix 4.11) between perception of the soil erosion problem and number of SWC technologies adopted in the area of the study. The implication is that farmers who feel that their farmlands are prone to soil erosion are more likely to adopt physical soil conservation measures than those who do not perceive the problem of soil erosion. This was proved by the findings of a study done by Tadesse & Belay (2004) in Ethiopia, which showed that farmers' perception of the soil erosion problem affects the adoption of soil conservation measures positively and significantly. Additionally, in relation to the findings of a research conducted by Simon et al., (2012) and Alufah et al., (2012) have shown that household size, perception of the soil erosion problem, training in soil erosion control, land ownership and access to institutional credit had significant effects on the adoption of SWC technologies.

As proposed by Wischmeier and Smith (1965), a method used to calculate rainwash erosion is currently in use in many countries as a universal method. This method is well-known under the name of the universal soil loss equation (USLE). The equation was developed in relation with erosion to slope steepness and slope length. Further, developments led to the addition of a climatic factor based on the maximum 30-minute rainfall total with a two-year return period, a crop factor, to take account of the protection effectiveness of different crops, a conservation factor and a soil erodibility factor. Changing the climatic factor to the rainfall erosivity index (R) ultimately yielded the Univeral Soil Loss Equation.

The equation is: A=R*K*L*S*C*P

Where: A is the mean annual soil loss, R is the rainfall erosivity factor, K expresses the soil erodibility factor and K varies for different soils ranging from the most resistant soil types up to most soil types susceptible to erosion. L is the slope length factor, S is the slope steepness factor, C is the crop management factor and P is the erosion-control practice factor (Morgan, 2005).

This equation is also applicable to the area of the study, where it is characterized by high rainfall, many hills (slope length and steepness) accompanied by agricultural activities. The adoption of crop management and soil erosion control practices are required in order to reduce high runoff and soil erosion in the area. However, due to the research objectives, the researcher did use the Universal Soil Loss Equation to measure the annual soil loss in the study area.

5.3.7. High slope

High slope was identified as one of the last factors affecting the adoption of SWC technologies in the area. The research findings indicate that slope situation affects the adoption of crop rotation, agricultural inputs, radical terraces and ditches (Table 5.16). In fact, the area of the study is characterized by high rainfall and many hills which facilitates high runoff, which in turn cause the excessive soil loss through soil erosion.

Table 5.16: Influence of high slope on adoption of SWC technologies

High Slope	CR	AI	RT	Ditches
	% of respondents			
None	20.4	28.5	42.2	22.2
Adopt due to high slope	17.4	15.9	3.7	4.8
Do not adopt due to high slope	62.2	55.6	54.1	73.0
Total	100	100	100	100

Source: Primary Data, 2015

CR: crop rotation, AI: agricultural inputs, RT: radical terraces

The results indicate that there is a connection (p=48. 388; Appendix 4.12) between the high slope and number of SWC technologies adopted. The implication is that farmers who cultivate in hillside areas tend to adopt more diverse SWC technologies than those who do not cultivate the land which is susceptible to excessive soil erosion. This was proved by many authors, including Ervin & Ervin (1982), Gould et al., (1989), Paulos (2002) and Wagayehu (2003) their findings revealed that the slope category of the plot has been found to be positively affecting the farmer's decision to invest in conservation technologies.

5.4.EXTENT OF USING ADOPTION OF SWC TECHNOLOGIES

Table 5.17 shows the extent of farmers' adoption of SWC technologies. The adoption score indicates the number of the four SWC technologies that farmers have adopted, and the frequency with the corresponding percentage refers to the number of farmers who have adopted the conservation practices. One hundred and thirteen farmers (41.9%) have adopted between one and two SWC technologies, and one hundred and fifty-seven farmers (58.2%) have adopted between three and four SWC technologies. In this group, one hundred and two farmers (37.8%) have adopted all the four SWC technologies.

Table 5.17: The extent of the adoption of SWC technologies

Adoption Score	Frequency	Percentage
1	25	9.3
2	88	32.6
3	55	20.4
4	102	37.8
Total	**270**	**100**

Source: primary Data, 2015

The reason behind the adoption of one or more SWC technology is that the study area is characterized by many hills and excessive rainfall which cause much soil loss and runoff. Due to the status of the study area, one SWC technique cannot be enough for controlling soil erosion as well as runoff or other disasters. This could also be explained by the program launched in by the Government of Rwanda to consolidate the land so that the land could be more protected by various technologies through farmers' participation approach. The program is called Land consolidation.

Figures from Table 5.18 indicate that overall, farmers in the study area used more agronomic measures (Crop rotation and agricultural inputs) than those who adopted physical measures SWC technologies (radical terraces and ditches). The results indicated that 90.7% of respondents adopted traditional SWC practices while 78.1% use improved SWC technologies.

Table 5.18: Agronomic and Physical measures

Adoption Score	Frequency	Percentage
Agronomic	245	90.7
Physical	211	78.1

Source: Primary Data, 2015

The high adoption of agronomic measures could be explained by the availability of improved seeds and fertilizers through governmental subsidies and the fact that they are easy and simple to apply. While on the other hand, physical measures are much higher dependent on much labor as well as financial means.

According to the Table 5.19 among the SWC technologies, crop rotation, ditches and agricultural inputs were the most used technologies, amongst farmers with proportions of 79.6%, 77.8% and 71.5% respectively. It can be seen that farmers have poorly adopted radical terraces (57.8%).

Table 5.19: Distribution of the adopted SWC technologies in the study area

Adoption score	Frequency	Percentage
Crop rotation	215	79.6
Ditches	210	77.8
Agricultural inputs	193	71.5
Radical terraces	156	57.8

Source: Primary Data, 2015

And the other reason which would be behind this adoption is that; crop rotation, ditches and agricultural inputs are easier and cheaper SWC technologies to be implemented. And they can be done by household itself while radical terraces are required much labor and inputs and also households alone cannot make radical terraces without external financial means or Governmental supports. Additionally to this low adoption of radical terraces, is that the technology is still new in the study area and was adopted by very few numbers of farmers.

Table 5.19 shows the distribution of the adopted SWC technologies in the area of study. Crop rotation is the first most adopted technologies in the study area. It is also the most traditional practices used for improving soil fertility and conserving the soils. The major crop rotation practiced by farmers in the area is from maize to beans. The reason behind this high adoption is due to the fact that it is a simple and easy technology, and additionally the availability of improved seeds through governmental subsidies. This technology plays an important role in improving soil productivity, soil cover, structure and fertility and thus enables soil erosion control. The second technology is ditches (Table 5.19), which used in the study area for protecting soil from erosion by draining excessive water, this facilitates the infiltration of water into the soil easily. The technology is very simple and easy to be established by any person in the area of study. This was explained by Yohannes (1999) by stating that the potential of this technology is that it demands less labor, and being flexible, it can be easily established by any farmer and competition with the crop area is minimal. Additionally, it is practicable where the slope of the land is very high, stony catchment and high quantity of water.

Agricultural inputs (organic and chemical fertilizers) are also used in the area for the achievement of increased agricultural production and productivity and thus are considered as a practice susceptible for soil fertility management (Table 5.19). Based on interview with households and key informants, farmers have increased the amount of agricultural inputs, especially applied manure because of the high price of inorganic fertilizers and also due to the accessibility of trainings of compost making as well livestock availability. Furthermore, according to the Ministry of Agriculture and Animal MINAGRI (2010), the Government subsidizes inputs to the farmers at 50% of all costs covering transportation and administration costs. It estimates that as a result of these efforts, the national average fertilizer use per year has increased from 8 Kg/Ha to 23 Kg/Ha in 2010. Actually, MINAGRI through the Crop Intensification Program distribute vouchers to farmers through service providers. And the farmers buy fertilizers from the distributors by presenting the vouchers. Lastly, radical terraces are less adopted by comparison with those three other technologies. This could be explained by the fact that radical terraces are much more labor intensive, require technical advisory input and in addition is still new technology introduced in the study area by comparison with other previous technologies.

