ADOPTION OF SOIL CONSERVATION TECHNOLOGIES AND CROP PRODUCTIVITY IN WEST USAMBARA HIGHLANDS, TANZANIA

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ABSTRACT

Soil erosion has continued to be an alarming problem in the West Usambara highlands, Tanzania. This study was conducted to investigate the level of adoption of Soil Conservation Technologiess and crop productivity in the West Usambara highlands following intensive campaigns on SWC from the early 1980s. A sample of 98 randomly selected households from four villages responded to the survey. During data collection, a structured questionnaire survey, interviews, focus group discussions and observation method were used. Multiple linear regression, Paired-samples t-test, and Chi-square were used for analysis in addition to descriptive statistics. Based on the variation of adoption, the Composite Index of Adoption was 0.512±0.156. The maximum and minimum Index adoption was 0.14 and 0.86 respectively. This indicates that each farming household managed to adopt at least one among the disseminated seven soil conservation technologies. Hence, the overall level of technology adoption was moderate. Grass strip, multipurpose trees and bench terraces were found to be the dominant technologies used by the majority of farmers in an integrated pattern. However, the study found overall significant association ($\chi^2_{(3)}$ =55. 237; $p<0.001$) of crop productivity between the two periods (before and after adoption of SCTs). Using t-test, the study also found a significant increase ($p<0.001$) in crop productivity before and after the adoption of SCTs. Therefore, it was concluded that the adoption of SCTs had a contribution on farm plot productivity in hillsides. The average household farm plot under soil conservation intervention in the hillside was 0.54±0.45 acre. However, an extension visit ($p<0.05$) and technical training ($p<0.05$) were found to have significant influence on the adoption of a number of Soil Conservation Technologies. The study recommends intensive soil conservation campaigns which are holistic, integrative and multisectoral.

DECLARATION

I, Emmanuel Paul Mzingula, do hereby declare to the Senate of Sokoine University of Agriculture that, this Dissertation is my own original work and has neither been submitted nor concurrently being submitted for a higher degree award in any other University.

……………………………. ……………………………..

Emmanuel Paul Mzingula Date

(M.A.Candidate)

The above declaration is confirmed by

……………………………. …………………………

Dr. E. E. Chingonikaya Date

(Supervisor)

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ABBREVIATIONS AND ACRONYMS

AHI	African Highlands Initiative
ANOVA	Analysis of variance
BMPs	Best Management Practices
DPIPWE	Department of Primary Industries, Parks, Water and Environment
DPPC	Development and Project Planning Centre
EfD	Environment for Development
FAO	Food Agriculture Organisation
GTZ	Gesellschaft fur Technische Zusammenarbeit
IDM	Institute of Development Management
IDRC	International Development Research Centre
ISCOC	International Soil Conservation Organisation Conference
ICRAF	International Center for Research on Agroforestry
MDGs	Millennium Development Goals
MCCA	Mitigation of Climate Change in Agriculture
MKUKUTA	Mkakati wa Kukuza Uchumi na Kupunguza Umaskini Tanzania (National Strategy for Growth and Reduction of Poverty)
NBS	National Bureau of Statistics
NGOs	Non-Governmental Organisatiions
NSGRP	National Strategy for Growth and Reduction of Poverty
NVS	Natural Vegetative Strips
PCARRD	Philippine Council for Agriculture, Forestry and Natural

	Resources Research and Development
PADEP	Participatory Agricultural Development and Empowerment Project
RTI	Research Triangle Institute
R^2	Coefficient of determination
SECAP	Soil Erosion Control and Agroforestry Project
SPSS	Statistical Package for Social Sciences
SCTs	Soil Conservation Technologies
SUA	Sokoine University of Agriculture
SWC	Soil and Water Conservation
TAFORI	Tanzania Forestry Research Institute
TRIC	Thames River Implementation Committee
TIP	Traditional Irrigation Program
UN	United Nations
UM	University of Minnesota
WS	Washington State
WAEO	Ward Agricultural Extension Officer
WOCAT	World Overview of Conservation Approaches and Technologies

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Soil erosion is one of the most important and challenging problems facing farmers and natural resource managers worldwide as farmers are losing an estimated 24 billion tonnes of topsoil each year (Lal, 1995; Pimentel, 1995 *et al*.; Stroosnijder, 1995, Duff *et al*., 1990). In developing countries erosion rates per acre are twice as high as the standard, partly because of population pressure which forces the land to be more intensively farmed (Kassie *et al*., 2011; Mowo *et al*., 2002; Cooper, 1997). For instance, in the Philippine uplands, soil erosion is widely regarded as the country's most serious environmental problem since it affects about 63-76 percent of the country's total land area (Paningbatan, 1990). Soil fertility depletion is considered the main biophysical limiting factor for increasing per capita food production for most smallholder farmers in Africa (Smaling *et al.*, 1997). Ethiopia being among the African country has become increasingly dependent on food aid particularly in most parts of the densely populated highlands where cereal yields average reported to be less than 1 metric ton per hectare following land degradation (Pender and Gebremedhin, 2007).

