EFFECT OF SOIL AND WATER CONSERVATION TECHNOLOGIES ON SOIL PROPERTIES IN MAZIBA SUB CATCHMENT, KABALE–UGANDA

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Declaration

This research thesis is my original work and has never been presented for a degree or any other award in any University.

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Dedication

This research work is dedicated to God almighty, my mother Mrs. Dorokasi K. Mukamukora, my wife Nomugisha loyce, my lovely sisters; Christine K, Kizza G, Kate N, Medias N, Tushabe V, Brother Magara Friday, Alex Saturday, course mates and all lecturers at Kenyatta University.

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List of Abbreviations and Acronyms

AHI	African Highland Initiative
BD	Bulk Density
DWRM	Directorate of Water Resources Management
FAO	Food and Agriculture Organization
KIRBMD	Kagera Integrated River Basin Management and Development
KRBMP	Kagera River basin Management Project
K_{sat}	Saturated hydraulic conductivity
MDGs	Millennium Development Goals
MWE	Ministry of Water and Environment
NBI	Nile Basin Initiative
NEMA	National Environmental Management Authority
NEPAD	New Partnership for Africa's Development
OM	Organic Matter
SSA	Sub-Saharan Africa
SWCTs	Soil and Water Conservation Technologies
UBOS	Uganda Bureau of Statistics
WCB	Water catchment bank
WOCAT	World Overview of Conservation Approaches and Technologies

Abstract

Soil and water resources are important for sustaining life on earth since they are the main components of sub catchment, however they are under threat of deterioration due to human activities (NEMA, 2011). Maziba sub catchment have high population pressure which have led to deforestation, over cultivation and wetland encroachment leading to soil erosion problems causing severe tension on soil and water resources while little attention is paid to their effects (NEMA, 2011). The purpose of the study was to analyze the effect of soil and water conservation technologies on soil properties in Maziba sub catchment of Kabale District, Uganda. The specific objectives of the study were to: (i) Identify soil and water conservation technologies used at different landscape positions by farmers in Maziba sub catchment, (ii) Evaluate the effects of selected soil and water conservation technologies on saturated hydraulic conductivity, organic matter and bulk density and (iii) Determine the factors influencing farmers' use of soil and water conservation technologies in Maziba sub catchment. The study employed both descriptive and analytical research designs utilizing mixed methodologies. Probability sampling technique was used to select 99 respondents, who were selected to obtain predominantly used soil and water conservation technologies and socio-economic data using semi-structured questionnaire. Thirty six soil samples were collected from mulched and trenched plots at 0-5 cm depth using soil core to analyze BD and OM from the laboratory and K_{sat} was measured *in situ* using inversed augur hole technique. Statistical analysis of the data collected was done using statistical packages for social scientists (SPSS 16.0) and Microsoft Excel 2007. The results obtained from treatment (mulched plots) were compared to those of control (none mulched plots) from the same sub catchment and conclusions regarding the soil properties were drawn based on internationally acceptable standards. Descriptive statistics were used to describe soil and water conservation technologies practiced in the study area. Chi-square tests were used to test the association between socio-economic data and soil and water conservation technologies used by farmers. The study revealed that terracing (36.4%), mulching (21.2%) and trenching (13.1%) were the predominant soil and water conservation technologies reported. The study results indicated that plots under mulching and trenching (treatment) significantly affects the soil OM (4.45 %), Soil BD (1.32 g /cm^3) and K_{sat} (6.13×10^{-2} cm/s) compared to results obtained from control plots OM (3.31%), BD (1.45 g/cm^3) and K_{sat} (11.92×10^{-2} cm/s) which was all within acceptable range. The study further revealed that marital status of respondents, age of respondents, level of education, fertility of the soil, farmland slope, size of land and land tenure influenced farmers' use of soil and water conservation technologies. The study recommends extensive use of mulching and trenching since they were proved to be effective in improving OM, BD and K_{sat} in the study area.

CHAPTER ONE: INTRODUCTION

1.1 Background to the study

Soil and water conservation technologies play a pivotal management role in many catchments of the world (Ouedraogo & Tiganadaba, 2015). This is simply because soil and water are the main natural resources in catchment areas essential to sustain life on earth. The reliable and scientifically proven soil and water conservation technologies include; ridge planting, zero tillage, crop rotation, strip cropping, grass strips, mulching, agroforestry, terracing, contour planting, cover crops, water harvesting, tree planting, digging trenches worldwide (Zlati & Todosijevi, 2012; World Overview of Conservation Approaches and Technologies (WOCAT), 2015).

New Partnership for Africa's Development (2010), reported that soil and water resources in sub catchments greatly support various socio-economic developments such as agriculture, livestock keeping, food production, industrial production and rural development in most developing countries. Regardless of all these, degradation of soil and water resources is a major threat in many catchments of developing countries. Food and Agriculture Organization (FAO), 2010) reported that degradation of soil and water resources in Africa was at alarming phase. In a related study by Huckett (2013), noted that Sub-Saharan Africa (SSA) is characterized by high soil erosion and water quality degradation problems than any other part of the world. Economically, the problem of soil erosion in Africa is estimated to cause a damage of $26 billion each year to the productive soils of the continent (Lal, 2014). According to Angima *et al*. (2010), 5 million grams per hectare of productive soils are lost each year because of soil erosion on the continent. Uganda is among the countries mostly affected by soil erosion and water quality problems (AHI, 2009).

Mulching and trenching are widely used soil and water technologies in banana and pineapple plantations (Majaliwa *et al.*, 2012; Nyombi, 2013). These technologies greatly improve soil

properties to support agricultural activities such as farming which is the source of livelihood to support farmers income (Okeyo *et al.*, 2014).

In Uganda, land degradation is categorized into three main classifications namely: soil erosion, soil infertility, and soil pollution. These have been the major environmental problems since colonial rule (WOCAT, 2015). Factors such as population pressure, deforestation, overstocking of animals which lead to overgrazing, wetland encroachment, soil erosion, and climate change are regarded as major sources of catchment resource degradation. According to Ellis (2010), conservation technologies on soil and water resources began long ago over the last 50 years. This is evidenced by a large number of soil and water conservation technologies projects implemented in many developing countries including Uganda among others (AHI, 2009).

In Kigezi region south western Uganda, 90% of the total population depends on agriculture to sustain their livelihood which has increased cases of land degradation (*NBI*, 2014). This makes the area mostly affected than any other parts of the country. In a related study by FAO (2011) reports that, water catchment areas located in Kigezi highlands are hot spot zones for degradation because of raised terrain which is prone to soil erosion problems compared to flatter areas.

In Maziba sub catchment, soil and water conservation technologies are mainly practiced by a reasonable proportion of farmers. However, it is reported that the available technologies such as terracing are less effective in controlling soil erosion leading to soil and water degradation (Ministry of Water and Environment, 2012). In addition, the sub catchment is currently facing a problem of soil erosion due to lack of adequate knowledge on soil and water management practices suitable for protection of agricultural land and environment (National Environment Management Authority, 2012). Therefore, this study aimed at analyzing the effect of soil and water conservation technologies on selected soil properties and factors influencing their use in Maziba sub catchment, Kabale district Southwestern Uganda.

1.2 Statement of the research problem

Soil and water resources are important for sustaining life on earth since they are the main components of sub catchment, however they are under threat of deterioration due to human activities (NEMA, 2011). Maziba sub catchment have high population pressure which have led to deforestation, over cultivation and wetland encroachment leading to soil erosion problems causing severe tension on soil and water resources while little attention is paid to their effects (NEMA, 2011). This has posed threats to farmers' economic development thus leading to low economic development of the country. Additionally, soil erosion has raised serious concerns on the future ecological functioning of ecosystems as well as sustainability of farmers' livelihood in the region.

Despite the various soil and water conservation technologies introduced in the study area, farmers have variations in technology acceptance because of financial constraints and lack of adequate knowledge on how to use them. All the technologies such as mulching, water catchment banks, level ditches, grasses and tree planting are practiced under terraced farms but their contribution towards controlling soil erosion and improving soil properties have less been analyzed. It was against this background that the study analyzed the effect of soil and water conservation technologies on soil properties in Maziba Sub-catchment, Kabale-Uganda.

1.3 Justification of the study

This study focused on the need to conserve soil and water resources in Maziba sub catchment. This is important because the sub catchment plays a vital role in the socio-economic transformation of Ugandans who live in the sub catchment and their country in general. Therefore, any practice meant to protect the sub catchment against soil erosion in the study area can significantly help farmers and other resource users to sustain livelihood activities such as agriculture.

The current research study contributes to the Government of Uganda's campaign on conservation of soil, water, and other environmental resources meanwhile putting forward sustainable development goals in practice for the country (KRBMP, 2012). This enhances soil and water management of the sub catchment to increase agricultural productivity, direct policy makers and environmental protection for sustainable development targets to be achieved.

The basis of conducting this research was guided by a number of reasons. First, Maziba sub catchment has rapid population growth rate of 0.6% to 8.1% from 1969 to 2014 respectively (UBOS, 2014). Therefore, this situation increases soil and water degradation for land use activities in the study area. Secondly, the sub catchment generally experiences the problem of soil erosion due to its nature of the terrain being steep, with sharp sided valleys and heavy downpour during rainy seasons (Kabale District Local Government, 2012). Thirdly, Maziba sub catchment has little been researched on the aspect of the analysis of effect of soil and water conservation technologies on soil properties in maziba sub catchment. Hence, data on soil and water conservation technologies and their effects on selected soil properties are paramount in achieving efficient management of soil and water resources in Maziba sub-catchment.

1.4 Research questions

i. What are soil and water conservation technologies used on different landscape positions by farmers in Maziba Sub catchment?

ii. What are the effects of selected SWC technologies on saturated hydraulic conductivity (K_{sat}), organic matter (OM) and bulk density (BD) in Maziba Sub catchment?

iii. What are the factors that influence farmers use soil and water conservation technologies in Maziba Sub catchment?

1.5 General objective

The general objective of this study was to analyse the effect of soil and water conservation technologies on soil properties in Maziba sub catchment, Kabale District-Uganda.

1.5.1 Specific objectives

This study was based on the following specific objectives:

i. To identify soil and water conservation technologies used on different landscape positions in Maziba Sub catchment.
ii. To evaluate the effects of selected soil and water conservation technologies on (K_{sat}), (OM) and (BD) in Maziba Sub catchment.
iii. To determine the factors influencing farmers' use of soil and water conservation technologies in Maziba Sub catchment.

1.6 Significance of the study

To ensure sustainability of Maziba Sub catchment, analysis of soil and water conservation technologies in agricultural and environmental point of view is essential for proper planning and management of soil and water resources.

The result of this research would be beneficial to local and district officials as it will generate baseline information for further studies, research, and policy dialogue. The findings would facilitate monitoring and evaluation of soil and water conservation technologies being used in regards to their effects on soil properties in maziba sub catchment.

The findings from this research study would act as a guide to agricultural experts and environmental management authorities to put measures in place on how best to help farmers and

other resource users to control soil erosion from farmlands, improve the productivity of their agricultural land and sound performance of the environment.

1.7 Scope of the study

This study focused on the analysis of soil and water conservation technologies and their effects on saturated hydraulic conductivity, organic matter and bulk density in Maziba Sub catchment. Farmers, experts and unselected soil and water conservation technologies outside the study area and unselected soil properties were not considered for this study.

1.9 Conceptual framework

The conceptual framework (Figure 1.1) was used to analyze soil and water conservation technologies and their effects on selected soil properties (K_{sat}, OM and BD). Soil and water conservation technologies were used as dependent variables. Exogenous factors were used as independent variables. The rate at which soil and water conservation technologies affect hydraulic conductivity, organic matter and bulk density greatly play a significant role in improving soil and water properties (Bagdi *et al.*, 2015). According to FAO (1987), soil organic matter, bulk density and hydraulic conductivity play a significant role in improving water infiltration, maintains soil moisture, soil erosion control, run offs and land stabilization and soil fertility management in most parts of African highlands.

A number of factors in the study area influenced the use of different soil and water conservation technologies and these are; socio-economic, institutional and environmental factors. These factors were termed as exogenous factors. Socioeconomic factors included; household size, the age of respondents, gender of respondents, the level of education and level of income. Environmental factors included farm size, slope, and distance from home to the farm. After completion, results of the study are expected to guide agricultural experts, environmental managers, and NGOs. Strategic

outcomes expected are; planning and management tool, enhance the use of soil and water conservation technologies, control and reduce soil erosion. The livelihood impacts expected are: increase income, food productivity and soil nutrient security.