Even if radical terraces are the less adopted in the study area (Table 5.19), the study found out that they play an important role regarding soil erosion and runoff control. Radical terraces are greatly used for reducing high slope in order to control high runoff and minimize soil erosion at the same time increasing agricultural productivity; they conserve soil moisture and fertility and facilitate cropping operations as well as promote intensive land use and permanent agriculture on the slope. Additionally, the adoption of radical terraces could be allied to the existing policies or programs, for instance land consolidation, land management and crop intensification programs. These policies or programs may improve the use of radical terraces by providing farmers more opportunity to easily access inputs such as improved seeds and manure for increasing the productivity of established radial terraces. Therefore, the low adoption of radical terraces may also relate to the high financial cost and much labor and manure demand for radical terraces. Bizoza & Graaff (2012) showed that radical terraces in the highlands of Rwanda are only financially viable when the opportunity cost of labour and manure are below the local market price levels and when an agriculture area on these radical terraces can be substantially intensified. Ten to 30 metric tons of manure (organic) are required to restore the soil fertility of newly established radical terraces.

5.5. EFFECTS OF SWC TECHNOLOGIES ON LIVELIHOOD OF SMALLHOLDERS FARMERS AND THEIR BENEFITS IN THE STUDY AREA

This section analyzed the effect of SWC technologies on the livelihoods of smallholder farmers and their benefits in the study area. Vulnerability context, access to livelihood assets, institutions, policy and process involved in and livelihood strategies were discussed.

5.5.1. Vulnerability context

A household's access to adequate livelihood assets can be affected by many factors over which household members themselves may have little control. These factors might include: seasonal changes, long-term or trends and shocks. These are all factors that may cause households to become more or less vulnerable to poverty. This context influences the ways in which households choose to use the various assets at their disposal. So, the information about the farmers' vulnerability context was generated by the farmers themselves through the household interview.

According to the farmers, there are many extreme events like heavy rainfall and excessive soil erosion that damage farmers' livelihoods. These trends are not favorable and lead to the adaptation and/or adoption of new SWC technologies. Thus, 74% of farmers reported to adopt SWC technologies due to soil erosion problem which is mainly associated with heavy rainfall in the study area. Due to the soil erosion and heavy rainfall, management measures in terms of SWC technologies would become more important and where it is possible, financial support could be used in order to lead to better SWC technologies. While 28.1% reported that they adopt different SWC technologies because of weather changes. It was also noted that 5.9% and 1.8% were using SWC technologies because of the selected seeds which are able to adapt to the changes in weather and also to the pests respectively. While, on the other hand 3.3% and 1.1% are using SWC technologies due to the land shortage as well as fluctuation occur in prices at market level (Table 5.20). Many experts would expect this trend due to the rapid population growth and strong overexploitation of land resources, accompanied by unsustainable agricultural practices along with issues of land shortage and steep slope land.

Table 5.20: Trends found in the study area

Trends	Frequency	Percentage
Soil erosion	200	74.1
Weather changes	76	28.1
Selected crops	16	5.9
Shortage of land	9	3.3
Pests	5	1.8
Changes in market prices	3	1.1

Source: Primary Data, 2015

5.5.2. Livelihood Assets

The members of a household combine their capabilities, skills and knowledge with the different resources at their disposal to create activities that would enable them to achieve the best possible livelihood for themselves and the households as a whole. However, the livelihood assets are distinguished into five different capitals: human, social, natural, physical and the financial capital.

Table 5.21: The five different capitals and used indicators

Human Capital	Age, HH size, Education and knowledge
Social Capital	Member of farmers' cooperatives
Natural Capital	Access to land, farm size
Physical Capital	Farm equipment
Financial Capital	Access to credit and saving, insurance, Livestock rearing

Source: primary Data, 2015

i. Human capital: Respondents' Age, Education, HH size and Knowledge

The research findings revealed that the majority of respondents are aged between 21 and 40 years (46.3%) followed by those who are in the range of 41 to 60 years old (37.4%) while those who are below or equal to 20 years and the one who are aged over or equal to 61 altogether are 16.3% (Table 5.1 and Table 5.22). Regarding their education level, the results showed that most of them have primary education (73.75%) followed by those who did not attend any schools (20.74%) while those with education beyond primary are 5.55% (Table 5.3 and table 5.22).

Additionally, the results show that households with members ranging from one to three persons are 20.7%, households with members ranging from four to six persons are 75.2%, family size ranging from seven to nine are 4.1% (Table 5.5 and table 5.22). Households with large family size are assumed to have labor availability in their families. The shortage of labor may affect the farm work which leads to the decline in farm incomes. Since most SWC technologies are labor intensive, it is assumed that they are often the first victims of farm labor shortage. However, using family size as a substitute for accessible family labour and taking into account that family labour is often complemented by hiring labour and through labour exchange. Also Table 5.22 shows the study findings, which indicate that farmers who have access to trainings and extension services as their source of knowledge are 53% and 98.89%, respectively, and only 2.2% said to get knowledge of SWC technologies through knowledge dissemination (from parents or eldest to children).

Table 5.22: Human Capital

Human Capital		**Frequency**	**Percentage**
Ages	≤ 40	129	47.8
	≥ 41	141	52.2
Education	Primary	199	73.7
	Beyond primary	15	5.6
HH size	≤ 3	56	20.7
	≥ 4	214	79.3
Source of Knowledge	Extension service	267	98.9
	Trainings	143	53
	Others	6	2.2

Source: Primary Data, 2015

Statistical results showed that there is no connection (p=12.642, p=9.666 and p=15.024; Appendix 4.1, 4.2 and 4.3 respectively) between age, household size and education and number of SWC technologies adopted and also the results indicate that access to extension service and dissemination of knowledge have no relationship (p=4.744 and p=3.519 in Appendix 4.4 and 4.6 respectively) with number of adopted SWC technologies, but on the other hand, the chi square results also indicated that access to trainings has a relationship (p=71.997; Appendix 4.5) with number of SWC technologies adopted in the area of the study.

This is contrary to the findings of a study carried out in Nigeria by Amanze et al., (2010) proved that the output of the crop, level of education, farm size and price of fertilizer were important factors influencing farmers' use of fertilizer in arable crop production and also farm size were shown generally to have a positive impact on a household's decision to adopt and use a new technology such as fertilizer. But on the other hand, it was found that access to trainings has a relation with the number of SWC adopted. This is similar to the study findings of Simon et al., (2012) and Alufah et al., (2012) showed that household size, perception of the soil erosion problem, training in soil erosion control, land ownership and access to institutional credit had significant effects on the adoption of SWC technologies.

ii. Natural capital: Land tenure and farm size

Land resource is either public or held by individuals under customary land rights. Customary land is acquired through inheritance, through allocation by the village government, or by purchase from others with customary land rights (MINITERE, 2004). Additionally, according to this principle, women, married or not, should not be excluded from the process of land access, land acquisition and land control, and female descendants should not be excluded from the process of family land inheritance (MINITERE, 2004). However, it has found that all respondents have their own land, either for living or cultivating, and the most cultivated land are found near their living homes. Most of the land was under land heritage and the majority (86.7%) of farmers have land with the size ranging below 2 hectares, while 13.3% have land with size greater than or equal to two hectares. Statistical results showed that the size of the farm has a connection (p=14. 315; Appendix 4.7) with a number of SWC technologies adopted.