The continued decline of soil fertility led by land degradation, low and poorly distributed rainfall, poor resource endowments, and lack of or inadequate institutions has been reported to be among the major causes of low and decreasing performance of sub-Saharan Africa's agricultural sector (Binswanger and Townsend, 2000;

Rosegrant *et al*., 2001; Pender *et al.*, 2006; Ajayi, 2007; Misiko and Ramisch, 2007). Meeting the food demand of a global population is expected to reach 9.1 billion in 2050 and over 10 billion by the end of the century will require major changes in agricultural production systems. Improving cropland management is a key to increasing crop productivity without further degrading soil and water resources (Branca *et al*., 2011). It is estimated that, by the year 2020, yield reduction due to soil erosion may be as much as 16.5% of the African continent and about 14.5% for sub-Saharan Africa (Lal, 1995).

Like many sub-Saharan African countries, Tanzania also faces a serious soil erosion problem. Soil erosion has been one of the major threats to agricultural production (Mushala and Forser, 1992; Kaihura *et al.*, 1999). Because of soil erosion, vast areas of once fertile lands have been left unproductive. The west Usambara highlands are among the areas which are adversely affected by soil erosion in Tanzania although soil and water conservation has a long history in the area. The highlands reported to have a very high rate of soil erosion reaching about 100t/ha/year (Semgalawe, 1998; Vigiak, 2005; Mwihomeke and Chamshama, 2001; Minderhoud, 2011). Population pressure has increased demand for food, fuelwood, construction materials and other socio-economic needs and hence, forests have been cleared and agriculture has expanded into marginal areas with steep slopes in order to meet these demands. Farmers cultivate on hillslopes approximately 18% to 60% repeatedly, clearing and burning vegetation. Therefore, this leaves the top soil open or with very little ground cover. It is estimated that about 84% of the original forest in the West Usambara highlands has been cleared (Johnson, 2001).

The adoption and diffusion of specific sustainable agricultural practices (SAPs) have become an important issue in the development policy agenda for sub-Saharan Africa in addressing the consequences of land degradation (Scoones and Toulmin 1999; Aiayi 2007). In the West Usambara highlands, various soil conservation interventions were introduced to farmers by the government of Tanzania in collaboration with Germany government through GTZ and other partners to steer the conservation process (Mowo *et al*., 2002). Similar conservation intervention was also implemented by the Ethiopian government in curbing environmental degradation and poverty, increasing agricultural productivity as well as food security enhancement (Kassie *et al.*, 2011). Major conservation projects introduced in the West Usambara highlands were SECAP, TIP and AHI which worked closely with TAFORI. These projects came with seven major soil conservation technologies disseminated to farmers for adoption. The technologies were bench terraces, "*fanya juu"* ("throw (earth) upwards"), grass strips, mulching, cut-off drains, multipurpose trees and contour ridges which were experimented in the West Usambara highlands and confirmed to be more effective in curbing soil erosion when properly used (AHI, 2000; Tenge, 2005).

Despite the efforts which have been undertaken by the government and other conservation partner organizations in curbing soil erosion, soil erosion continues to be a major problem contributing to the loss of fertile topsoil in the West Usambara highlands (Tenge, 2005). The consequences of this erosion are; reduced crop yields, food deficiency, silting up of waterways, damage of various structures, and loss of land value (Meliyo, 2002).

1.2 Problem Statement

Although soil conservation technologies have high dissemination and promotion of adoption in the West Usambara highlands, soil erosion continues to be a major problem contributing at large in the reduction of household crop production on the hillside farm plots. Understanding on how far the previous and prevailing soil conservation initiatives have been achieved in controlling soil erosion problem in the West Usambara highlands is essential.

Although studies done by Semgalawe (1998) and Tenge (2005) focused on the adoption of soil conservation technologies in the West Usambara highlands, none of them focused on the level of soil conservation technology adoption and its contribution to crop production on the hillsides farm plots. Instead, authors studied the incidence of technology adoption few years after SECAP to wind up its activities in the West Usambara highlands in 1990s. Therefore, the study has provided knowledge to bridge the information gap by assessing the level of soil conservation technology adoption, social and institutional determinants as well as improvement of crop production in hillside farm plot since SECAP incepted soil conservation technologies in the West Usambara highlands in the early 1980s.