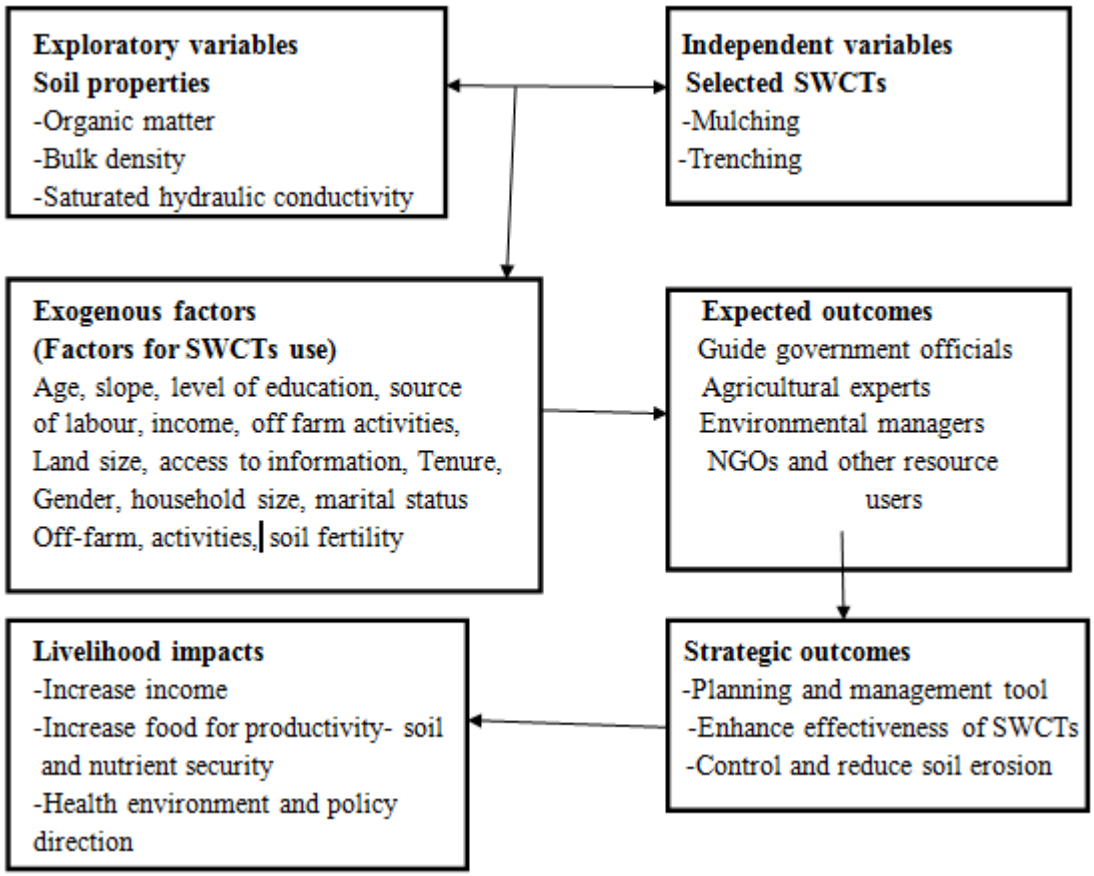


Figure 1.1: Conceptual and theoretical framework of soil and water conservation technologies and soil properties (Modified after Bagdi *et al.*, 2015).

CHAPTER TWO: LITERATURE REVIEW

This chapter reviewed past studies conducted on the Soil and water conservation technologies, effects of selected soil and water conservation technologies on selected soil properties and factors influencing farmer's use of soil and water conservation technologies.

2.1 Soil and water conservation technologies

Soil and water conservation technologies play a big role in reducing the effects of soil erosion in many catchments while maintaining soil and water quality and quantity (Adimassu *et al.*, 2013). Soil and water conservation technologies are made up of any set of measures and practices in order to ensure soil functions for long-term by humans and nature. Soil and water conservation technologies can be divided into mechanical, biological and vegetative technologies (Nyborg & Paudel, 2008; Schmidt & Zemadim, 2015). Mechanical technologies control soil erosion after the soil starts moving. Vegetative technologies prevent erosion by intercepting raindrops and thus prevent erosion process to take place. Vegetative technologies commonly used as soil and water conservation technologies include; grass strips planted perpendicular to the hill slope or associated with terraces and tree rows. Agroforestry practices consist planting trees with crops and bushes for fodder and wood products. These are widely adopted and play a great role to enrich soils by fixing atmospheric nitrogen (Khanal, 2011).

SWC technologies can be subdivided into annual technologies and one-time investment technologies. Annual SWC technologies form part of ploughing and cultivation practices and require an effort of each cropping season. Annual SWC technologies are: mulching, contour ploughing, organic fertilizers, cover crops, crop rotation among others (Schmidt & Zemadim,

2015). One-time investments are mainly mechanical in nature (Schmidt & Zemadim, 2015)**.** They require a one-time investment of labour, capital and afterward recurrent maintenance activities. It often involves modification of the slope such as; terracing, and prevent runoff water through infiltration ditches, benches, trenches, hedgerows among others. The major benefits of erosion control are to conserve water, retain soil nutrients, soil moisture, and organic matter as well as maintain soil depth and soil structure (Alemu *et al.*, 2013).

Generally, there are soil and water conservation technologies on erosion control, soil fertility management and quality enhancement practices that are used by agriculturalists across many continents in the world including Africa. Mugonola *et al.* (2013) report mulching, tied ridges, agroforestry as the predominantly used SWC technologies in Rwizi sub catchment in Mbarara district, Uganda. This has been also emphasized by other studies Barungi *et al*. (2013) from other parts of the country. According to the studies by Huckett (2013) and Obando *et al.* (2012) in Njoro and Ngaciuma Sub catchments respectively, it was found out that crop residues, fanya juu, tree planting, and terraces are the main soil and water conservation technologies used.

In Rwanda, the main soil and water conservation technologies commonly used by most of the farmers are; terraces, growing of grass strips (Stalia) along the contours, agroforestry, crop rotation, mulching and fertilizer application (Teshome *et al.,* 2013). In Ethiopian highlands, stone lines, Stover bounding, and terraces have been reported as predominantly used soil and water conservation technologies (Kato & Bryan, 2009; Alemu *et al.*, 2013).

In Tanzania west Usambara highlands, smallholder farmers carry out subsistence agriculture using agro-forestry, strips of Napier grass (*Pennisetum purpureum*), *fanya juu,* infiltration ditches and cut-off drains as the main predominantly used soil and water conservation technologies (Mwango *et*

al., 2012). The study, however, did not characterize soil and water conservation technologies in Usambara highland and the current study, therefore, seeks to fill the gap with the information.

2.2 Effects of soil and water conservation technologies on soil properties

Soil organic matter and bulk density is the main indicator of soil quality both as a single soil or compound (SOM) attribute was reported (FAO, 1987). The total organic carbon is the carbon stored in soil organic matter; organic carbon enters the soil through the decomposition of plant and animal residues, root exudates, living and dead microorganisms, and soil biota (Nelson & Sommers, 1982). SOM is the organic fraction of soil exclusive of non-decomposed plant and animal residues. USDA (1998) has indicated that the distribution of SOM, expressed as organic carbon, is 38% in trees and ground cover, 9% in the forest floor and 53% is in the soil including the roots plus the SOM associated with soil particles. Soil organic matter is about 58% carbon; therefore, soil organic matter conversions can be made by taking soil C values and dividing by 0.58 or multiplying by 1.72.

Uncultivated soils have higher OM and BD (both on surface and in soil) than those soils cultivated yearly (Nelson & Sommers, 1982). FAO (1987) reported that some of the functions of OM and BD are: (a) aids in water management as residues or plants protect the soil surface from rain drop impacts, resist wind action, and thus, greatly aid in erosion control. Furthermore, decomposing OM causes soil aggregation, which aids infiltration and increases pore space in clay soils. (b) increases exchange and buffering capacity since well decomposed OM or humus has a very high CEC that adds to the buffering capacity of the soil, (c) minimizes leaching loss because organic substances have the ability of holding substances other than cations against leaching, (d) sources of nutrients (N, P, S and most micronutrients) (e) stabilizes soil structure, and (f) provides energy for microbial activity.

Wheaton & Monke (2011) reported that soil and water conservation technologies are promoted as the best soil and water management practices for effective soil and water conservation. The effects of soil and water conservation technologies in sub catchments have long been studied. Results suggest that these technologies generally reduce agricultural surface runoff and soil erosion, improve soil properties as well as decrease the need for fertilizer and pesticide application (Adgo *et al.*, 2013). For instance, terracing changes the landscape, directly affect local hydrology and runoff characteristics. In addition, terraces indirectly affect soil organic matter and other soil characteristics (Chow *et al*., 2011). Terracing has only an effect on water erosion; it does not stop or reduce the impacts of wind erosion.

Mulching has for long been recommended by different scholars as the one of the best soil and water conservation technology. It is a useful technology in soil erosion control, control soil temperature by providing a shield for the soil, reduces water loss through evaporation, improve soil bulkiness and increases soil organic matter (Diaz *et al*. (2005; Maiga, 2012; Kaliisa *et al.* 2012; (Okeyo *et al.* 2014; Zhang *et al.* 2016) noted that mulching reduces water loss through evaporation by 92% and 52% on 10 and 2 cm mulch thickness respectively. Mulch thickness has an effect on the amount of moisture retained in the soils hence improving hydraulic conductivity.

A study by Njomo (2013) reported that the hydraulic or water content of soil mulched with artificial materials ranged from 37 cm^2 to 45 cm^2 at 15-30 cm soil depth. In the control experiment, moisture content values ranged from 27 cm^2 to 31 cm^2. Chiroma *et al.* (2008) revealed 22.2 cm^2 as the highest soil moisture retained at 7.5 cm depth using artificial mulches.

Arnold *et al*. (2009) reported that wet soils at 7.6 cm mulch thickness attained tension of -5.8 kPa. Soil moisture decline and soil fertility reduction are reported as key barriers to food and nutrient

productivity (Nyombi, 2013). A study by Rubaihayo *et al*. (2000), ranked soil moisture from mulching ahead of soil fertility and pest management as an important supplier to food productivity. The study further showed high production (66%) due to high soil moisture because of mulching. However, none of the studies established the effects of mulches and trenches on saturated hydraulic conductivity, bulky density, and organic matter.

Trenches are excavated at selected landscape positions to control soil erosion at a slope above 5 %. Trenches are reported successful technologies in controlling water erosion in affected regions (Sussman, 2007). They are usually set up above valleys to divert runoff from runways, farms, hill tops, buildings and plantations (Sussman, 2007). The collected runoff slowly percolate into the soil via sides and bottom of the trenches for a period not more than three days in hilly or mountainous areas (Sussman, 2007).

A study conducted by Widomski (2009) on Japanese fruit farm cultivating Satsuma mandarin seedlings revealed that trenching was a successful technology in controlling erosion by approximately 88.2%. According to Widomski (2009), the highest efficiency of trenches in controlling soil erosion was 88.2% in 2002 and 94.7% in 2003 in the same area of study.

Additionally, trenching was also reported as a successful technology tested in retaining soil moisture during long and short rains (Sussman, 2007). The mean soil moisture for trenches was 34% for long rains and 33% for short rains. Other values noted for terraces and un-conserved area was; 20.1%, 24.9% and 26.8%, 30.7% for short and long rains respectively. Increase on soil moisture by trenches was equal to 8.4% and 9.6% of water which relatively was increased by 20.1% and 30.7% (Gülser & Candemir, 2014). However, this study did not examine the effects of mulching and trenches on saturated hydraulic conductivity, bulk density and organic matter.

2.3 Factors influencing farmers use of soil and water conservation technologies

There are several factors influencing farmers use of soil and water conservation technologies which are analyzed by different scholars (Huckett, 2013; Abdul-hanan *et al.,* 2014). Their studies show that farmers use soil and water conservation technologies are influenced by socio-economic factors such as education, age, labour availability, income and household size of different farmers. Chomba (2004) considered investments in education by building management capacity through farmer field schools as this would improve the use of soil and water conservation technologies.

A study by Pedzisa *et al.* (2015) also reported that education of farmers' increases experience to technology users and this reduces labour supply in conservation agriculture. The major outputs show that the experienced farmers in conservation agricultural were able to save five days of basin management time compared to inexperienced farmers. Pedzisa *et al.* (2015) pointed out that conservation agricultural technologies are knowledge intensive and hence complex technologies. Therefore, the level of education was hypothesized to be positively associated with the use of soil and water conservation technologies.

A study by Obando *et al.* (2012) in Ngaciuma sub catchment revealed that older farmers were using SWC technologies than their younger counterparts. This was attributed to the fact that old farmers are more experienced in conservation agriculture than younger farmers. Therefore, the age of farmers has a direct influence on the use of soil and water conservation technologies.

Furthermore, engagement in off-farm activities such as business and teaching lead to increased dependence on non-agricultural activities and reduces resources such as finances, time and human labour necessary for soil erosion control (Rusu *et al.,* 2015). This is because, involvement in off-

farm activities creates competition for resources such as time, labour and interest required to install and maintain conservation technologies. Workineh *et al.* (2015) established that lack of access to cash or financial credit may hamper smallholder farmers from using soil and water conservation technologies that require initial capital.

According to FAO (2011), the settlement of farmers at one place has an important implication on access or control of resources and long term investment on the farm. A migrant with short stay on the land will be unwilling to invest capital and labour in practices of which the effects can only be realized after a long period of time. Farmers are not likely to invest on a land whose long term access is not secured. The hired land especially when it is rented for 2-3 years can be a constraining factor for use of soil and water conservation practices because the land owner might need the land back when the soil fertility has distinctly improved and crop production has increased (Njomo et al., 2013). A study by ICRAF Uganda in 2005 on the policy environment of Conservation Agriculture with Trees (CAWT) in Western Uganda, found that security of land tenure offered the best motivation for them to use of soil and water conservation practices.

John & Tenga (2015) found out that households that depend heavily on farming as a means of livelihood are ready to embrace soil and water conservation technologies than non-farmers in Malawi. In Zambia, Nyombi (2013) discovered that accessibility to income plays a role in the acquisition of soil and water conservation technologies. Findings show that off-farm returns lower the odds of acquiring soil and water conservation technologies by small scale farmers. However, the study did not establish whether factors such as gender, distance from home to farms, the size of farms, marital status terrain influence farmers use of soil and water conservation technologies.

CHAPTER THREE: MATERIALS AND METHODS

3.0 Introduction

This chapter describes materials and methods used during the study, and they include: the study area, experimental design, field data collection methods, statistical and laboratory analysis techniques.

3.1 Study area

The study was carried out in Maziba sub catchment, kabale district southwestern Uganda covering a total area of 144 km^2 (Figure 3.1). The sub catchment lies between latitude of 1^o15.30" South and 29^o 56" East, towards the southern boundary of Uganda with Rwanda. It has a total population of 96,917 with 6,975 households (UBOS, 2014). Approximately 90% of the population are small-scale farmers (NBI, 2014). The sub-catchment has a mean annual temperature of 19^oC and experiences bimodal rainfall with less than 1,200 mm mean annual rainfall (NEMA, 2012).

The terrain is characterized by high hills dissected by steep-sided valleys, with altitude ranging between 1,200 - 3,600 m above sea level (KDLG, 2012). With such steep gradients and high altitude, there is a generation of high and erosive run-off resulting in severe soil erosion. This soil erosion process has been largely accelerated by human activities such as over-cultivation of land, overstocking of animals, bush burning, deforestation, and wetland encroachment (KDLG, 2012).