Here, natural capital is talking about natural resources, mainly land and water. However, most of the people in the area of study rely on the environment for their livelihoods. All households require water for consumption. Farming activities also require much water for producing crops and raising livestock and also people are much depending on the type and quality of soils and fodder for their livestock found in the area. Any type of degradation of these resources can reduce the livelihood status of households that depend on them for production and consumption. According to the statistical results, farm size has a relationship with a number of SWC technologies adopted in the area of the study. This association is similar to the findings of various studies; including findings of Tadesse & Belay (2004) stated that farm size has a positive and significant influence on the farmers' decision to adopt physical soil conservation measures. Additionally to this, the findings of Mulugeta, (2000), Tadesse & Belay (2004) and Yishak (2005) indicated there is a positive relationship between farm size and adoption. However, according to them; farm size and number of plots owned have a positive influence on the adoption of SWC practices. This is also similar to the findings of a study carried out in Nigeria by Amanze et al., (2010) proved that output of the crop, level of education, farm size and price of fertilizer were important factors influencing farmers' use of fertilizer in arable crop production and also farm size were shown generally to have a positive impact on a household's decision to adopt and use a new technology such as fertilizer. But, on the other hand, the findings of studies carried out in Cameroun and Ethiopia by Gockowski & Ndoumbe (2004) and Degnet et al. (2001) respectively, revealed that there is negative relationship between farm size and adoption of mono-crop horticulture as well as between farm size and adoption of high yielding maize varieties.

iii. Social capital

As indicated by the household interview and key informant results, it was found that 73% of farmers are in different cooperatives, and each cooperative is formed by 20 to 30 people. It is in these cooperatives where farmers get access to different supports including trainings.

Table 5.23: Social Capital

Social Capital	Frequency	Percentage
Member of cooperative	197	73
None	73	27

Source: Primary Data, 2015

The results of the Chi square indicate that being a member of a cooperative have a relationship (p=163. 312; Appendix 4.9) with the number of SWC technologies adopted the area.

Social assets are about unity and community actions. Nowadays, in area of study as well as in Rwanda, many farmers are operating in cooperatives. Thus, the study findings indicate that 73% (Table 5.23) are in different cooperatives, related to agricultural activities (farming and livestock) and women's cooperatives. These cooperatives represent a form of social capital that provides value to individual households. Social capital is also helpful in organizing the operation and maintenance of a community infrastructure scheme and bringing workers together to perform necessary tasks. For example, in Rwanda, there is always a community work at every last Saturday of a month. The type of work is mainly based on environmental protection activities, including planting trees, creating radical terraces and waterways, etc. Strong social capital helps in allocating water resources among households and their farms in ways that are acceptable to community members and beneficial to the community as a whole.

Furthermore, according to the statistical results, it was found that there is a connection between being a member of such cooperative and number of SWC technologies adopted. This is was also proved by a study conducted in Ethiopia by Tesfaye (2003); indicating that land size, livestock ownership, family size, risk perception, land tenure on non-arable lands, labor organization, characteristics of technology, indigenous institution and physical factors are significant determinants of SWC.

iv. Financial capital: Access to credit and saving and Livestock rearing

Many households have inadequate financial capital. The most source of financial capital is from raising livestock, farming activities (including crop production, forest, coffee) and credit from cooperatives. The study results revealed that 95.6% and 73% get financial capital through raising livestock and cooperatives respectively (Table 5.24).

Table 5.24: Main source of Financial Capital

Financial Capital	Frequency	Percentage
Member of cooperative	197	73
Raising livestock	258	95.6

Source: Primary Data, 2015

Taking into part in farmers' cooperatives is a main means of access to financial capital in the study area. It is in these cooperatives where farmers get access to credit and savings through their contribution which is equal to two hundred Rwandan francs (0.27$) per week. Through these cooperatives, farmers are enabling to get health insurance, schooling materials for their children and other needs which require much money. In fact, every cooperative is made by 20 or 30 persons and every person has to contribute two hundred Rwanda francs per week.

However, the reason behind these cooperatives are due to the fact that in Rwanda there is a politics of helping people (smallholder farmers in general) throughout cooperatives. They get trainings and support through these cooperatives. Because of the inadequate financial means, farmers are unable to invest in new SWC technologies especially radical terraces. They wait intervention of Governmental support in terms of financial means or materials as well as trainings. Additionally, limited financial resources also prevent farmers accessing all of the complementary inputs required to maximize the productivity of land and water resources.

Thus, livestock rearing has a big contribution to the increasing of farmers' income throughout the production of meat, milk, eggs as well as manure. Unfortunately, according to the statistical results, it was found that there is no relationship (p=3. 348; Appendix 4.8) between livestock rearing with a number of SWC technologies adopted while on the other hand, there is an association between being a member of the cooperative (p=163. 312; Appendix 4.9) and number of SWC technologies adopted in the study area. This could be explained by the findings of a study done in Ethiopia by Derajew et al. (2013) which indicated that distance of the plot from residence, livestock holding and the fertility of the farm plot affect negatively and significantly farmers' conservation decision and the extent of use of improved soil conservation technologies**.** But in addition, the findings of Tesfaye (2003) revealed that land size, livestock ownership, family size, risk perception, land tenure on non-arable lands, labor organization, characteristics of technology, indigenous institution and physical factors are significant determinants of SWC. Furthermore, the research findings of Simon et al., (2012) and Alufah et al., (2012) showed that household size, perception of the soil erosion problem, training in soil erosion control, land ownership and access to institutional credit had significant effects on the adoption of SWC technologies.

5.5.3. Policies, Institutions and Processes (PIP)

Policies and institutions which influence rural household's access to livelihood assets are important aspects of the livelihood framework (DFID, 2000). However, in the DFID framework, there is no specific list of transforming structure and processes. So, it is the reason why the researcher decided to consider the main key elements, including institutions performing in SWC technologies and other factors influencing livelihoods and adoption of SWC. As an institution, MINAGRI as Ministry is in charge of agricultural activities and its development. In fact, in Rwanda, at the national level, there is MINAGRI which aims at increasing or promoting sustainable agriculture along with promotion and dissemination of adoption of SWC technologies and also acts at District and Sector levels.

But agricultural development as well as poverty reduction cannot succeed without effective and real consideration of the environment dimensions. It is for this reason that environment is one of the first priorities identified by the Economic Development and Poverty Reduction Strategy in Rwanda (EDPRS) and is among the leading fundamental programs selected within Agricultural transformation and Rural development. It was found that over the course of EDPRS I, agriculture contributed significantly to poverty reduction. In recognition of its potential in economic development, food security and poverty reduction, the government has set a very ambitious agriculture agenda aiming at an annual average growth of 8.5% over the course of the EDPRS II (2012-2017) (NISR, 2014). However, agricultural transformation and rural development have to be accompanied by environmental safeguard activities including SWC technologies.

Furthermore, it is essential to note that various activities concerning SWC are done by MINAGRI and REMA in countrywide. It was remarkable through farmers' interview that MINAGRI is strongly involved in agriculture and organizes many projects (including VUP and LWH in the study area) and trainings on soil erosion conservation techniques. Additionally, the results from households' interview, most of them reported to get access on trainings, supports on SWC through mainly in accessing different services provided by MINAGRI at District and Sector levels. It was also noted that many activities were also carried out to empower the smallholder farmer and to enhance their livelihoods. The empowerment of these farmers is done through the access to different livelihood assets, including human, natural, social and financial assets.

As said by Scoones, (1998), institutions are the social cement which link stakeholders to access to capital of different kinds to the means of exercising power and so define the gateways through which they pass on the route to positive or negative (livelihood) adaptation. And additionally, according to various studies, the institutions play a great role in agricultural development. For example**;** in relation to the findings of a study done by Turner et al., (1993), they finally confirmed the significance of supportive socio-economic organizations and structures in ensuring sustainable agricultural intensification. But on the other hand, a research conducted in Rwanda, Kenya and Ghana by Place & Hazell1993): they concluded that the rights over specific land resources varied significantly in these studied regions and were in many cases surprisingly privatized. According to their findings, the land rights were not found to be a significant factor in determining whether or not farmers made an improvement in land investments or a yield enhancing inputs.