1.3 Justification of the Study

It was envisaged that the research findings would provide information concerning social and institutional factors which have influence on farmer’s level of soil conservation technology adoption.

Furthermore, the findings were expected to be useful for policy makers and other stakeholders who are responsible for agricultural development and natural resource management, partcularly in the formulation and implementation of various national and international development strategies. Some of the national strategies are MKUKUTA II and Kilimo Kwanza. MKUKUTA II which is NSGRP phase II through its cluster 1 aims at improving Economic Growth and Reduction of Income Poverty (URT, 2010). In Kilimo Kwanza, the findings are in line with pillar number 8 which promotes the application of science and technology in achieving agricultural revolution (URT, 2009). Internationally, the study is in line with the 1992 Rio Declaration principle 22 (UN, 1992) and MDG 7 (UN, 2000) which proclaim the need of collaboration between local communities and the state for environmental management; and advocacy on environmental sustainability respectively. Moreover, the study is in line with the 1996 National Agricultural Policy and 1997 National Environmental Policy which accords the need for environmental conservation in agricultural development using cross-sectional collaboration to achieve positive environmental outcomes. Soil conservation is among the important agenda (Howlett and Nagu, 1997; Thaxton, 2007).

1.4 Objectives

1.4.1 General objective

The general objective of the study was to assess household adoption of soil conservation technologies and farm plot improvement on crop productivity in the West Usambara highlands, Tanzania.

1.4.2 Specific objectives

Specifically, the study aimed at;

i. exploring types and level of adoption of soil conservation technologies in the study area;
ii. evaluating the contribution of adoption of soil conservation technologies on crop production; and
iii. identifying social and institutional factors which influence farmers' decision making on the choice of the number of soil conservation technologies to adopt.

1.5 Research Questions

The following were the research questions which reflect the specific objectives of this study.

i. What are the types and level of adoption of soil conservation technologies in the study area?
ii. Is there any significant contribution of adoption of soil conservation technologies on crop production in hillsides?
iii. What are the social and institutional factors influencing farmers' decision-making on the choice of the number of soil conservation technologies to adopt?

1.6 Conceptual Framework for Adoption of Soil Conservation Technology and Crop Productivity

The framework for this study explains the level of adoption of soil conservation technologies as it involves a direct relationship with agricultural productivity and soil erosion intensity. The framework is further paying attention on the interplay of social and institutional factors that govern farmers since they can have an influence on the level of adoption (Fig. 1).

There could be a negative relationship between the number of soil conservation technologies used by the farmers on the hillside plots and the intensity of soil erosion. It was assumed that the plot on the hillside which is highly invested with a diversity of soil conservation technologies was likely to have low intensity of soil erosion compared to the hillside plot which is less invested with soil conservation technologies. Therefore, there is often higher crop productivity on the hillside plot invested with a diversity of soil conservation technologies than the plot on the hillside which is less invested with soil conservation technologies since the former plot is likely to experience low intensity of soil erosion.

However, the adoption of soil conservation technologies can be influenced by social and institutional factors which govern individual farmers. Social factors such as household size, education, experience in farming activities, marital status and age of individual farmers as well as institutional factors including access to extension worker, access to training, cooperative membership and exposure to a demonstration plots can affect at different level the capacity of farmers to opt the size of package of soil conservation technologies to invest on their hillside agricultural plots. It was expected that household size, faming experience, access to extension agent, access to technical training, cooperative membership and exposure to a demonstration plot would have a positive relation to the adoption of the number of soil conservation technologies. However, age of individual farmer, lack of land ownership and distance of the plot to the nearby market centre were expected to have negative relation with the level of adoption of the number of soil conservation technologies in the study area.