Most areas in the sub catchment have slopes ranging from 35–75% except the valley bottoms where it ranges from 0–15%. According to FAO (2008), the dominant soil types in Maziba sub catchment area are; Luvisols (42%), Acric ferralsols (31%) and planosols (22%).

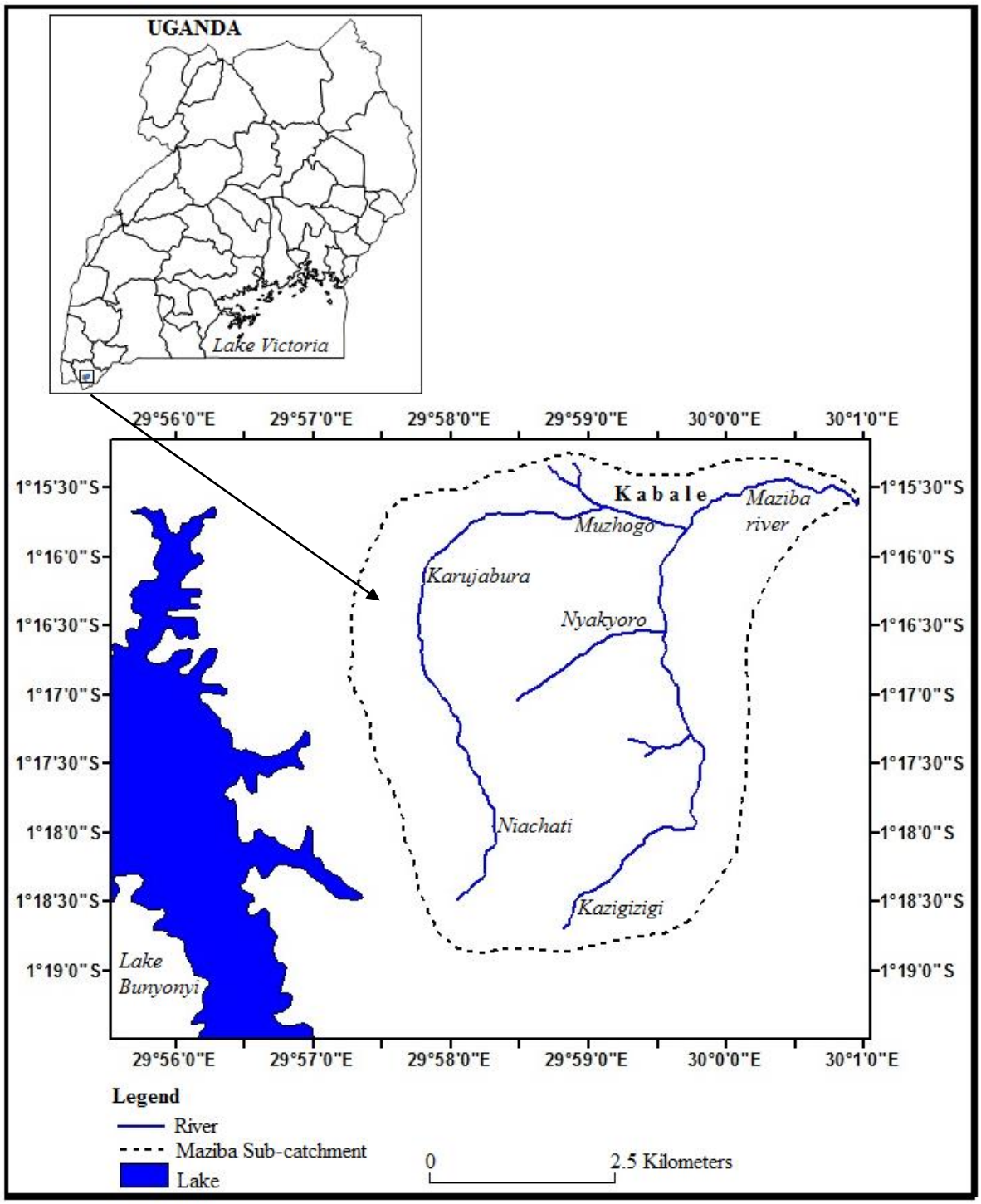


Figure 3.1: Map of maziba sub-catchment

(Source: Topographic Sheet 93/4 – Uganda)

3.2 Research design

The research involved both field and laboratory experiments for objective two and socio-economic survey for objectives one and three.

3.3 Indemnification of soil and water conservation technologies

To identify soil and water conservation technologies used by farmers in maziba sub catchment, the study used observation research guide (Appendix 3.0) and structured questionnaires to 99 farmers (Appendix 1.0). Furthermore, a digital camera was used to capture predominantly used soil and water conservation technologies from the study area. This gave the researcher an opportunity to identify the predominantly used soil and water conservation technologies in the study area.

3.4 Evaluation of effects of selected SWCTs on K_{sat}, OM and BD

3.4.1 Field experimental design

The study plots were selected based on their suitability to collect desired samples. Five years and above old treated and untreated plots was selected because of their ability to have established in terms of soil erosion, runoff control and improving soil properties (USDA, 1998). The experiment was set up at different landscape positions which include; foot slope, back slope and summit on eighteen (18) plots each measuring 3 x 6 m to analyze the variation of OM, BD and K_{sat} (Figures 3.2 and 3.3). Of the 18 experimental plots, 9 were treatment plots and the remaining 9 were control plots on purposively selected three slopes (Plates 3.1). From each 3 slopes, 6 soil samples were collected totaling to 18 soil samples. All the soil samples were analyzed for OM and BD in the

laboratory. K_{sat} was determined *in-situ* on experimental plots using inversed auger hole method as described by (Mulqueen & Rodgers, 2001).

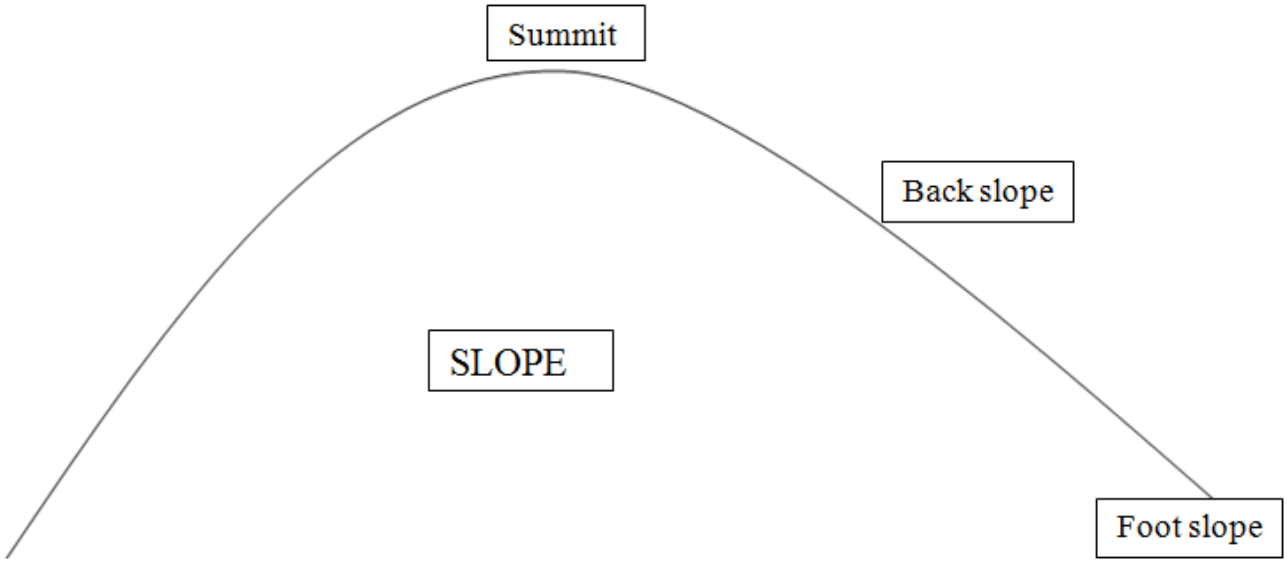


Figure 3.2: Showing different landscape positions

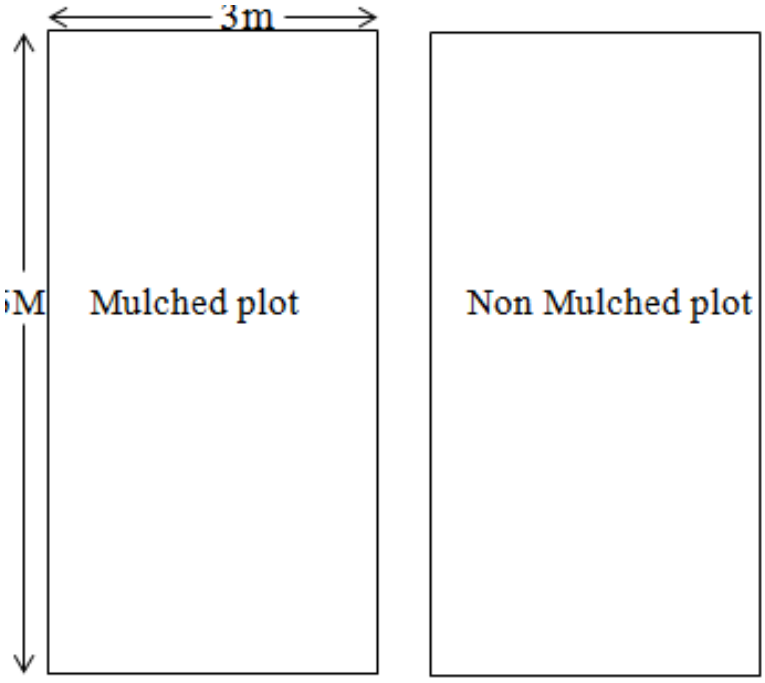


Figure 3.3: Experimental layout

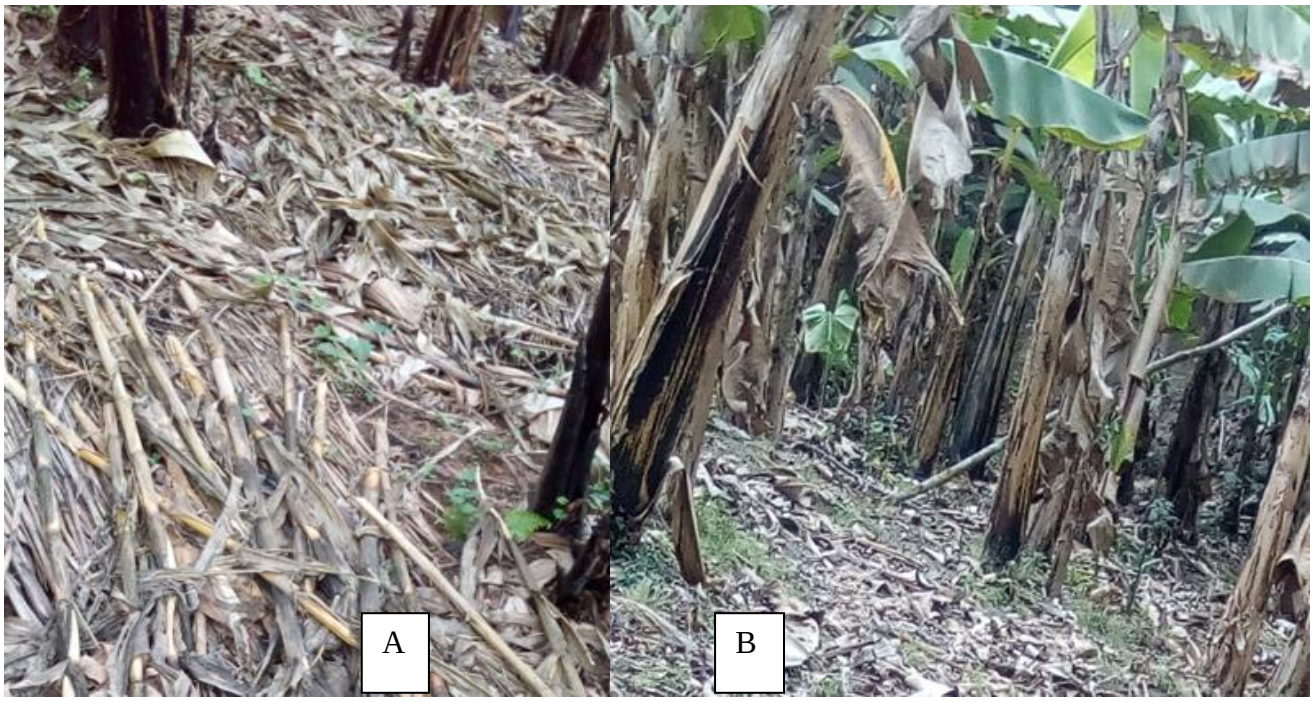


Plate 3.1: Plate A shows Mulched and B shows None Mulched experimental plots

3.4.2 Soil sampling procedure and sample preparation

Soil samples were collected randomly at the depth of 0-5 cm using soil core at 18 sampling points on the 18 selected experimental plots measuring 3×6m from the three slopes. The collected soil samples were carefully placed in polyethene bags and transported to Makerere University soil science laboratory for analysis. Soil samples were oven-dried at 105 ºC for 24 hours in shallow wooden trays in a well-ventilated place protected from rain and contamination. All soil samples were ground and made to pass through a 0.5 mm sieve after all the gravel, live and dead organic residues have been removed. A representative soil sample of approximately 500 g was retained by cone and quartering. This representative sample was then analyzed of organic matter and bulk density.