5.5.4 Livelihood strategies

On the word of DFID (1999), access to different levels and combinations of assets is probably the major influence on their choice of livelihood strategies; a good endowment with assets leads to more positive livelihood choices. Further, good transforming structures and processes can reinforce positive choices; if they function well; they would facilitate mobility in the labor market, reduce risks and transaction costs of embarking on a new venture and can increase the efficiency of investments. In addition, livelihood strategies are composed of activities that generate the means of household survival and are the planned activities that men and women undertake to build their livelihoods (Ellis, 2000). Thus, the study considered agricultural activities as a means to conceptualize livelihood strategies in the area of study.

As indicated by FAO (2007), Agriculture in Rwanda is dominated by small-scale, subsistence oriented family farming units. Approximately 1.4 million rural households depend on agriculture as their main livelihood source. And also, through Second Economic Development and Poverty Reduction Strategy (EDPRS II), Rwanda in general needs to achieve at least 11.5 per cent average GDP growth per annum, and also aims to reduce poverty to below 30 per cent. It is focused on ensuring that poverty is reduced from 44.9% to below 30% by 2018. This would be achieved through focus on increased productivity of agriculture, which engages the vast majority of the population and ensures sustainable poverty reduction (GovR, 2013).

In point of fact, the livelihoods of people in the study area are based on agricultural activities including farming and livestock activities. Their basic needs are from both crop and livestock production. Their sources of labor are from household members and sometimes from neighboring families/friends or from cooperative members. Due to high relying on natural resource for their livelihoods, the institutions and stakeholders have promoted and implemented sustainable agricultural practice along with the promotion of sustainable land management practices. This is done through providing different supports, including trainings and access to extension services to all farmers through their farming or livestock cooperatives. These have the aim of improving people's livelihoods and reduce/control soil erosion and high runoff. And as reviewed in the literature, FAO (2006) stated that the country of Rwanda is experiencing moderate to severe soil erosion on 50% of its land surface. MINAGRI has attempted to address this problem through a program of soil erosion protection and the Land Consolidation Program. However, according to Zhou (1999) land consolidation is generally considered as putting together small plots with the aim of making them viable and more productive per unit of investment, through economies of scale. These need not change the amount of land controlled by individuals, and is therefore not necessarily an instrument for social justice.

5.5.5.Benefits of adoption of SWC technologies

Farmers were asked to mention the effects or benefits of SWC technologies through household questionnaires. The most of the respondents (70.4%) considered increase/improve crop yield to be a major benefit, while 55.6% indicated that SWC technologies improves soil fertility. 45.9% stated that adoption of SWC technologies has reduced soil erosion/runoff in their farms as well as 33.7% said to play a great role in fodder production, especially radical terraces and others, including improved water quantity and quality, access to credit and savings as well as increase of income (Table 5.25).

Table 5.25: Benefits of SWC technologies in the study area

Benefits	Frequency	Percentage
Improved agricultural productivity	190	70.4
Improved soil fertility	150	55.6
Reduced soil erosion/runoff	147	54.4
Increased vegetation cover/ fodder production	91	33.7
Others	126	46.7

Source: Primary Data, 2015

Multiple responses

However, the use of crop rotation and agricultural inputs play an important role in improving soil properties especially soil structure and chemical properties. They have various beneficial effects as erosion is reduced, the physical, chemical, and biological soil properties are improved, and crop production is increased. They help the balance of the soil fertility demands of various crops to avoid excessive depletion of soil nutrients. Radical terrace and ditches are designed as the methods of soil conservation to slow or prevent the rapid surface runoff of irrigation water. In fact, the radical terraces are used to reduce runoff or its velocity and to minimize soil erosion, to conserve soil moisture and fertility and to facilitate modem cropping operations and to promote intensive land use and permanent agriculture on slopes and reduce shifting cultivation.

In fact, a great number of respondents considered an improvement of crop yield as major benefits of SWC technologies. This is associated with the fact that most of the respondents as well as 98% of al Rwandan depend on agricultural production as their major source of living. This is in relation with the ambition of Rwanda which in general needs to achieve at least 11.5 per cent average GDP growth per annum, and also aims to reduce poverty to below 30 per cent. It is focused on ensuring that poverty is reduced from 44.9% to below 30% by 2018. This possibly will be achieved through focus on increased productivity of agriculture, which engages the vast majority of the population and ensures sustainable poverty reduction (GovR, 2013).

Further, according to the results from households' and key informant interviews, they indicated that adoption of SWC technologies has reduced soil erosion by controlling runoff in hillsides and improve soil fertility. In fact, severe soil erosion has led to the loss of soil fertility which now is improving due to the adoption of the SWC technologies. Rwanda as well as study area is characterized by high excessive rainfall and steep which make worse the situation of the soil erosion problem. This was also stated by FAO, where declared that the soil of Rwanda is very degradable due to high excessive soil erosion mainly because of unsustainable land use and steep slopes.

Respondents also mentioned the availability of fodder as benefit from adoption of SWC technologies. Actually, due to the zero grazing system used in Rwanda, people were facing a shortage of forage for their livestock mainly during the dry season. The farmers suffer from a fodder shortage, especially in dry season. So implementation of radical terraces was helping them to get more fodder easily and near their farms. They also declared that due to the zero grazing system, livestock manure is not spread everywhere, but is collected into the shed for livestock and afterward used on their farms in support of improving soil properties. According to the results generated from households' and key informants, they indicated that implementation and adoption of SWC technologies played an important role in the improvement of water quality and quantity, food security, access to credit and savings as well as increased household income in the area of the study. The findings of a study by Demeke (2003) also showed that farm size and perception of benefit from conservation measures positively and significantly affect the farmers' decision to adopt conservation structures.

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATION

6.1.Introduction

This section presents the summary of key findings, conclusion and recommendation to policy makers as well as for further researches.

6.2.Summary of key findings

The research revealed that the most adopted SWC technologies are crop rotation, ditches, agricultural inputs and radical terraces. And the major factors contributing to the adoption of SWC technologies in the area of study are as follows: farm size, rearing of livestock, crop yield, support of inputs, access to extension services and experience, perception of soil erosion as a major problem as well as steep slope. Statistical results showed that some of these factors have a relationship with a number of SWC technologies adopted in the study area, while others do not have a connection between them.

The study also found out that 41.9% respondents have adopted at least one SWC technology while 37.8% have adopted all four SWC technologies. The results showed that according to the WOCAT classification, agronomic measures are greatly adopted than physical measures. Furthermore, it was found that crop rotation, ditches and agricultural inputs are more adopted than radical terraces.

The study revealed that having access to the livelihood assets (human, natural, physical, social and financial) influence the adoption of SWC technologies in one way or another. The statistical results showed the relationship between some of livelihood assets and number of SWC technologies adopted. Those livelihood assets are: farmers' experience, training, farm size cooperatives. But on the other hand, the study showed that there is no relationship between the following livelihood assets and a number of SWC technologies used. These are age, education, household size, access to extension services and dissemination as well as rearing livestock. As Ministry of Agriculture in charge of agricultural development, it has developed various programs and policies through which would develop and enhance the agricultural sector more sustainable. It is due to the fact that is one of the major sources of livelihoods of farmers. As with this effort put on the agricultural sector and sustainable land management, the participants pointed out that they benefit more from adoption of SWC technologies, including improvement of crop yield, increase of availability of fodder, reduced of soil erosion and runoff as well as increase of household income. According to the benefits of adoption of SWC technologies, the findings indicated that the most of them are not far from the livelihood outcomes. These include improvement of crop yield and soil fertility, prevention/control of soil erosion and runoff, increased availability of fodder and others, for instance improved water quantity and quality, access to credit and savings as well as the increase of income

6.3. Conclusion

As conclusion, the main purpose of the study was to investigate the effect of Soil and Water management technologies on livelihood of smallholder farmers in Burega Sector, Rulindo District of Northern Province, Rwanda. The most used SWC technologies were identified and the major factors contributing to their adoption were seen as; farm size, livestock rearing, crop yield, support, knowledge from extension services and experience, farmers' perception of soil erosion and steep slope. And it was found that respondents were willing to adopt SWC technologies. It was found that at least one technology has been adopted. But it was also found that a combination of SWC technologies is preferred over the section of single technology. As a matter of fact, the adoption of these SWC technologies has made respondents feeling secure of their assets. Those include human, natural, physical, social and financial capitals. The study also found that the institutions played an important role in combating major vulnerability context and in the development of policies and processes useful to farmers' livelihood strategies in order to achieve the livelihood outcomes. Furthermore, the study concluded that most of the participants were willing to maintain soil as a valuable resource and apply SWC technologies for maximizing their benefits including improvement of agricultural productivity as well as soil fertility and same time reduced soil erosion. But the study expressed the need for the continuing support of the implementation. Further, it also brings to a close that conservation efforts should target areas where expected benefits are higher, especially on the steeper slopes, in order to encourage the use of the SWC technologies.