3.4.3 Laboratory analysis

3.4.3.1 Bulk density

A total of 18 composite soil samples were collected from the field using soil core and taken to the laboratory for analysis of bulk density using the core method as described by (Okalebo *et al.,* 2002). The soil around soil core was removed and the soil beneath the core was cut off using a knife. Both ends of the soil core were trimmed and flushed with a straight edge knife. The soil samples were oven dried to a constant heat using the WTC Binder Oven at 105^{o}C for 24 hours. The soil bulk density was then calculated using the formula in equation 3.1 as shown below:

$BD = \frac{M}{V}$ ……..……...…….3.1

Where by:

"BD" is bulk density in g/m^3

"M" is mass of oven dry soil in g and

"V" is volume of core cm^3

3.4.3.2 Organic matter

Organic matter was determined using modified Walkley and Black wet oxidation procedure (Ali & Jenkins, 1995). Half a gram of oven dried soil passed through 0.5 mm sieve was weighed into 500 ml wide mouth conical flasks and 10 ml of 1 nitrogen potassium dichromate added into the flasks using a burette. In a fume cupboard, 15 ml concentrated sulphuric acid was rapidly added directing

the stream into the suspension. The flasks were swirled gently at first until all soil and reagents mixed and then more vigorously for about one minute. They were then allowed to stand for exactly 30 minutes. About 150 ml of distilled water was added and allowed to cool, after which 10 ml 85% ortho-phenanthroline monohydrate and finally 10 drops diphenylamine indicator were added. The solutions were titrated with 0.5 N ferrous ammonium sulphates. Organic matter was then calculated (Cottenie, 1980; Okalebo, 1990; Ali & Jenkins, 1995) using Equation 3.2.

$$OM = (\ bt\ x\ 0.3x\ conc.FeSo4\ x1.72x1.22) \div 0.5 \ldots\ldots 3.2$$

Where by:

"OM" is organic matter

"bt" is black titre

"$conc.FeSo4$" is concentrated ferrous ammonium sulphate

4.4.4 In-situ saturated hydraulic conductivity analysis

To perform the experiment, a hole of 10 cm radius and 25 cm depth was augured. Next, the hole was filled with water and regularly refilled to saturate the soil and to avoid air entrance through the wall of the hole for an hour. After the soil was saturated, the hole was refilled with water to measure the waterfall against height three times for each of the experiment to get a good representation of results. The rate of water fall in the hole is the indicator of hydraulic conductivity (Kesseler, 1994; Mulqueen & Rodgers, 2001; Torfs, 2008). Considering the decrease in the amount

of water in the hole is equal to the amount of water flowing out of the hole with a unit gradient and this through the bottom and the sidewalls of the hole, K_{sat} was calculated as per the equation 3.3.

$$Ksat = 1.15r \frac{\log(ho + r/2) - \log(ht + r/2)}{t} \quad \ldots\ldots 3.3$$

Where by:

"K_{sat}" is saturated hydraulic conductivity

"t" = time since the start of measuring (s)

"h_t" = the height of the water column in the hole at time t (cm)

"h_o" = h_t at time t = 0 (Nwokocha *et al.*, 2007; Torfs, 2008).

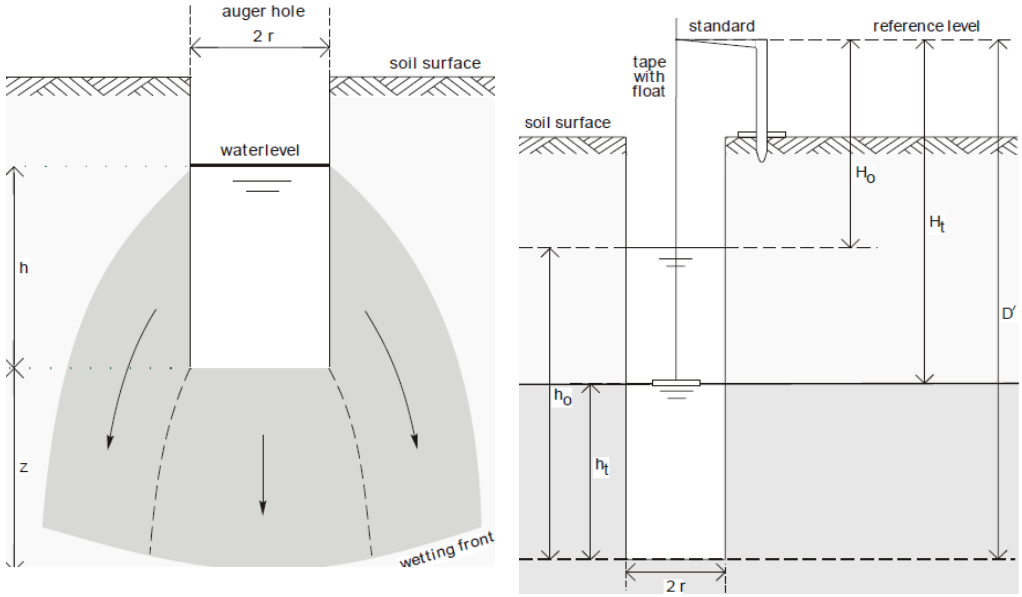


Figure 3.4: Inversed auger-hole method (Torfs, 2008)



Plate 3.2: Saturated hydraulic conductivity determination (*In-situ*)

3.5 Determination of factors influencing farmers' use of soil and water conservation technologies

3.5.1 Population sample size determination

The sample size was calculated using simple random sampling formula in order to get a representative number of famers to use in the study. According to Israel (2012), the sample size of the study population is calculated by using the simplified formula in which 90% confidence level, margin error of 10% are assumed for the equation 3.4.

$$n = \frac{N}{1+N(e)^2}$$ ……3.4

Where: "n" is the desired sample size, "N" is the population size 96917 (UBOS, 2014), and "e" is the precision level (10 % [standard value of 0.01] at 90 % confidence level). Therefore:

$$\frac{n = 96917}{1+96917(0.01)} = 99$$

3.5.2 Sampling procedure

The study adopted probability sampling technique in which stratified random sampling was used to select sample population from the area of study. Then, simple random sampling was conducted from each stratum to select sample size. The basis of the study to form strata was the fact that the population within the sub catchment is distributed on different landscape positions which are foot slope, back slope, and summit. With this sampling procedure, a proportionate stratified random sampling based on equal proportions of each landscape was employed as shown in table 3.1.

Table 3.1: Number of farmers selected per stratum

	Land scape positions	Total no. of farmers per selected stratum	Sample size per selected stratum	Percent of selected farmers (%)
Valid	Summit	24197	25	25
	Back slope	45159	47	47
	Foot slope	27561	28	28
	Total	96917	99	100

To determine factors influencing farmers' use of soil and water conservation technologies in maziba sub catchment, structured questionnaires were administered to 99 respondents (Appendix 1.0). The

researcher also interviewed 10 key informants who are well informed about soil and water conservation technologies used in the study area for example agricultural officers (Appendix 2.0). This gave the researcher an opportunity to determine the factors influencing farmers' use of soil and water conservation technologies in the study area.

3.6 Data analysis

The data obtained from the socio-economic survey, field and laboratory experiments was entered in Microsoft office Excel 2007 and SPSS 16.0 for statistical analyses. The Summary statistics such as frequencies, percentages, error bar graph and pie charts were generated for interpretation and analysis. Descriptive statistics were used to explain the soil and water conservation technologies and socio-economic data from the Maziba Sub catchment. Chi-square tests were used to test the association between socio-economic factors and the soil and water conservation technologies used by farmers.

3.7 Pilot study

Pilot study was carried out in Maziba Sub catchment for three days. The main objective of this study was to test the research tools (questionnaire and field observation guide) and get familiar with the environment before the actual study was conducted. Consequently, after the pilot study was conducted, research tools were reviewed to correct existing errors that needed to be corrected and unwanted questions removed as well as to simplify them for easy understanding by research assistants in order to get the intended data from respondents.

3.8 Selection and training of research assistants

Three research assistants were identified and selected from Maziba Sub catchment. The condition for selection was based on knowledge about the subject matter, fluency in English and local language (Runyankore-Rukiga) and being familiar with the geographical location of the study area to ease movement. The research assistants were trained for two days on the techniques of questionnaire interpretation and administration. The training also involved translating the questions into the local language (Runyankore-Rukiga) which was also followed by a pairwise testing exercise of the interview in order to ensure consistency in the way questions was to be administered.

3.9 Data management

Filled questionnaires were checked for completeness at the end of each data collection day to identify any missing data before leaving the field. Soil samples were diligently labeled and transported to the laboratory for analysis. Soil samples were stored at room temperature before they were analyzed.

3.10 Ethical consideration

Before the real field study, the researcher secured approval letter for data collection from Kenyatta University graduate school. This was the main testimonial to different people such as the sub-county and parish chiefs, agricultural officers, environmental officers and local leaders who are the main stakeholders in sub catchment management. During data collection, research instruments were introduced to the respondents by seeking their okay as their participation was voluntary. The main

goal was to ensure full participation of participants without any fear or lack of confidence in their identity and information are given by them was to be kept confidential.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.0 Introduction

This chapter presents the results and discussion of findings from the field survey, *in situ* experiments and laboratory analyses conducted in Maziba sub catchment Kabale District southwestern Uganda. Results on the predominantly used soil and water conservation technologies and their effects on saturated hydraulic conductivity, bulk density, and organic matter and factors for their use are discussed in this chapter.

4.1. Soil and Water Conservation Technologies used in Maziba Sub catchment

This section describes the predominantly used soil and water conservation technologies in Maziba Sub catchment and seeks to respond to the first objective of the study.

The findings of the study revealed that majority of respondents were using terracing (36.4%). Other technologies reported include mulching (21.2%), trenching (13.1%), water catchment banks (7.1%), level ditches (4%), tree plantations (11.1%) and Grasses (7.1%) as shown in table 4.1 and figure 4.1.

A total of 36.4 % respondents reported that they use terracing on their land to conserve soil and water resources against soil erosion. Terracing as soil and water conservation technology were dominant at the foot slope, back slope, and summit of the sub catchment plate 4.3. This is because the sub catchment is located in the steep slopes and sharp sided valleys of kigezi highlands which are prone to soil erosion. The high rate of using terracing in the study area was reported by farmers desire to conserve water and land resources as a way of improving agricultural output since the area

is one of the productive parts of Kabale district. These findings are in line with Kaliisa *et al.* (2012), who reported that terraces (53%) were the dominant form of mechanical SWC technology along the different slope positions of Bufundi Sub-catchment in Kabale district. Amsalu and Graaff, (2006) also revealed that terraces are a good measure for conserving soil and water resources in Ethiopian highland watersheds.



Plate 4.1: Terraces (Source: Author 2016)

A total of 13.1% respondents reported that they use trenches to collect runoffs that can result in soil erosion on their land hence conserving soil and water resources against soil erosion. Trenches were commonly used on the foot and back slopes in the study area to control the effects of runoff, erosion on the summit, back slope and increases soil stabilization. The study further revealed that trenches were being used because they are cheap and simple to construct, effective in controlling soil erosion, maintains soil moisture and collects sediments and runoffs. The results of the study are in agreement with Beijing (2002) and Okeyo *et al,* (2014), who reported that trenches reduce water rate, promotes water infiltration and soil moisture on different landscape positions of Kigezi highlands and Kenyan highlands, respectively. Plate 4.2 shows one of the newly constructed trenches on the foot slope in the study area.



Plate 4.2: Trench constructed on foot slope (Source: Author 2016).

Furthermore, 7.1% of respondents reported that they use water catchment banks to reduce runoff speed that can result in soil erosion on their land, therefore, conserving soil and water resources against soil erosion. Water catchment banks were predominantly practiced on foot slope and back slope in the study area to reduce runoff speed for the purposes of improving water infiltration, soil moisture conservation and controlling soil erosion. Additionally, the study revealed that water catchment banks collect runoff and the soils collected from water catchment banks are very rich with nutrients which are suitable for crop farming to improve yields. Results from the study are in line with Mugonola *et al.* (2015) and Geremu *et al.* (2016), who reported that water catchment banks are crucial in reducing water velocity that promotes soil erosion in Daro Labu District, Ethiopia and Rwizi sub catchment Mbarara district, Uganda. Plate 4.3 illustrates one of the water catchment banks witnessed during field study survey.



Plate 4.3: Water catchment banks (Source: Author 2016).

The study findings further revealed that 4.0% of respondents use level ditches to reduce water velocity that can result into soil erosion on their land hence conserving soil and water resources against soil erosion. Level ditches were commonly used on summit and back slope to promote water infiltration in the study area. As shown in plate 4.4, level ditches are augured in such way that it collects water from runways, buildings so that water penetrates into the soil. The study further revealed that level ditches are effective in reducing soil erosion in hilly slopes and improve water infiltration hence recharging underground water sources. "If well maintained and protected, the collected water can be used for other purposes such as domestic use, watering crops and animals, key informants". The study results are supported by Bashaasha *et al.* (2006) and Tang *et al.* (2014), who reported that level ditches play a significant role in controlling soil erosion and soil moisture conservation in Ankole region and Yangtze River Basin china, respectively.



Plate 4.4: Level ditch (Source: Author 2016)

The study findings indicated 11.1% of respondents were using tree planting to stabilize the fragile hilly areas by reducing water velocity that can result in soil erosion on their land hence conserving soil and water resources against soil erosion. Tree planting was one of the technologies reported in promoting soil and water conservation in the sub catchment most especially in summit and back slopes. Some of the tree species that were commonly planted in the sub catchment were pines, and avocado trees. These tree species play crucial roles in improving soil properties, erosion control, and supply of tree products such as firewood, timber, construction materials like poles. The findings of this study are in line with Bashaasha *et al.* (2006); Kaliisa *et al*. (2012) and Alufah *et al*. (2012), respectively who found out that 13%, 28 % and 51 % of the farmers in Kigezi highlands and Ngaciuma sub catchment were using tree planting as soil and water conservation technology to control soil erosion.



Plate 4.5: Tree plantations (Source: Author 2016).

The study findings again indicated 7.1% of respondents were using grasses in the study area to stabilize terraced lands by promoting water infiltration and reducing water rate that can result into soil erosion on their land hence conserving soil and water resources against soil erosion.

Grasses were commonly planted at the back slopes. This technology was largely used by farmers simply because grasses stabilizes soils on terraced land, promotes water infiltration, offer cheap and large quantities of fodder to feed livestock, and maintains soil moisture alongside controlling soil erosion. The major grasses identified in the study area were Napier and Stalia grasses (Plate 4.6). These findings are supported by Atampugre (2014) and Bashaasha *et al.* (2006), who reported that Napier grass provides enough fodder for livestock and control soil erosion on steep slopes of Kenyan and Kigezi highlands, respectively.