6.4.Recommendations

The specific recommendations this study envisage would enhance the usage of SWC technologies in the area as well in other regions of the country.

6.4.1Recommendations to the policy makers:

- Promotion of environmental education, by providing appropriate trainings on environmental dimensions and management to local communities.
- Ensuring proper monitoring and evaluation of the progress of implementation of Soil and water conservation technologies already established and additionally, according to the radical terraces technologies, farmers need more trainings before the undertaking the terracing process to ensure technical efficiency and sustainability of established terraces.
- Developing proper strategies for increasing farm financial resources as well as investment in Soil and water conservation activities. And also promoting greater involvement of NGOs in investment in SWC activities
- Develop more roads in order to facilitate market access and shorten the effective distance to markets. This would reduce the excessive loss of foods due to the inappropriate transport mode and help the farmers to get more from their crop production.
- Promote the use of Agroforestry, forestry and water harvesting technologies in the study area by providing adequate training.

6.4.2 Recommendations for further research:

This study found that there were no researches done on Soil and Water Management practices in Burega Sector. Hence, it recommends further research to work on the following areas:

- As climate change is one of the challenges farmers are facing, it's better to assess the contribution of SWC practices to the mitigation of climate change in Burega Sector.
- To assess the socioeconomic impact of radical terraces on women in the study area.
- A comparative study of investment in agricultural inputs and final agricultural productivity in radical terraces.
- A study of financial cost analysis of radial terraces in the study area
- A study of an assessment of soil erosion control by radical terraces, its effect on water infiltration and on soil properties (physical and chemical properties)

- Future research can investigate the impacts of crop rotation technique on food security and market price changes in the area of the study as well as in other regions.
- In addition, research is required to assess the impacts of radical and ditches on soil properties as well as long-term land sustainability

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APPENDICES

APPENDIX I: HOUSEHOLD QUESTIONNAIRE

UNIVERSITY OF NAIROBI

EFFECTS OF INTEGRATED SOIL AND WATER MANAGEMENT ON LIVELIHOODS OF SMALLHOLDERS IN BUREGA SECTOR, RULINDO DISTRICT, RWANDA

My name is Delphine MUTUYIMANA, a post-graduate student at University of Nairobi. I am conducting a research project to assess effects of integrated soil and water management on livelihoods of smallholders in Burega Sector, Rulindo district, Rwanda. To meet the objectives of the study several techniques are being used including conducting discussion with smallholders. Please assist by completing this questionnaire. The information obtained will be used sorely for the purposes of this study and will be confidential. Thank you very much.

HOUSEHOLD QUESTIONNAIRE

NAME OF VILLAGE: **DATE:**

NAME OF CELL:

NAME OF HOUSEHOLD HEAD:

SECTION A: DEMOGRAPHICS

1.Gender of respondents

1. ☐ Male 2. ☐ Female

2. Marital Status of respondent

1	2	3	4
☐ Single	☐ Married	☐ Widowed	☐ Divorced

3. Occupation of respondents

(i)……………………………………………….

(ii)……………………………………………….

(iii)………………………………………………

(iv)………………………………………………

(v)……………………………………………….

(vi)………………………………………………

4. i. Ages of respondents

☐ 10-20 ☐ 21-30 ☐ 31-40 ☐ 41-50 ☐ 51-60 ☐ 60 and above

ii. Family size:

5.Level of Education

☐ Primary ☐ Ordinary level ☐ 9 years education basic ☐ High school ☐ University

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6.

SECTION B: LAND USE SYSTEM

7. Farm characteristics

7.1. Where is your farm located?

☐ Upland ☐ Marshland

7.2. If it is in marshland, did you consolidate your farm?

☐ Yes ☐ No

8. (a) Which type of land use system do you use

………………………………………………………………………………………………

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(b) What is the size of your farm?

☐ Below 0.3ha ☐ 0.3.-0.8ha ☐)-1.4ha ☐ .5-2ha ☐ ove 2ha

(c) (i) What type of crop do you plant?

………………………………………………………………………………………………

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(ii) What kind of animal do you raise?

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……………………………………………………………………………………………………….....

9. Do you have any problem of land/ soil degradation?

☐ Yes ☐ No

If yes, what type of land degradation?

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……………………………………………………………………………………………………

10.What are causes of land degradation on your farm?

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SECTION C: SOIL AND WATER MANAGEMENT TECHNOLOGIES

11. What do you do to minimize of land /soil degradation?

……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………

12. Do you know about SWC Technologies?

☐ Yes ☐ No

13. Do you use any SWC technologies? If yes, what ones?

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

14. At which extent those SWC technologies are being used?

1	2	3	4
☐ Below 25%	☐ 25 -50%	☐ 50 – 75%	☐ 5 – 100%

15. What are the factors conducted you to use SWC technologies?

……………………………………………………………………………………………

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16. For how long have you been using these technologies?

……………………………………………………………………………………………

……………………………………………………………………………………………

17. How did you know about these SWC technologies?

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18. Why did you choose to use SWC technologies?

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………………………………………………………………………………………………
………………………………………………………………………………………………
………………………………………………………………………………………………

19. Have women participated in SWC Technologies? ☐ Yes ☐ No

20. What are the benefits you get by using the SWC technologies?

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………………………………………………………………………………………………
………………………………………………………………………………………………
……………………………………………………………………………………………..

21. What are the advantages and disadvantages of SWC Technologies? What problems do you face in using SWC technologies?

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………………………………………………………………………………………………
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………………………………………………………………………………………………
………………………………………………………………………………………………

22. What are the effects on your livelihood?

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………………………………………………………………………………………………
………………………………………………………………………………………………
………………………………………………………………………………………………

23. What are the effects of SWC technologies on the natural environment?

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24. What help do you receive from Government and NGOs?

(i) Government

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………………………………………………………………………………………………..

(ii) NGOs

………………………………………………………………………………………………

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25. What more help would you like to receive as far as SWC technologies is concerned?

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APPENDIX II: INTERVIEW GUIDE

UNIVERSITY OF NAIROBI

EFFECTS OF INTEGRATED SOIL AND WATER MANAGEMENT ON LIVELIHOODS OF SMALLHOLDERS IN BUREGA SECTOR, RULINDO DISTRICT, RWANDA

My name is Delphine MUTUYIMANA, a post-graduate student at University of Nairobi. I am conducting a research project to assess effects of integrated soil and water management on livelihoods of smallholders in Burega Sector, Rulindo district, Rwanda. To meet the objectives of the study several techniques are being used including conducting discussion with smallholders. Please assist by completing this questionnaire. The information obtained will be used sorely for the purposes of this study and will be confidential. Thank you very much.

INTERVIEW GUIDE

BUREGA SECTOR

NAME OF CELL:

NAME OF VILLAGE: **DATE:**

NAME OF RESPONDENT:

DEPARTMENT/SECTION:

1.There are any SWC technologies in this area?

1 ☐ Yes 2 ☐ No

If Yes, which ones?

……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
…………………………………………………………………………………………………..

2.What are factors contributing to the adoption of SWC technologies?

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…………………………………………………………………………………………………..

3.What are the most SWC technologies used in the study area and what are the criteria used to choose such SWC technologies?

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They are used at which extent?