Plate 4.6: Distribution of Napier grasses (A) and Stalia grass (B) (Source: Author 2016)

The study findings further revealed that 21.2 % of respondents they use mulching to reduce soil erosion on their land resources, hence conserving soil and water resources against soil erosion. The reported benefits of mulching were; it controls erosion and runoffs from washing off the top soils, soil fertility management, improve soil properties, reduce evaporation, soil moisture retention and promote infiltration. Zhang *et al.* (2016) asserted that mulching is effective in controlling soil erosion once integrated with other technologies such as terracing. In a related study, Mtambanengwe *et al.* (2015) observed that 41% farmers did not use *Tephrosia candida* because it was only used as mulch and had no direct benefit as fodder.



Plate 4. 7**:** Mulching.

Table 4.1: Farmers response on benefits of soil and water conservation technologies in %.

SWC Technologies	Soil fertility	Promotes infiltration	Maintains soil moisture	Control erosion	Collects runoffs	Improve soil properties	Percent (%)
Terraces		5		22	9		36.4
Mulching	9	2	1	4	2	3	21.2
Trenches		2	2	4	3	2	13.1
Level ditches		1	1	1	1		4.0
WCBs		2	1	2	2		7.1
Tree planting		2		4	2	3	11.1
Grasses	2		1	2	1	1	7.1

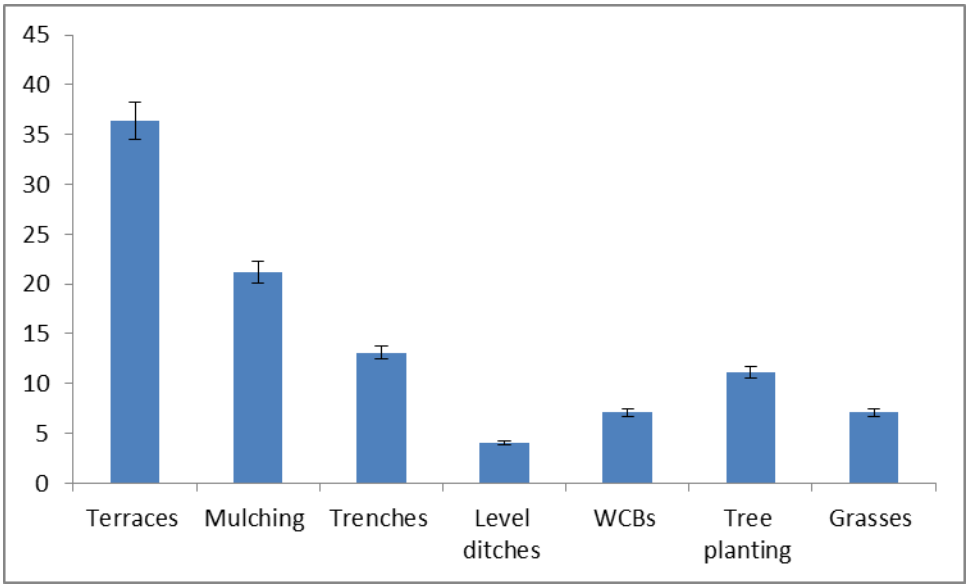


Figure 4. 1: Soil and Water Conservation Technologies identified in the study area.

4.2 Effects of selected SWC technologies on K_{sat}, organic matter and bulk density

This section of research seeks to respond to the second objective of the study. For this matter, therefore, trenching and mulching soil and water conservation technologies were selected because they were repeatedly reported by majority of respondents, 34.3 % during the field study survey in the study area. Their effects on selected soil properties, for example, saturated hydraulic conductivity; bulk density and organic matter are discussed in subsequent sub-sections.

4.2.1. Effects of trenches on K_{sat}, organic matter and bulk density

As shown in table 4.2, trenches significantly affected OM, BD and K_{sat} at the foot slope, back slope, and summit (0.01). The mean OM values recorded on treatment sites at foot slope, back slope and summit were 4.44%, 4.11%, and 3.54%, respectively. Whereas on the control sites, the mean values recorded were 3.37%, 3.13% and 2.51% at foot slope, back slope, and summit respectively. *OM* values for both treatment and control experimental sites were within the set standards for retaining water in soils (>3%) (Cottenie, 1980; Okalebo *et al.* 2002; Loveland &Webb, 2003; Musinguzi *et al.*, 2013). Organic matter is important for retaining water in the soils, adsorb and hold positively charged ions, maintain soil structure and maximize nutrient retention.

Additionally, *OM* also reduces bulk density of soils, resist soil erosion and increase soil biological activities (USDA, 1998; Dumanski & Peiretti, 2013; George & Rolf, 2013). The decrease in organic matter decreases the value of soils in terms of productivity and quality because plants require organic matter for growth and maintain soil stabilization against soil erosion (Lelei *et al*., 2009). The high values of OM observed on treatment sites might be attributed to the presence of soil and water conservation technologies on experimental plots. According to Joel (2015), mulching improved OM in Kibaale sub-catchment from 1.97% to 3.91%.

The mean *BD* values on treatment sites recorded were 1.29 g/cm^3, 1.31 g/cm^3 and 1.15 g/ cm^3 at the foot slope, back slope, and summit, respectively. Whereas the mean *BD* values recorded on control sites were 1.44 g/cm^3, 1.52 g/cm^{3,} and 1.22g/cm^3 at foot slope, back slope, and summit, respectively.

The bulk density values on both treatment and control experimental sites were below critical values (<1.7 g/cm^3). Bulk density (<1.7 g/cm^3) allows water infiltration, root penetration improves soil porosity and soil organisms' activity which influence soil properties and productivity (USDA, 1998; George *et al.*, 2013). According to Chaudhari *et al.* 2013), the decrease in bulk density increases the value of soils in terms of productivity and quality because plant roots and water penetrates easily in soils with low bulk density than compacted soils. All the values recorded for bulk density are within the guideline values of <1.7 g/cm^3 for soils predetermined by (Cottenie, 1980; USDA, 1998; Okalebo *et al.*, 2002). The study findings concur with Reichert *et al.* (2009) who reported that bulk density was found to be highly on top slope soils for crop production in tropics than on lowland plots with soil and water conservation technologies.

The mean K_{sat} values recorded on treatment sites were 11.32×10^{-2} cm/s, 10.90×10^{-2} cm/s and 9.54×10^{-2} cm/s at the foot slope, back slope, and summit, respectively. Whereas, the mean K_{sat} values recorded on control sites were 9.59×10^{-2} cm/s, 8.28×10^{-2} cm/s and 7.62×10^{-2} cm/s at foot slope, back slope, and summit, respectively in the study area. The saturated hydraulic conductivity (K_{sat}) values on both treatment and control experimental sites were within set standards <20 cm/s (USDA, 1998). Saturated hydraulic conductivity is important for promoting nutrient flow and water storage and influence groundwater quantity and quality in catchments. The increase in saturated hydraulic conductivity increases the value of soils in terms of quality since it improves water infiltration and reduces the severity of soil erosion (Dumanski & Peiretti, 2013).

All the values recorded for saturated hydraulic conductivity are below critical values <20 cm/s for soils in highland areas (USDA, 1998).

Table 4. 2: Effects of trenches on OM , BD and K_{sat}

Landscape positions	Technology tested	OM (%)		BD (g/cm^3)		K_{sat} (10^{-2} cm/s)	
		Treatment	Control	Treatment	Control	Treatment	Control
Summit	Trench	3.54^{d}	2.51^{e}	1.15^{d}	1.22^{e}	9.54^{d}	7.62^{d}
Backslope	Trench	4.11^{c}	3.13^{b}	1.31^{c}	1.52^{c}	10.90^{c}	8.28^{d}
Foot slope	Trench	4.44^{c}	3.37^{a}	1.29^{a}	1.44^{d}	11.32^{d}	9.59^{a}
	P value	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

Means with the same letter in each column are not significantly different at p<0.01

4.2.2. Effects of mulching on OM , BD and K_{sat}

Table 4.3 presents the effect of mulching on OM , BD and K_{sat} . The mean values of OM recorded on treatment sites at foot slope, back slope and summit were 5.87%, 4.81%, and 3.77%, respectively. Whereas on the control sites, the mean OM values recorded were 4.17%, 3.72% and 2.94% at foot slope, back slope, and summit respectively. OM is one of the important parameters used to assess the quality of soils. The OM levels in all the sampled experimental sites were above 3% guideline value prescribed by (FAO, 1987).

Organic matter above FAO (1987) and USDA (1998) guideline value of (>3%) in the sampled experimental sites may be due to the presence of soil and water conservation technologies for example use of mulching and household wastes. This is supported by Mudyiwa *et al.* (2016), who reported that organic matter was found to be negligible at the top positions compared to the lower positions of sloppy areas. Lozano-García *et al.* (2016) reported similar results and argued that the

increase in organic matter at the bottom slope could be attributed to the accumulation of minerals that have been eroded from the summit and back of sloppy positions.

The study further recorded 1.23 g/cm^3, 1.24 g/cm^{3,} and 1.26 g/cm^3 as the mean *BD* values recorded at the foot slope, back slope, and summit, respectively. The mean *BD* values recorded on control sites were 1.33 g/cm^3, 1.41 g/cm^{3,} and 1.44 g/cm^3 at foot slope, back slope, and summit, respectively. The findings of the current study lie within the ideal bulk density for controlling soil erosion since it has the capacity to improve infiltration (Table 4.3). This reveals that soils within the study area are considered to be good and health since the measured bulk density is within set standards <1.7 g/cm^3 (Cottenie, 1980; Chaudhari *et al.* 2013). The study findings agree with Agim (2015) who reported that bulk density was found to be higher at the upper sloppy lands than bottom lands. Jacobs *et al.* (2015) reported that the increase in bulk density at the top of slopes could be attributed to the low levels of organic matter, and high organic matter levels at the bottom slope are caused by the accumulation of organic minerals eroded from the top and middle slopes.

Saturated hydraulic conductivity is essential to measure infiltration in order to know drainage, infiltration level and pollutant transport in agricultural fields (USDA, 1998). However saturated hydraulic conductivity improves nutrient flow and water storage in sub catchments (Dumanski & Peiretti, 2013). The Saturated hydraulic conductivity level in all the sampled experimental sites was below 20 cm/s guideline value prescribed by (USDA, 1998).

The mean K_{sat} values recorded on treatment sites were 11.46×10^{-2} cm/s, 9.29×10^{-2} cm/s and 7.45×10^{-2} cm/s at the foot slope, back slope, and summit, respectively. The mean K_{sat} values on control sites recorded were 9.58×10^{-2} cm/s, 7.17×10^{-2} cm/s and 6.53×10^{-2} cm/s at foot slope, back slope, and summit, respectively in the study area. The saturated hydraulic conductivity (K_{sat}) values on both treatment and control experimental sites were within set standards <20 cm/s (USDA,

1998). The low levels of saturated hydraulic conductivity 6.53×10^{-2} cm/s in the sampled experimental sites may be due to presence of soil and water conservation technologies. These findings are in agreement with Zhang *et al.* (2015) who reported that soil properties were found to be minimal at the summit of slopes compared to the accumulation zone of sloppy areas. Xiukang *et al.* (2015) noted that mulching is efficient in maintaining water infiltration in tropics.

The high mean values of OM, BD and K_{sat} in the accumulation zone could be attributed to the presence of soil and water conservation technologies that control and collects eroded organic minerals and sediments from the summit and back slopes. Basing on the study results, all the plots visited can be classified as good and health since the sampled soils are within the set guidelines.

Table 4.3: Effects of mulching on OM, BD and K_{sat}

Landscape positions	Technology tested	OM (%)		BD (g/cm^3)		K_{sat} (10^{-2} cm/s)	
		Treatment	Control	Treatment	Control	Treatment	Control
Summit	Mulching	3.77^{d}	2.94^{b}	1.26^{c}	1.44^{e}	7.45^{b}	6.53^{e}
Back slope	Mulching	4.81^{b}	3.72^{a}	1.24^{a}	1.41^{a}	9.29^{b}	7.17^{b}
Foot slope	Mulching	5.87^{b}	4.17^{a}	1.23^{a}	1.33^{c}	11.46^{e}	9.58^{d}
	P value	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

Means with the same letter in each column are not significantly different at p<0.01

4.3. Factors influencing farmers use of soil and water conservation technologies.

This part of research seeks to respond to the third objective of the study. It describes the factors influencing farmers' use of soil and water conservation technologies in Maziba sub catchment as shown in subsequent sub-sections.

4.3.1. Gender of respondents

The findings revealed that majority of respondents 64.6 % were females and the remainder 36.4 % was males (Figure 4.2). The high dominance of female respondents can be linked to the belief that female farmers are caretakers of land resources in the study area since they are actively involved in agricultural activities and management of water resources such as water harvesting and tree planting. The small percentage of male farmers 36.4 % in soil and water conservation can be linked to engagement in off-farm activities such as teaching, providing security services, trade, and commerce which are time demanding and leaves little or no time to participate in soil and water conservation. The study findings showed no relationship between gender and the use of soil and water conservation technologies in the sub-catchment (χ 2 = 2.837, d.f = 6, p = 0.829). This is in agreement with Tenywa & bekunda (2008), who reported no evidence relationship between gender and use of terraces for soil and water conservation in sub-Saharan Africa. The findings further support the idea suggested by John & Tenge (2015) who reported that if women were to be given equal opportunity to resource access and information on soil and water conservation, they would contribute much towards erosion control than men.