1	2	3	4
☐ Below 25%	☐ 25 – 50%	☐ 50 – 75%	☐ 75 – 100%

4.How have these SWC technologies impacted farmers' livelihood?

……………………………………………………………………………………………

……………………………………………………………………………………………

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5.How have SWC technologies impacted women farmers?

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6. How do you support farmers whose farms are at hillside and which kinds of support do you provide them?

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7. What do you plan for the farmers whose farms have not any SWC technologies and are susceptible to land/ soil degradation?

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8. What are the effects of SWC technologies on natural environment?

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9. What would you like to do for supporting farmers to invest in SWC technologies in order to maximize the SWC technologies benefits?

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APPENDIX III: OBSERVATION SCHEDULE

The observation helped the researcher to observe the characteristics of the study area along with the most SWC technologies adopted in the study area. Additionally, types of crops and livestock were also observed.

The following are the important things that were observed:

1.The most SWC technologies used in the study area

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……………………………………………………………………………………………………

2.Types of crops

……………………………………………………………………………………………………

……………………………………………………………………………………………………

3.Types of livestock

……………………………………………………………………………………………………

……………………………………………………………………………………………………

4.The size of farm

……………………………………………………………………………………………………

……………………………………………………………………………………………………

5.The location of farm

……………………………………………………………………………………………………

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APPENDIX IV: CHI-SQUARE RESULTS

Appendix 4.1. Age and Number of SWC Technologies adopted

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Age * Number of SWC adopted	270	100.0%	0	0.0%	270	100.0%

Age * Number of SWC adopted Crosstabulation

		Number of SWC adopted				Total
		1	2	3	4	
≤20	Count	0	2	1	1	4
	Expected Count	.4	1.3	.8	1.5	4.0
	% within Age	0.0%	50.0%	25.0%	25.0%	100.0%
	% within Number of SWC adopted	0.0%	2.3%	1.8%	1.0%	1.5%
	% of Total	0.0%	0.7%	0.4%	0.4%	1.5%
21-40	Count	15	36	31	43	125
	Expected Count	11.6	40.7	25.5	47.2	125.0
	% within Age	12.0%	28.8%	24.8%	34.4%	100.0%
	% within Number of SWC adopted	60.0%	40.9%	56.4%	42.2%	46.3%
	% of Total	5.6%	13.3%	11.5%	15.9%	46.3%
41-60	Count	10	32	19	40	101
	Expected Count	9.4	32.9	20.6	38.2	101.0
	% within Age	9.9%	31.7%	18.8%	39.6%	100.0%
	% within Number of SWC adopted	40.0%	36.4%	34.5%	39.2%	37.4%
	% of Total	3.7%	11.9%	7.0%	14.8%	37.4%
≥61	Count	0	18	4	18	40
	Expected Count	3.7	13.0	8.1	15.1	40.0
	% within Age	0.0%	45.0%	10.0%	45.0%	100.0%

	% within Number of SWC adopted	0.0%	20.5%	7.3%	17.6%	14.8%
	% of Total	0.0%	6.7%	1.5%	6.7%	14.8%
Total	Count	25	88	55	102	270
	Expected Count	25.0	88.0	55.0	102.0	270.0
	% within Age	9.3%	32.6%	20.4%	37.8%	100.0%
	% within Number of SWC adopted	100.0%	100.0%	100.0%	100.0%	100.0%
	% of Total	9.3%	32.6%	20.4%	37.8%	100.0%

Chi-Square Tests

Statistic	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	12.642	9	.179

Appendix 4.2. Chi Square tests HH size and Number of SWC Technologies adopted

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
HH size * Number of SWC adopted	270	100.0%	0	0.0%	270	100.0%

HH size * Number of SWC adopted Crosstabulation

		Number of SWC adopted				Total
		1	2	3	4	
1to 3 persons	Count	8	21	14	13	56
	Expected Count	5.2	18.3	11.4	21.2	56.0
	% within HH size	14.3%	37.5%	25.0%	23.2%	100.0%
	% within Number of SWC adopted	32.0%	23.9%	25.5%	12.7%	20.7%
	% of Total	3.0%	7.8%	5.2%	4.8%	20.7%
4 to 6 persons	Count	17	62	38	86	203
	Expected Count	18.8	66.2	41.4	76.7	203.0
	% within HH size	8.4%	30.5%	18.7%	42.4%	100.0%

	% within Number of SWC adopted	68.0%	70.5%	69.1%	84.3%	75.2%
	% of Total	6.3%	23.0%	14.1%	31.9%	75.2%
7 to 9 persons	Count	0	5	3	3	11
	Expected Count	1.0	3.6	2.2	4.2	11.0
	% within HH size	0.0%	45.5%	27.3%	27.3%	100.0%
	% within Number of SWC adopted	0.0%	5.7%	5.5%	2.9%	4.1%
	% of Total	0.0%	1.9%	1.1%	1.1%	4.1%
Total	Count	25	88	55	102	270
	Expected Count	25.0	88.0	55.0	102.0	270.0
	% within HH size	9.3%	32.6%	20.4%	37.8%	100.0%
	% within Number of SWC adopted	100.0%	100.0%	100.0%	100.0%	100.0%
	% of Total	9.3%	32.6%	20.4%	37.8%	100.0%

Chi-Square Tests

Statistic	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9.666	6	.139

Appendix 4.3. Chi Square tests Education level and Number of SWC Technologies adopted

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Education * Number of SWC adopted	270	100.0%	0	0.0%	270	100.0%

Education * Number of SWC adopted Crosstabulation

		Number of SWC adopted				Total
		1	2	3	4	
Illiterate	Count	1	20	9	26	56
	Expected Count	5.2	18.3	11.4	21.2	56.0
	% within Education	1.8%	35.7%	16.1%	46.4%	100.0%

	% within Number of SWC adopted	4.0%	22.7%	16.4%	25.5%	20.7%
	% of Total	0.4%	7.4%	3.3%	9.6%	20.7%
Primary	Count	23	63	41	72	199
	Expected Count	18.4	64.9	40.5	75.2	199.0
	% within Education	11.6%	31.7%	20.6%	36.2%	100.0%
	% within Number of SWC adopted	92.0%	71.6%	74.5%	70.6%	73.7%
	% of Total	8.5%	23.3%	15.2%	26.7%	73.7%
Lower Secondary	Count	1	5	2	1	9
	Expected Count	.8	2.9	1.8	3.4	9.0
	% within Education	11.1%	55.6%	22.2%	11.1%	100.0%
	% within Number of SWC adopted	4.0%	5.7%	3.6%	1.0%	3.3%
	% of Total	0.4%	1.9%	0.7%	0.4%	3.3%
Upper Secondary	Count	0	0	3	3	6
	Expected Count	.6	2.0	1.2	2.3	6.0
	% within Education	0.0%	0.0%	50.0%	50.0%	100.0%
	% within Number of SWC adopted	0.0%	0.0%	5.5%	2.9%	2.2%
	% of Total	0.0%	0.0%	1.1%	1.1%	2.2%
Total	Count	25	88	55	102	270
	Expected Count	25.0	88.0	55.0	102.0	270.0
	% within Education	9.3%	32.6%	20.4%	37.8%	100.0%
	% within Number of SWC adopted	100.0%	100.0%	100.0%	100.0%	100.0%
	% of Total	9.3%	32.6%	20.4%	37.8%	100.0%

Chi-Square Tests

Statistic	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	15.024	9	.090

Appendix 4.4. Knowledge from Extension services and Number of SWC Technologies adopted

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Extension service * Number of SWC adopted	270	100.0 %	0	0.0%	270	100.0%