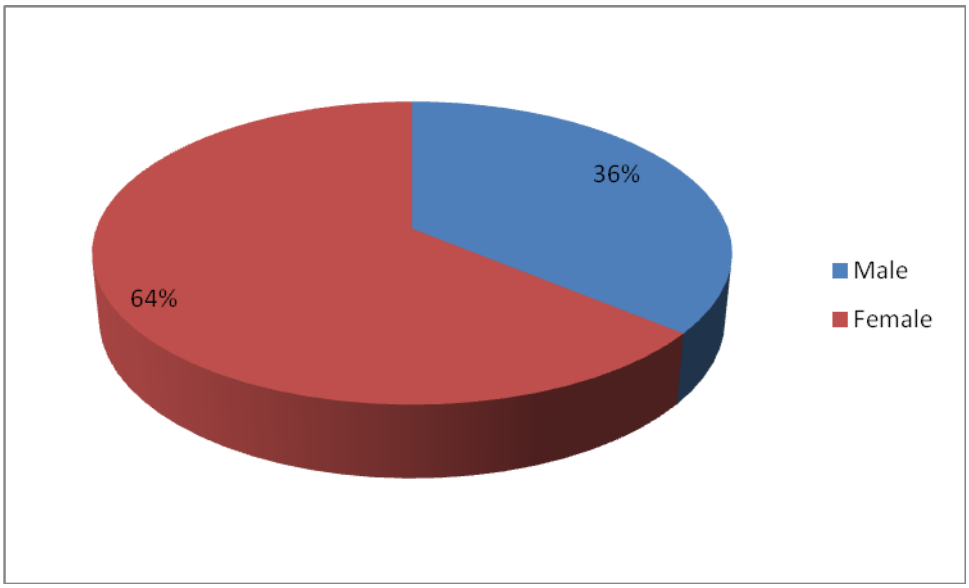


Figure 4.2: Gender of respondents

4.3.2. Age of respondents

As shown in Table 4.4, majority respondents 96% were aged between 18−49 years compared to 4 % that were above 50 years. This shows that farmers within the age bracket of 18 − 49 are seen as very active inhabitants in soil and water conservation than those above 50 years of age (FAO, 2011). Miiro (2011) reported that age is one of the social factors influencing farmers to use soil and water conservation technologies in Kigezi highlands. This disagrees with the perception that older farmers are more likely to use soil and water conservation technologies because of their experience in farming and having benefited from them before than young farmers (Beatrice et al., 2014). On the other hand, it is also possible that because of the technologies being time and labour demanding, older farmers may not be possible to use them because they are not likely to get actively involved in long-term technologies since their planning horizon is limited compared to young ones. The study findings showed evidence relationship between age and use of soil and water conservation technologies in the study area (χ^2 = 22.135, d.f = 18, P = 0.026). This means that age of farmers is correlated to the use of soil and water conservation technologies used in the study area. The study findings agree with Obando *et al.* (2012) who reported a relationship between age and use of soil and water conservation technologies in Ngaciuma sub-catchment in Kenya.

Table 4.4: Age of respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18-28	26	26.3	26.3	26.3
	29-39	37	37.4	37.4	63.6
	40-50	32	32.3	32.3	96.0
	50+	4	4.0	4.0	100.0
	Total	99	100.0	100.0	

4.3.3 Marital status of respondents

The study findings revealed that majority respondents 66.7% were married, 16.2% single, 8.1% windowed, 5.1% divorced whereas 4.0% had separated their marriages (Figure 4.3). The lowest number of widows 5.1% and divorced 4.0% could be linked to the low HIV prevalence in the study area (Bashaasha *et al.,* 2006). The influence of marital status on use of soil and water conservation technologies can be linked to high level of married respondents 66.7% to agree on key decisions related to use of soil and water conservation technologies. Key informants reported the strength of family ties in the transmission process of technology in which in their discussion they said "use of new soil and water conservation technologies can be influenced by family labour than any other factor". The key informants further explained that, if some family members introduce a technology, then other members of the family or community are likely to use it as well. The study tested evidence relationship between marital status of respondents and the use of soil and water conservation technologies (χ^2 = 22.766, d.f = 24, P = 0.034). This study, therefore, shows that marital status of respondents is dependent to the use of soil and water conservation technologies in maziba sub catchment. The study findings are in agreement with Rusu *et al.* (2015), who found out that marital status of respondents was influencing farmers' use of soil and water conservation technologies in Romania.

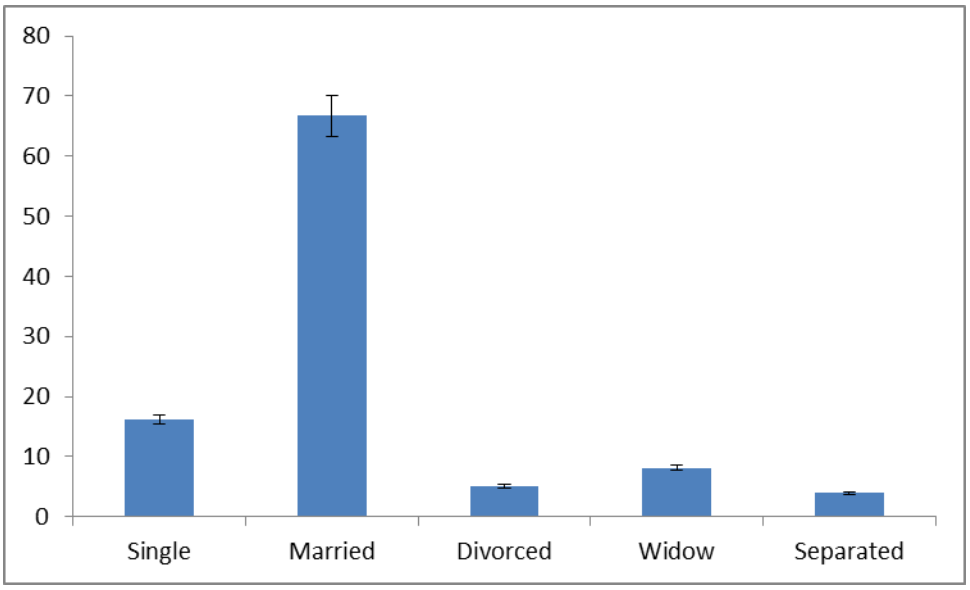


Figure 4.3: Marital status of respondents

4.3.4 Education level of respondents

The study findings revealed that 39.4% of respondents had not attained any form of education, 45.5% completed primary level, 10.1% completed secondary school and 5.1% attained tertiary education (Figure 4.4). The level of education is related to use of soil and water conservation technologies whereby educated farmers 59.6% could be more informed on the best soil and water conservation technologies than uneducated farmers 39.4% since they are assumed to be aware of the benefits coming from soil and water conservation technologies. The chi-square test showed a significant relationship between education and the use of soil and water conservation technologies (χ^2 =18.457, d.f= 18, P = 0.026). This implies that the level of education is related to the use of soil and water conservation technologies by farmers. The study findings concur with Nkonya & Andersson (2015) who reported that level of education significantly influenced the use of technological innovations in agriculture in Nepal. In a related studies by Miiro (2011) and Teshome *et al.* (2013), they reported a significant relationship between use of soil and water conservation technologies and the level of education in Kigezi and Ethiopian highlands, respectively.

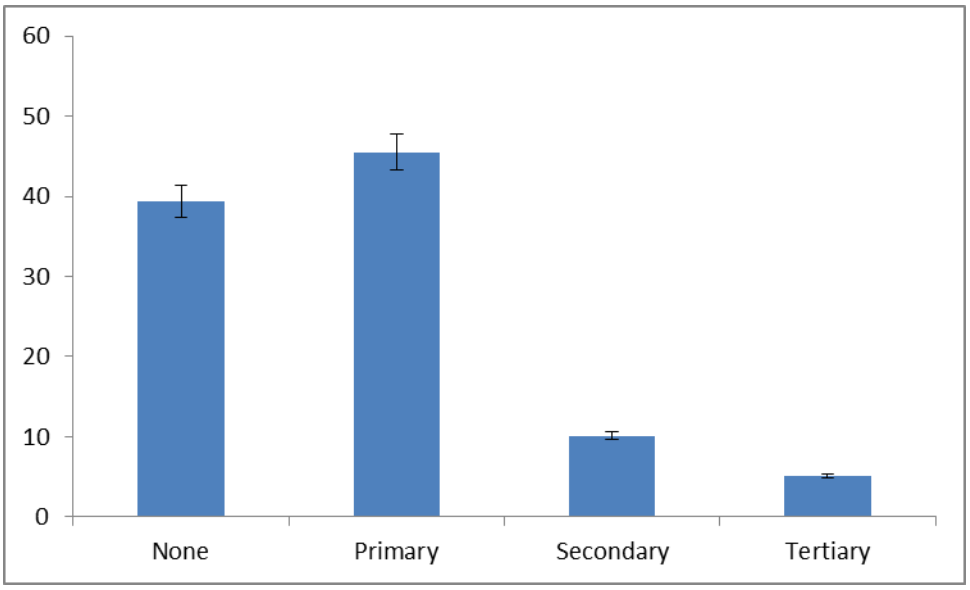


Figure 4.4: Education level of respondents

4.3.5. Size of land

The study estimated land size in terms of hectares. It was found out that 59.6% of respondents had land below one hectare, 30.3% ranged from one to two hectares, 7.1% three to four hectares and 3.0% had five hectares and above (Table 4.5). It was observed that farmers with small pieces of land were actively involved in soil and water conservation activities unlike those with large chunks of land. This is perhaps because large chunks of land require a lot of labour, time and capital to ensure successful use of soil and water conservation. When chi-square test was run, land size showed no influence on the use of soil and water conservation technologies ($\chi^2 = 15.395$, d.f = 18, $P = 0.635$). The size of land was found not related to use of soil and water conservation technologies in maziba sub catchment. These findings are not supported by Alufah *et al.* (2012) who found out that there is a relationship between use of soil and water conservation technologies and land size. A study by Majaliwa *et al.* (2012), in the lake Victoria basin Rakai District revealed that, the larger the size of land a farmer possess, the difficulty in maintaining them in regards to conservation and management they face.

Table 4.5: Size of land in Maziba sub catchment

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Below 1 ha	59	59.6	59.6	59.6
	1-2ha	30	30.3	30.3	89.9
	3-4ha	7	7.1	7.1	97.0
	5ha above	3	3.0	3.0	100.0
	Total	99	100.0	100.0	

Source: Author, 2016

4.3.6 Source of labour of respondents

Table 4.6 shows the different sources of labour for implementing soil and water conservation in maziba sub catchment. The study findings revealed that majority respondents 86.9% were using family members as the only source of labour, 11.1% hired labour whereas 2.0% of respondents were getting labour from the community members. Government support to promote soil and water conservation on individual farmland was not reported in the study area. The high number of family labour 86.9% could be attributed to the nature of marital status of most families being married 66.7% which can contribute to a large number of family labour in the study area. The chi-square test showed evidence relationship between source of labour and use of soil and water conservation technologies at 90% confident interval (χ^2= 11.687, d.f = 12, p = 0.071). The study findings are in line with Bashaasha *et al.* (2006) and Teshome *et al.* (2012) who reported a significant relationship between the source of labour and use of soil and water conservation in Kigezi and Ethiopian highlands, respectively.

Table 4.6: Sources of labour of respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Family labour	86	86.9	86.9	86.9
	Hired labour	11	11.1	11.1	98.0
	Community labour	2	2.0	2.0	100.0
	Total	99	100.0	100.0	

Source: Author, 2016

4.3.7. Land tenure

The study findings revealed that 43.4% of the respondents had inherited land from their parents, 41.4% had bought land while 15.2% had rented land from their neighbors (Figure 4.5). Averagely, the household had a populace of above 7 persons on each one hectare of land (FARA, 2009). This put land resources in the study area at stake of scarcity due to population pressure. This further clarifies that farmers who own their land tend to invest in soil and water conservation technologies than those who perceive tenure insecurity of their land resources. The study further observed that lack of access to land tenure may lead to negligence of farmers' use of soil and water conservation technologies in the study area. This is evidenced by 15.2% of farmers who rented land to practice agriculture for a short period of time because majority of farmers grow seasonal crops rather than annual or perennial crops which do not accommodate for soil and water conservation technologies to be realized in long run. Chi-square test showed no evidence relationship between use of soil and water conservation technologies and land tenure (χ^2 = 10.849, d.f = 12, p = 0.542). The study results disagree with Alufah *et al*. (2012); Kaliisa *et al.* (2012) and Bashaasha *et al.* (2006) who

reported that land tenure influences farmers' decision to use soil and water conservation technologies in Ngaciuma-Kenya and Kabale-Uganda, respectively. Additionally, the study findings agree with Chilot & Hassan (2013) who reported no relationship between land tenure and use of soil and water conservation technologies in central Ethiopian highlands.

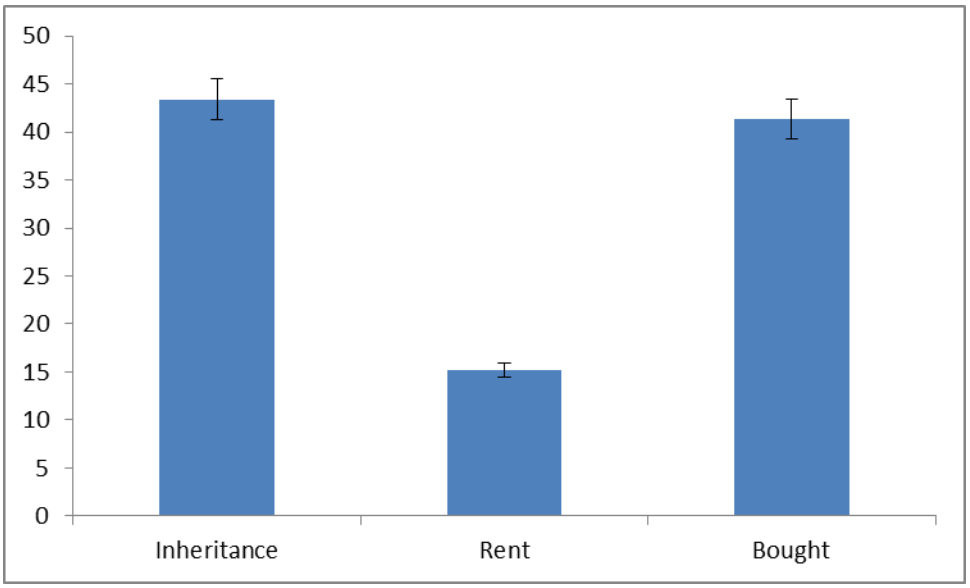


Figure 4.5: land tenure

4.3.8. Farmland slope

Three major categories of slopes for land use were identified and these are; foot slope, back slope, and summit. The findings of the study estimated nature of slope in terms of percentages. This revealed that soil and water conservation technologies on the summit had 10.1%, back slopes had 45.5 % and foot slopes had 44.4% as shown in figure 4.6 and plate 4.8. This means that the location of the slope of the farmland is related to the use of soil and water conservation technologies in the study area. It was noted that farmers cultivating back slopes perceived dangers of soil erosion more than farmers cultivating summit fields. This means that farmers cultivating fields that are vulnerable to soil erosion were more likely to use soil and water conservation technologies in their farmland than those cultivating on less susceptible lands. Furthermore, the selection of soil and water

conservation technologies on the identified slopes depends on the land position. For example, trenches 13.1% were dominating on the back slopes and terraces 36.4% dominated on the three identified landscape positions while mulching 21.2% was also dominate on the foot and back slopes of the sub-catchment. The study results are supported by Barungi *et al*. (2013) and Teshome *et al*. (2012), who reported that, the nature of slope is linked with the use of soil and water conservation technologies in eastern Uganda and Ethiopian highlands, respectively. When subjected to chi-square test, it yielded a significant relationship at 90 percent confident interval (χ^2 = 13.917, 12, p = 0.006). This implies that use of soil and water conservation technologies in the sub catchment dependent on farmland slope.