Extension service * Number of SWC adopted Crosstabulation

		Number of SWC adopted				Total
		1	2	3	4	
Have knowledge	Count	24	86	55	102	267
	Expected Count	24.7	87.0	54.4	100.9	267.0
	% within have Extension service	9.0%	32.2%	20.6%	38.2%	100.0%
	% within Number of SWC adopted	96.0%	97.7%	100.0%	100.0%	98.9%
	% of Total	8.9%	31.9%	20.4%	37.8%	98.9%
Don't have	Count	1	2	0	0	3
	Expected Count	.3	1.0	.6	1.1	3.0
	% within extension service	33.3%	66.7%	0.0%	0.0%	100.0%
	% within Number of SWC adopted	4.0%	2.3%	0.0%	0.0%	1.1%
	% of Total	0.4%	0.7%	0.0%	0.0%	1.1%
Total	Count	25	88	55	102	270
	Expected Count	25.0	88.0	55.0	102.0	270.0
	% within Extension service	9.3%	32.6%	20.4%	37.8%	100.0%
	% within Number of SWC adopted	100.0%	100.0%	100.0%	100.0%	100.0%
	% of Total	9.3%	32.6%	20.4%	37.8%	100.0%

Chi-Square Tests

Statistic	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.744	3	.192

Appendix 4.5. Trainings and Number of SWC Technologies adopted

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Trainings * Number of SWC adopted	270	100.0%	0	0.0%	270	100.0%

Trainings * Number of SWC adopted Crosstabulation

		Number of SWC adopted				Total
		1	2	3	4	
Adopt due to trainings	Count	22	78	21	37	158
	Expected Count	14.6	51.5	32.2	59.7	158.0
	% within Trainings	13.9%	49.4%	13.3%	23.4%	100.0%
	% within Number of SWC adopted	88.0%	88.6%	38.2%	36.3%	58.5%
	% of Total	8.1%	28.9%	7.8%	13.7%	58.5%
Don’t adopt due to trainings	Count	3	10	34	65	112
	Expected Count	10.4	36.5	22.8	42.3	112.0
	% within Trainings	2.7%	8.9%	30.4%	58.0%	100.0%
	% within Number of SWC adopted	12.0%	11.4%	61.8%	63.7%	41.5%
	% of Total	1.1%	3.7%	12.6%	24.1%	41.5%
Total	Count	25	88	55	102	270
	Expected Count	25.0	88.0	55.0	102.0	270.0
	% within Trainings	9.3%	32.6%	20.4%	37.8%	100.0%
	% within Number of SWC adopted	100.0%	100.0%	100.0%	100.0%	100.0%
	% of Total	9.3%	32.6%	20.4%	37.8%	100.0%

Chi-Square Tests

Statistic	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	71.997	3	.000

Appendix 4.6. Knowledge form others and Number of SWC Technologies adopted

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Knowledge from others * Number of SWC adopted	270	100.0 %	0	0.0%	270	100.0%

Knowledge from others * Number of SWC adopted Crosstabulation

		Number of SWC adopted				Total
		1	2	3	4	
Knowledge from others	Count	0	4	1	1	6
	Expected Count	.6	2.0	1.2	2.3	6.0
	% within Knowledge from others	0.0%	66.7%	16.7%	16.7%	100.0%
	% within Number of SWC adopted	0.0%	4.5%	1.8%	1.0%	2.2%
	% of Total	0.0%	1.5%	0.4%	0.4%	2.2%
Don't have	Count	25	84	54	101	264
	Expected Count	24.4	86.0	53.8	99.7	264.0
	% within Knowledge from others	9.5%	31.8%	20.5%	38.3%	100.0%
	% within Number of SWC adopted	100.0%	95.5%	98.2%	99.0%	97.8%
	% of Total	9.3%	31.1%	20.0%	37.4%	97.8%
Total	Count	25	88	55	102	270
	Expected Count	25.0	88.0	55.0	102.0	270.0
	% within Knowledge from others	9.3%	32.6%	20.4%	37.8%	100.0%
	% within Number of SWC adopted	100.0%	100.0%	100.0%	100.0%	100.0%
	% of Total	9.3%	32.6%	20.4%	37.8%	100.0%

Chi-Square Tests

Statistic	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.519	3	.318

Appendix 4.7. Farm size and Number of SWC Technologies adopted

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Farm Size * Number of SWC adopted	270	100.0%	0	0.0%	270	100.0%

Farm Size * Number of SWC adopted Crosstabulation

		Number of SWC adopted				Total
		1	2	3	4	
Farm Size <2ha	Count	25	76	53	80	234
	Expected Count	21.7	76.3	47.7	88.4	234.0
	% within Farm Size	10.7%	32.5%	22.6%	34.2%	100.0%
	% within Number of SWC adopted	100.0%	86.4%	96.4%	78.4%	86.7%
	% of Total	9.3%	28.1%	19.6%	29.6%	86.7%
Farm size ≥2ha	Count	0	12	2	22	36
	Expected Count	3.3	11.7	7.3	13.6	36.0
	% within Farm Size	0.0%	33.3%	5.6%	61.1%	100.0%
	% within Number of SWC adopted	0.0%	13.6%	3.6%	21.6%	13.3%
	% of Total	0.0%	4.4%	0.7%	8.1%	13.3%
Total	Count	25	88	55	102	270
	Expected Count	25.0	88.0	55.0	102.0	270.0
	% within Farm Size	9.3%	32.6%	20.4%	37.8%	100.0%
	% within Number of SWC adopted	100.0%	100.0%	100.0%	100.0%	100.0%
	% of Total	9.3%	32.6%	20.4%	37.8%	100.0%

Chi-Square Tests

Statistics	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	14.315	3	.003

Appendix 4.8. Livestock rearing and Number of SWC Technologies adopted

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Livestock rearing * Number of SWC adopted	270	100.0%	0	0.0%	270	100.0%

Livestock rearing * Number of SWC adopted Crosstabulation

		Number of SWC adopted				Total
		1	2	3	4	
Have Livestock rearing	Count	23	82	54	99	258
	Expected Count	23.9	84.1	52.6	97.5	258.0
	% within Livestock rearing	8.9%	31.8%	20.9%	38.4%	100.0%
	% within Number of SWC adopted	92.0%	93.2%	98.2%	97.1%	95.6%
	% of Total	8.5%	30.4%	20.0%	36.7%	95.6%
Don’t have	Count	2	6	1	3	12
	Expected Count	1.1	3.9	2.4	4.5	12.0
	% within Livestock rearing	16.7%	50.0%	8.3%	25.0%	100.0%
	% within Number of SWC adopted	8.0%	6.8%	1.8%	2.9%	4.4%
	% of Total	0.7%	2.2%	0.4%	1.1%	4.4%
Total	Count	25	88	55	102	270
	Expected Count	25.0	88.0	55.0	102.0	270.0
	% within Livestock rearing	9.3%	32.6%	20.4%	37.8%	100.0%
	% within Number of SWC adopted	100.0%	100.0%	100.0%	100.0 %	100.0%
	% of Total	9.3%	32.6%	20.4%	37.8%	100.0%

Chi-Square Tests

Statistic	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.348	3	.341

Appendix 4.9. Member of Cooperative and Number of SWC Technologies adopted

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
cooperatives * Number of SWC adopted	270	100.0%	0	0.0%	270	100.0%

Cooperatives * Number of SWC adopted Crosstabulation

		Number of SWC adopted				Total
		1	2	3	4	
Member of Cooperative	Count	0	59	1	0	60
	Expected Count	5.6	19.6	12.2	22.7	60.0
	% within cooperatives	0.0%	98.3%	1.7%	0.0%	100.0%
	% within Number of SWC adopted	0.0%	67.0%	1.8%	0.0%	22.2%
	% of Total	0.0%	21.9%	0.4%	0.0%	22.2%
	Count	25	29	43	83	180
	Expected Count	16.7	58.7	36.7	68.0	180.0
	% within cooperatives	13.9%	16.1%	23.9%	46.1%	100.0%
	% within Number of SWC adopted	100.0%	33.0%	78.2%	81.4%	66.7%
	% of Total	9.3%	10.7%	15.9%	30.7%	66.7%
Cooperatives	Count	0	0	11	19	30
	Expected Count	2.8	9.8	6.1	11.3	30.0
	% within cooperatives	0.0%	0.0%	36.7%	63.3%	100.0%
	% within Number of SWC adopted	0.0%	0.0%	20.0%	18.6%	11.1%
	% of Total	0.0%	0.0%	4.1%	7.0%	11.1%
Total	Count	25	88	55	102	270
	Expected Count	25.0	88.0	55.0	102.0	270.0
	% within cooperatives	9.3%	32.6%	20.4%	37.8%	100.0%
	% within Number of SWC adopted	100.0%	100.0%	100.0%	100.0%	100.0%
	% of Total	9.3%	32.6%	20.4%	37.8%	100.0%