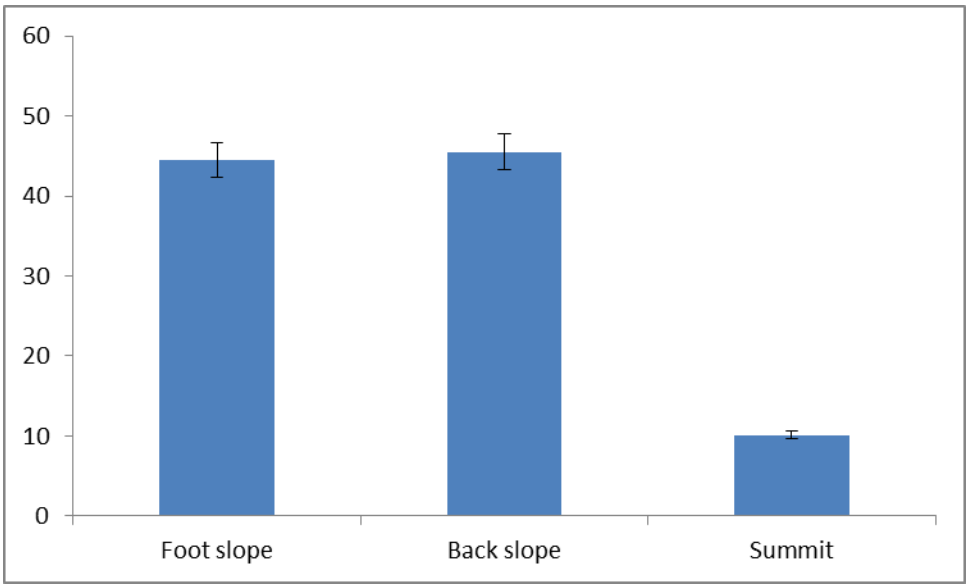


Figure 4.6: Slope of farmlands in maziba sub-catchment



Plate 3.8: Farmland slope (source: Author, 2016)

4.3.9. Distance from home to farmland of respondents

As shown in Table 4.7, the majority of the farmlands 60.6% were located within less than a distance of one kilometer, 23.2% within 1-2 kilometers, 11.1% within 3-4 kilometers and 5.1% above 5 kilometers. This indicates that the available labour for use of soil and water conservation technologies was closer on farmlands that are near to home than distant farmlands A study by Chilot & Hassan (2013), showed that farmlands located near their homes (<1 km away from home) receive more attention in terms of management than those far away from homes (> 1 km away from home). This means that the closeness of land to owners' homes encourages the use of soil and water conservation technologies than distant farmlands. The chi-square test showed that farmers use of soil and water conservation technologies is independent on the distance of farmlands from their homes (x^2 = 15.017, d.f = 18, P = 0.661). The study findings are in disagreement with Kesseler (2006) who reported that farmers manage well farmlands located near their homes than distant farmlands. These findings are not in line with Nkonya (2012), who also revealed that distant

farmlands had cases of soil erosion than farmlands nearness to farmers homes. For example, results reported by Nkonya & Anderson (2015) show that farmers are less likely to use mulching or household wastes on distant farmlands than closer farmlands to their homes.

Table 4.7: Distance from home to farmland of respondents.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 1Km	60	60.6	60.6	60.6
	1-2Km	23	23.2	23.2	83.8
	3-4Km	11	11.1	11.1	94.9
	Above 5Km	5	5.1	5.1	100.0
	Total	99	100.0	100.0	

Source: Author, 2016

4.3.10. Off-farm activities

The findings of the study showed that 79.8% of the farmers were not involved in any form of off-farm activity. Whereas 20.2% of the farmers were involved in at least one form of off-farm activities such as mini-businesses 9.1%, civil services 4.0%, brick lying 2.0%, charcoal burning 2.0% and providing security services 3.0% (Figure 4.7 and Table 4.8). This implies that agriculture 79.8% is the major source of income to sustain farmers' livelihood in the study area. Off-farm activities 20.2% are seen as an alternative source of income, food and other people's needs which are important in supplimenting the families growth and development of their homes in the study area. Since agriculture is a seasonal venture with a lot of risks involved, this discourages farmers to invest in soil and water conservation technologies to increase yield because of limited finance, time and labour. A study by Obando *et al.* (2012) and Kaliisa *et al.* (2012), reported that farmer's involvement in off farm activities (35% and 38%) respectively, help them to get quick money

which is used in paying school fees for their children, buying cloth and other human needs since agriculture is seasonal in nature and could not help them during off season in Bufundi sub-catchment Kabale district, Uganda. This indicates that any category of off-farm activity is independent of neither invest time nor finance in soil and water conservation technologies.

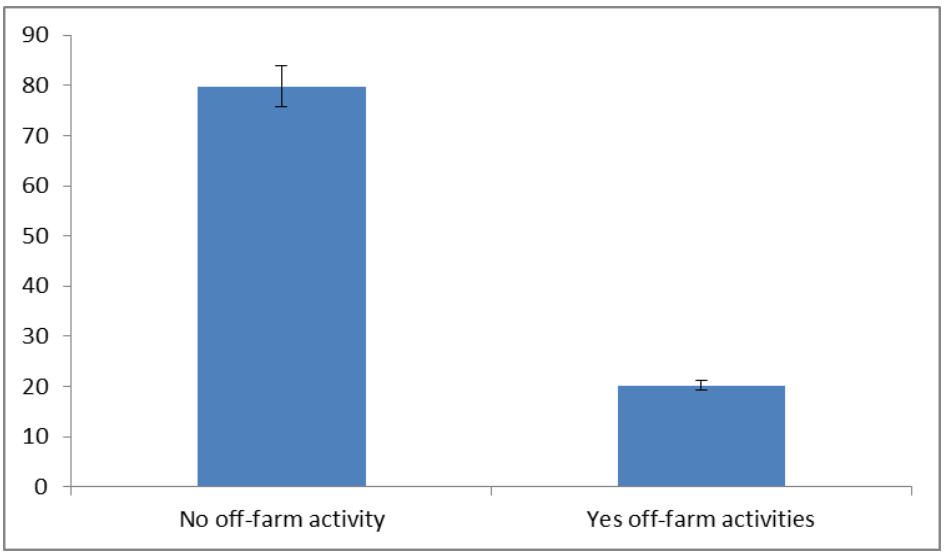


Figure 4.7: Percentage of farmers' involvement in off-farm activities

Table 4.8: Off-farm activities of respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Minibuses	9	9.1	9.1	9.1
	Civil services	4	4.0	4.0	13.1
	Charcoal burning	2	2.0	2.0	15.2
	Brick making	2	2.0	2.0	17.2
	Security services	3	3.0	3.0	20.2
	Agriculture only	79	79.8	79.8	100.0
	Total	99	100.0	100.0	

Source: Author, 2016

4.3.11. Access and Sources of information to respondents

As shown in figure 4.8, majority respondent 96% had no access to information only 4% of respondents reported they had access to information on soil and water conservation services when needed. Although 4% of the farmers had access to information, its transfer and dissemination were limited due to the fact that the ration of farmers to extension agents is significantly high. Basing on the results of the study, it is observed that 96% of farmers do not have access to information which means they are still using either indigenous knowledge or traditional practices which are not sustainable to environmental conservation and management against soil erosion.

Table 4.9 shows the different sources of information to farmers on the use of soil and water conservation technologies identified in the study area. Fellow farmers 63.6%, extension agents 26.3%, does not have 4.0% and Non-Governmental organizations 6.1% were repeatedly reported sources of information. The study findings showed that farmers use of soil and water conservation technologies were independent on source and access to information at 90% confident interval (χ^2 = 3.445, d.f= 6, $P = 0.751$. The findings disagree with Mugonola *et al.* (2015) and Hall (2015), who reported that access to information in regards to soil and water conservation are very crucial because the use of soil and water conservation technologies is influenced by farmers close contact with agricultural or environmental extension agents.

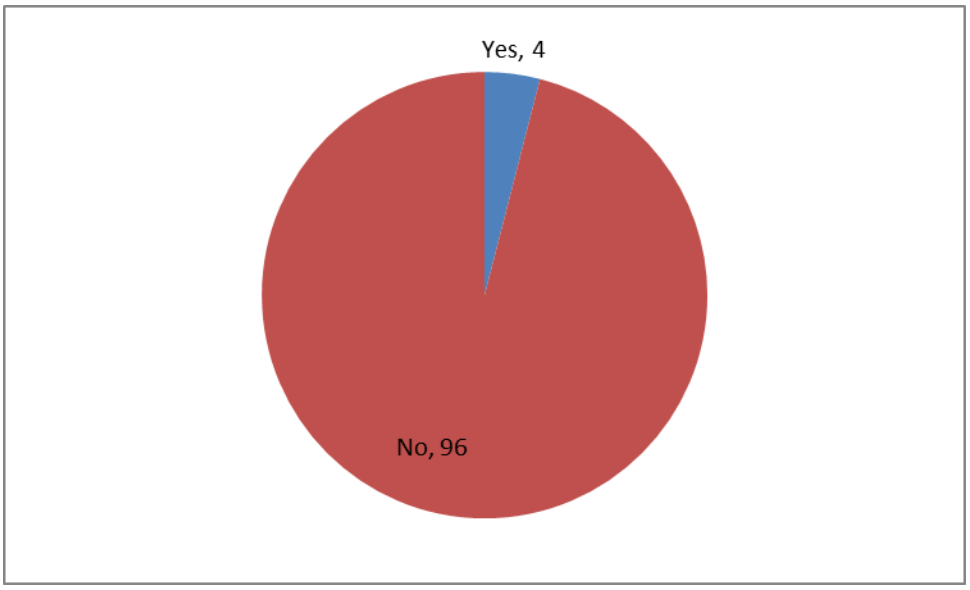


Figure 4.8: Access to information of respondents

Table 4.9: Sources of information of respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Fellow farmers	63	63.6	63.6	63.6
	Extension agents	26	26.3	26.3	89.9
	NGOs	6	6.1	6.1	96.0
	Non	4	4.0	4.0	100.0
	Total	99	100.0	100.0	

Source: Author, 2016

4.3.12 Causes of soil erosion

The study findings further revealed that agricultural land in the study area is located on gentle and steep slopes with high rainfall intensity leading to erosion. It was observed that erosion had caused a considerable damage on farmlands. The major causes of soil erosion on agricultural farmlands according to respondents were: steep slopes 38.4%, intensive agriculture 28.3%, deforestation 20.2% and high rainfall 13.1% as shown in figure 4.9. The study findings are supported by

Satriawan, Harahap & Karim (2015) who reported that sheet and rill erosion are considered as the most common types of soil erosion on cultivated farmlands in the steep slopes of Rwanda and Ugandan highlands. Morgan (2009) also confirmed that heavy rainfall causes soil erosion on agricultural lands where soil and water conservation structures are not installed most especially in steep and gentle slopes.

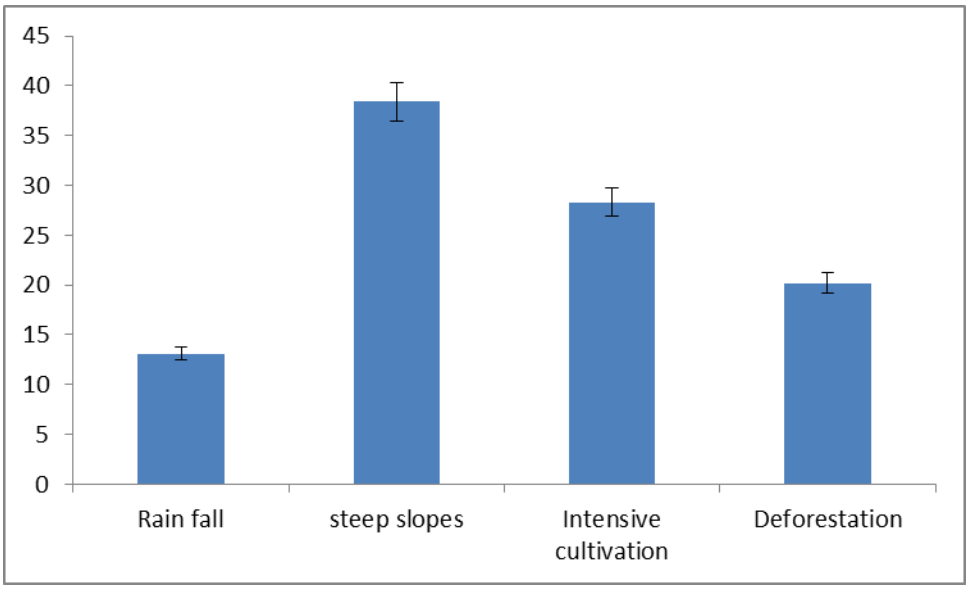


Figure 4.9: Farmers response on the causes of soil erosion

4.3.13. Rate of soil fertility

Farmers estimated their land fertility in terms of not aware, low, moderate and high fertility rate. Figure 4.10 shows that 82.8% of respondents reported that their agricultural land had low fertility status, 8.1% moderate, 2.0% not aware and 7.1% of respondents revealed that their agricultural land was highly fertile. This was estimated according to farmers' agricultural output harvest. The majority of farmers attributed soil fertility decline as a result of soil erosion, shortage of land, erratic rainfall and inadequate agricultural and environmental extension services. The study findings agree with Tadesse *et al.* (2011) who found out that soil erosion had created severe limitations to sustainable agricultural land use and reduced on-farm soil productivity leading to environmental degradation. Therefore, this kind of observation provides negative indicators for the use of soil and

water conservation technologies in the study area. When subjected to chi-square test, it showed a relationship at 90 percent confident interval (χ^2 = 23.033, 18, p = 0.149). This implies that use of soil and water conservation technologies in the sub catchment dependent on fertility of the soils.