Chi-Square Tests

Statistic	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	163.312	6	.000

Appendix 4.10: Crop yield and Number of SWC Technologies adopted

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Crop yield * Number of SWC adopted	270	100.0%	0	0.0%	270	100.0%

Crop yield * Number of SWC adopted Crosstabulation

		Number of SWC adopted				Total
		1	2	3	4	
Due to crop yield	Count	22	74	45	98	239
	Expected Count	22.1	77.9	48.7	90.3	239.0
	% within Crop yield	9.2%	31.0%	18.8%	41.0%	100.0%
	% within Number of SWC adopted	88.0%	84.1%	81.8%	96.1%	88.5%
	% of Total	8.1%	27.4%	16.7%	36.3%	88.5%
Don't report	Count	3	14	10	4	31
	Expected Count	2.9	10.1	6.3	11.7	31.0
	% within Crop yield	9.7%	45.2%	32.3%	12.9%	100.0%
	% within Number of SWC adopted	12.0%	15.9%	18.2%	3.9%	11.5%
	% of Total	1.1%	5.2%	3.7%	1.5%	11.5%
Total	Count	25	88	55	102	270
	Expected Count	25.0	88.0	55.0	102.0	270.0
	% within Crop yield	9.3%	32.6%	20.4%	37.8%	100.0%
	% within Number of SWC adopted	100.0%	100.0%	100.0%	100.0 %	100.0%
	% of Total	9.3%	32.6%	20.4%	37.8%	100.0%

Chi-Square Tests

Statistic	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9.869	3	.020

Appendix 4.11: Soil erosion and Number of SWC Technologies adopted

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Soil erosion * Number of SWC adopted	270	100.0%	0	0.0%	270	100.0%

Soil erosion * Number of SWC adopted Crosstabulation

		Number of SWC adopted				Total
		1	2	3	4	
Experience SE	Count	14	61	41	84	200
	Expected Count	18.5	65.2	40.7	75.6	200.0
	% within Soil erosion	7.0%	30.5%	20.5%	42.0%	100.0%
	% within Number of SWC adopted	56.0%	69.3%	74.5%	82.4%	74.1%
	% of Total	5.2%	22.6%	15.2%	31.1%	74.1%
Don't experience SE	Count	11	27	14	18	70
	Expected Count	6.5	22.8	14.3	26.4	70.0
	% within Soil erosion	15.7%	38.6%	20.0%	25.7%	100.0%
	% within Number of SWC adopted	44.0%	30.7%	25.5%	17.6%	25.9%
	% of Total	4.1%	10.0%	5.2%	6.7%	25.9%
Total	Count	25	88	55	102	270
	Expected Count	25.0	88.0	55.0	102.0	270.0
	% within Soil erosion	9.3%	32.6%	20.4%	37.8%	100.0%
	% within Number of SWC adopted	100.0%	100.0%	100.0%	100.0%	100.0%
	% of Total	9.3%	32.6%	20.4%	37.8%	100.0%

Chi-Square Tests

Statistic	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.936	3	.030

Appendix 4.12: High slope and Number of SWC Technologies adopted

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
High slope * Number of SWC adopted	270	100.0%	0	0.0%	270	100.0%

High slope * Number of SWC adopted Crosstabulation

		Number of SWC adopted				Total
		1	2	3	4	
Due to high slope	Count	3	37	4	6	50
	Expected Count	4.6	16.3	10.2	18.9	50.0
	% within High slope	6.0%	74.0%	8.0%	12.0%	100.0%
	% within Number of SWC adopted	12.0%	42.0%	7.3%	5.9%	18.5%
	% of Total	1.1%	13.7%	1.5%	2.2%	18.5%
Don't adopt due to high slope	Count	22	51	51	96	220
	Expected Count	20.4	71.7	44.8	83.1	220.0
	% within _High slope	10.0%	23.2%	23.2%	43.6%	100.0%
	% within Number of SWC adopted	88.0%	58.0%	92.7%	94.1%	81.5%
	% of Total	8.1%	18.9%	18.9%	35.6%	81.5%
Total	Count	25	88	55	102	270
	Expected Count	25.0	88.0	55.0	102.0	270.0
	% within High slope	9.3%	32.6%	20.4%	37.8%	100.0%
	% within Number of SWC adopted	100.0%	100.0%	100.0%	100.0%	100.0%
	% of Total	9.3%	32.6%	20.4%	37.8%	100.0%

Chi-Square Tests

Statistic	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	48.388	3	.000

Appendix 4.13. Availability of inputs and Number of SWC Technologies adopted

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Inputs (Support) * Number of SWC adopted	270	100.0%	0	0.0%	270	100.0%

Inputs (Support) * Number of SWC adopted Crosstabulation

		Number of SWC adopted				Total
		1	2	3	4	
Reported due to availability of inputs	Count	14	83	36	55	188
	Expected Count	17.4	61.3	38.3	71.0	188.0
	% within Inputs (Support)	7.4%	44.1%	19.1%	29.3%	100.0%
	% within Number of SWC adopted	56.0%	94.3%	65.5%	53.9%	69.6%
	% of Total	5.2%	30.7%	13.3%	20.4%	69.6%
Don’t report	Count	11	5	19	47	82
	Expected Count	7.6	26.7	16.7	31.0	82.0
	% within Inputs (Support)	13.4%	6.1%	23.2%	57.3%	100.0%
	% within Number of SWC adopted	44.0%	5.7%	34.5%	46.1%	30.4%
	% of Total	4.1%	1.9%	7.0%	17.4%	30.4%
Total	Count	25	88	55	102	270
	Expected Count	25.0	88.0	55.0	102.0	270.0
	% within Inputs (Support)	9.3%	32.6%	20.4%	37.8%	100.0%
	% within Number of SWC adopted	100.0%	100.0%	100.0%	100.0%	100.0%
	% of Total	9.3%	32.6%	20.4%	37.8%	100.0%

Chi-Square Tests

Statistic	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	39.916	3	.000

Appendix 4.14: Farmers' experience and Number of SWC Technologies adopted

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Experience * Number of SWC adopted	270	100.0%	0	0.0%	270	100.0%

Experience * Number of SWC adopted Crosstabulation

		Number of SWC adopted				Total
		1	2	3	4	
Below 10 years	Count	0	1	51	102	154
	Expected Count	14.3	50.2	31.4	58.2	154.0
	% within Experience	0.0%	0.6%	33.1%	66.2%	100.0%
	% within Number of SWC adopted	0.0%	1.1%	92.7%	100.0%	57.0%
	% of Total	0.0%	0.4%	18.9%	37.8%	57.0%
More than 10 years	Count	25	87	4	0	116
	Expected Count	10.7	37.8	23.6	43.8	116.0
	% within Experience	21.6%	75.0%	3.4%	0.0%	100.0%
	% within Number of SWC adopted	100.0%	98.9%	7.3%	0.0%	43.0%
	% of Total	9.3%	32.2%	1.5%	0.0%	43.0%
Total	Count	25	88	55	102	270
	Expected Count	25.0	88.0	55.0	102.0	270.0
	% within Experience	9.3%	32.6%	20.4%	37.8%	100.0%
	% within Number of SWC adopted	100.0%	100.0%	100.0%	100.0%	100.0%
	% of Total	9.3%	32.6%	20.4%	37.8%	100.0%

Chi-Square Tests

Statistic	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	250.829	3	.000