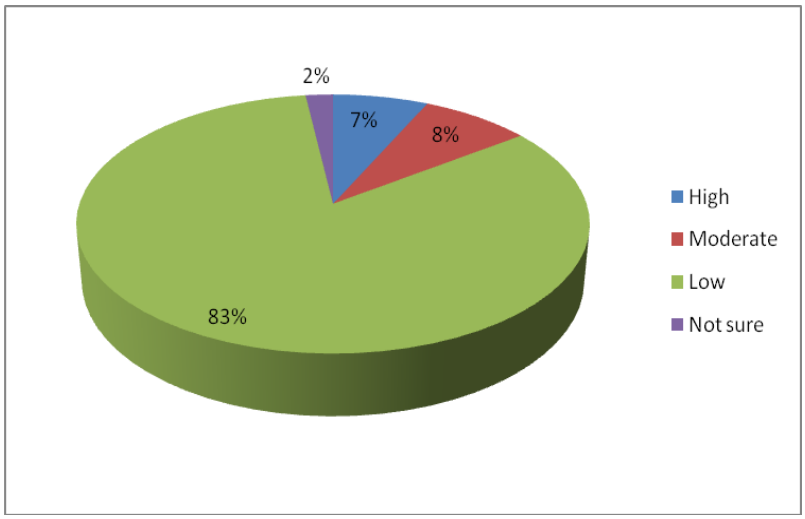


Figure 4.10: Rate of soil fertility

4.3.14: Farmers' suggestion on use of soil and water conservation technologies

Table 4.10 shows farmers' response to the use of soil and water conservation technologies in the study area. Providing technical support 28.3%, farmer training and education 50.5%, incentives like subsidized farm inputs/tools 11.1%, intensive awareness and sensitization 6.1%, and the introduction of demonstration farms and agricultural loans 4% were some of the suggestions to improve soil and water conservation technologies to ensure sustainable environmental management in the study area. These recommendations may have an impact on the uptake of soil and water conservation technologies by farmers. Beatrice *et al.* (2014) confirmed that sharing knowledge amongst farmers enhanced the use of soil and water conservation technologies in sub-Saharan Africa by 20%.

Table 4.10: Farmers' suggestion on use of soil and water conservation technologies

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Technical support	28	28.3	28.3	28.3
	Training and education	50	50.5	50.5	78.8
	Provision of Incentives	11	11.1	11.1	89.9
	Awareness and sensitization	6	6.1	6.1	96.0
	Demonstration farms and loans	4	4.0	4.0	100.0
	Total	99	100.0	100.0	

Source: Author, 2016

CHAPTER FIVE:

SUMMARY OF FINDINGS CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

This chapter is divided into four major sections. The first section presents a summary of the research objective and methodology used in this study. The second section summarizes major key findings of the study and is presented as per objective of the research study. The third section concludes the study and finally, the fourth section provides major recommendations for further research.

5.1 Objectives and Methodologies

The general objective of this study was to analyse the effects of soil and water conservation technologies on selected soil properties in Maziba sub-catchment of Kabale District, Uganda. Specific objectives were (i) to identify soil and water conservation technologies at different landscape positions by farmers in Maziba sub-catchment, (ii) to evaluate the effects of selected soil and water conservation technologies on saturated hydraulic conductivity, organic matter and bulk density, and (iii) to determine the factors influencing farmers' use of soil and water conservation technologies in Maziba sub-catchment. Research objectives were achieved by using semi-structured questionnaires, researcher observation guide.

5.2 Summary of Study Findings

Majority farmers reported trenching and mulching as their preferred soil and water conservation technologies (34.4%). Other technologies identified were terracing (36%), water catchment banks (7.1%), level ditches (4.0%) and tree planting (11.1%). Use of trenching (13.1) and mulching (21.2%) significantly improved all the soil properties tested (saturated hydraulic conductivity, bulk density, and organic matter), unlike the differential content of organic matter, bulk density and hydraulic conductivity recorded on control sites at different landscape positions. The study further

identified various factors that influence farmers to use of soil and water conservation technologies in the study area. These were; age, soil fertility, farmland slope, the source of labour, and level of education of farmers. Other factors were not influencing farmers' use of soil and water conservation technologies: the marital status, land tenure system, source and access to information, distance from home to farmland and gender of respondents.

5.3 Conclusions

The study findings reported that majority respondents were using terracing and mulching as the soil and water conservation technologies. It was also revealed that technologies such as water catchment banks, level ditches terraces were also used to a small extent in the study area. The study further confirmed that landscape positions significantly influence the type of soil and water conservation technologies used on farmland.

The study findings revealed that the selected soil and water conservation technologies affected organic matter, bulk density and saturated hydraulic conductivity of the soils at the foot slope, back slope, and summit. The study findings further confirmed that mulching and trenching significantly influence the level of organic matter, bulk density and hydraulic conductivity at the foot slope, back slope, and summit.

The study further confirmed that marital status, level of education, size of land, land tenure, farmland slope, distance from home to farmland, categories of erosion, and soil fertility rate influences the use of soil and water conservation technologies.

5.4 Recommendations

Based on the findings of this study, the following are the recommendations to the policy makers, NGOs and farmers in Maziba sub-catchment Kabale District to ensure sustainable management of soil and water resources.

i. The study recommends the use of mulching and trenching since they proved to be effective in improving organic matter, bulk density, and saturated hydraulic conductivity.

ii. The study found out that age difference influences use of soil and water conservation technologies. The researcher therefore recommends that extension and training on soil and water conservation technologies from NGOs and government should be targeted towards young and active inhabitants as majority of the farmers were within 18-49 years of age (96%).

iii. The government should introduce formal education to farmers who are not educated so that they can at least attain some education level to help them actively participate in implement soil and water conservation technologies after getting some trainings and sensitization from NGOs.

5.5 Suggestions for Further Research in the study area

This study mainly focused on analysis of soil and water conservation technologies and their effects on saturated hydraulic conductivity, bulk density and organic matter to improve understanding of soil and water conservation technologies in Maziba sub-catchment. For the purposes of comparison, this study can be replicated in different sub-catchments or same catchment area using the different

theoretical framework and data collection methods. For proper planning and management purposes in the sub-catchment, further research should be carried out to carefully monitor and analyze how farmers continue using the indentified soil and water conservation technologies in the study area. This will tell whether there is need to modify and use new technologies by farmers or not. Further research can be carried out in the following areas;

i. Analysis of effects of terracing and water catchment banks on soil and water conservation in Maziba sub-catchment.

ii. Analysis of limiting factors in the adoption of soil and water conservation technologies in Maziba sub-catchment.

iii. Assessment of the impacts of land tenure systems on soil and water conservation in Maziba sub-catchment.

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Appendix 1: Structured Questionnaire

Dear respondent, I am a postgraduate student of Kenyatta University currently pursuing a Master of Science degree in Geography (Integrated Watershed Management) in the school of Pure and Applied Science. I therefore kindly request you to accept and complete this research questionnaire. And the research topic is titled **"Effects of Soil and Water Conservation Technologies on selected Soil Properties in Maziba Sub-Catchment, Kabale in Uganda".**

Your views and opinions are highly valuable and will be kept strictly confidential. So please feel free to answer and raise as many valuable suggestions as possible.

Thank you in advance.

Yours,

Julius Ndemere

Postgraduate student

Kenyatta University

A: INTRODUCTION

(i) Date…….Months…….……...…2016

(ii): Village……..……

(iii): Parish ……

(iv): Sub-county……..…….

(v): Mobile contact number……

B: INFORMATION ON FARMERS

INSTRUCTIONS: Please TICK on the response appropriately.

Questionnaire coding…….……..……

SOCIAL ECONOMIC CHARACTERISTICS OF RESPONDENTS

☐ **Use Tick**

1. Gender: ☐ Male ☐ Female

2. Age group: ☐ Below 20 ☐ 20–25 ☐ 26–31 ☐ 32–37 ☐ 38+

3. Marital status: ☐ Single ☐ Married ☐ Divorced ☐ Widow

4. Education Level: ☐ None ☐ Primary ☐ Secondary ☐ Tertiary ☐ Others

C. INFORMATION ON FARM PLOTS

5-13. How many plots of land do you have……....

Variable (s)	First Plot	Second Plot	Third Plot	Fourth Plot	Fifth Plot
1. Size of farm (Ha)					
1=Below 1ha					
2=1–2ha					
3=3–4					
4=5 above					
Sources of labour on your farmlands					
Family labour					
Hired labour					
Government					
Community service					
Others					
Land tenure					
Inheritance					
Leasehold					
Rent					

Bought					
Others					
Terrain					
Gentle					
Steep					
Very steep					
Distance from home to farm					
Less than 1 km					
1-2 km					
3-4					
Above 5 km					
Do you perform off-farm activities					
Yes					
No					
List off-farm activities do you practice					
Mini business					
Civil servants					
Charcoal burning					
Brick making					
Security guards					
Sources of income					
Agriculture only					
Agric + business					
Sallies + Agric					
Wages only					
Do you have access to information in regards to SWCTs					
No					
Yes					

List sources of information do know in regards to SWCTs					
Fellow farmers					
Radio broadcast					
Extension agents					
NGOs					
Others					
Major crops that are grown in the study area					
Food crops					
Cash crops					
Both cash and food crops					
Others					
Land use					
Annual crops					
Perennial crops					
Both A&P					
Others					
Do you experience soil erosion on your farm					
Yes					
No					
Agents of soil erosion on your farms					
1=Unknown					
2=Water					
3=Wind					
4=Man					
5=Animals					
6=None					
Chose the main causes of soil erosion on your farm					
Bush burning					

Nature of slope					
Lack of information					
Intensive cultivation					
Cutting of bushes					
Others					
Rate of soil fertility on you farmlands					
High					
Medium					
Low					
Not known					
Do you normally grow cover crops on you farms					
Yes					
No					
Others					
Do you use soil and water conservation technologies on your farm?					
Yes					
No					
How do you control soil erosion on your farm?					
1=Tree plantations					
2=level ditches					
3=Terracing					
4=Grasses					
5=Mulching					
6=Trenching					
7=WCBs					
8=Others					
Reasons for use of soil and water conservation technologies on your farm					
Cheap and simple					

Collects runoffs					
Maintains soil moisture					
Control soil erosion					
Collects runoffs					
Soil fertility mgt					
Effects of SWCTs on soil properties on your farms					

D. INFORMATION ON SOIL AND WATER CONSERVATION TECHNOLOGIES

19. In your own opinion, what should be done to improve the effectiveness of SWC Technologies in maziba sub-catchment?

……

Thank you for your cooperation!

Appendix 2: Key Informant Questionnaire

I am Ndemere Julius pursuing a master's course in watershed management). I am carrying out a research titled "**Effects of Soil and Water Conservation Technologies on selected Soil Properties in Maziba Sub-Catchment, Kabale in Uganda".**

Kindly, I request you to answer these questions to fulfill my research objectives and the answers given will be treated with total confidentiality and will be used for academic purposes only basing on the rules and regulations governing the university. Feel free to share your opinion with me. Thank you in advance!

Yours

Julius Ndemere

MSc. Integrated Watershed Management

Kenyatta University, Kenya.

Kindly provide the following information

Surname: …….First name: …….....

Gender

0=Female 1=Male

A. INSTITUTION AND ADDRESS:

Name of institution: .....

Address of institution: .....

Position……...…….....

Tel: ..... E-mail: .....

INSTRUCTIONS: FILL IN THE SPACES PROVIDED AND USE **TICK** WHERE NEED BE.

1. Define SWC technology (ies) (be precise)

.....

2. List major SWC Technologies used by farmers in Maziba sub-catchment.

……

3. List the main causes of soil and water degradation in Maziba sub-catchment?

……

4.0 Do farmers benefit economically from technologies applied?

Not at all ☐ Yes ☐

4.1 If yes, explain your answers?

.....

5. List the major advantages of the SWC technologies used by farmers on their farms.

.....

6. List the major disadvantages of the technologies used by farmers and how they overcome them.

.....

7. What are the effects of SWC technologies on the farms and their farmers?

……

8. What recommendations would you give to enhance SWCT transfer and subsequent adoption in the sub-catchment?

Thank you for your cooperation!

Appendix 3: Field Research Observation Guide and photograph taking

This study, the main focus was on effects of selected soil and water conservation technologies on soil properties on different landscape positions. This field research was guided by the following selected SWC technologies categories used in the study area.

Table 1: SWC technologies identification from the study area

S/N	Soil and water conservation technologies identification in the study area	Good	Fair	Poor	Crops Grown
1	Trenches				
2	Mulching				
3	Terraces				
4	Water catchment banks				
5	Tree planting				
6	Level ditches				
7	Strips of grasses				

Table 2: Saturated hydraulic conductivity

Sites	Hydraulic gradient	Percolate (Cm^3)	Time (s)	$\mathbf{K_{sat}}$ (cm/hs)
1				
2				
3				

Table 3: Bulk density

	Weigh		
Can number	Can	Can - oven dry soil	Can + oven dry soil

Table 4: Selected soil properties preamble

Landscape positions	Technologies tested selected	Organic Matter (%)		Bulk Density (g/cm^3)		K_{sat} (cm/s)	
		Treatment	Control	Treatment	Control	Treatment	Control
Summit	Trench						
Back slope	Trench						
Foot slope	Trench						
Summit	Mulch						
Back slope	Mulch						
Foot slope	Mulch						