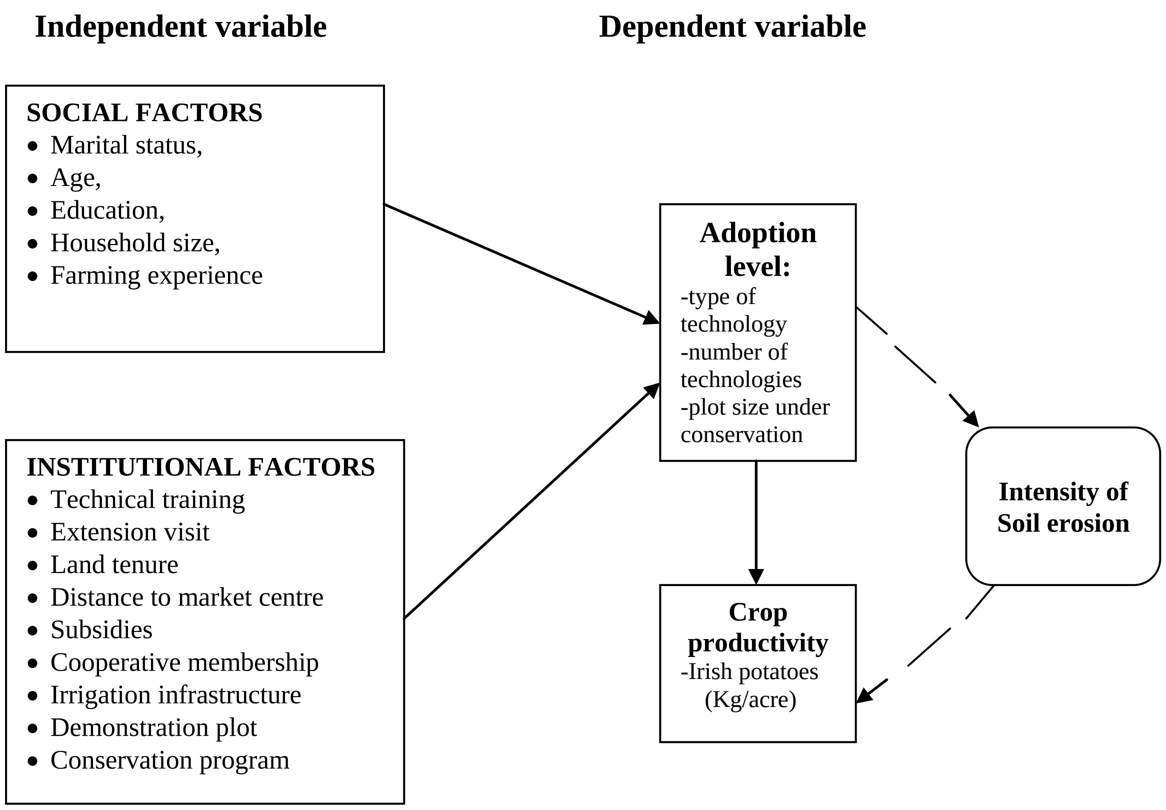

Figure 1: Conceptual Framework for adoption Soil Conservation Technologies adoption and Crop production

Source: Modified from Ervin and Ervin (1982).

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Definition of Key Terms

2.1.1 Soil conservation

Sanders (2004) defined soil conservation as the combination of the appropriate land use and management practices that promote the productive and sustainable use of soils and, in the process, minimizes soil erosion and other forms of land degradation.

2.1.2 Soil erosion

Cooper (1997) defines soil erosion as the deterioration of soil by the physical movement of soil particles from a given site. Wind, water, ice, animals, and the use of tools by man are usually the main causes of soil erosion.

2.1.3 Soil conservation technology

According to Corradi (2006), soil conservation technology is a practice that applied by farmers, agricultural officers, Non-Governmental Organizations (NGOs) and other stakeholders to protect the soil and agricultural land from dangers such as soil erosion or degradation.

2.2 Soil Erosion in the West Usambara Highlands

Soil erosion is a natural process which usually does not cause any major problems. It becomes a problem when human activity causes it to occur much faster than under normal conditions (Sanders, 2004). Duff *et al*. (1990) assert that nutrient leaching;

acidification and soil erosion are environmental processes that occur regardless of human activity. The degree to which these processes can reduce the productive potential of land resources and/or cause pollution is dependent on the nature and extent of human interference. Land degradation, climate change, population growth, deforestation, acid rain, toxic waste, resource depletion, species extinction, and so on are symptoms of environmental degradation that raise doubts over our ability to maintain the biosphere as the inheritance for future generations. This is a consequence of our history that treated the land as an infinite resource (Duff *et al*., 1990; Sanders, 2004).

The ideal goal of soil conservation is to maintain a rate of soil loss not to exceed 6.7t/ha/year. This is roughly the rate at which soil can rejuvenate itself. Worldwide, farmers are losing an estimated 24 billion tonnes of topsoil each year which is equivalent to an annual loss of 7.5 to 10 tonnes per acre. In developing countries erosion rates per acre are twice as high as the standard (Cooper, 1997), partly due to population pressure which forces the land to be more intensively farmed (Cooper, 1997; Kassie *et al*., 2011).

Despite the conservation effort, soil erosion rates in the West Usambara highlands reported to be among the highest in Tanzania. The highlands had annual losses of top soil up to 100 t/ha and this is contributed by high population growth increases demand for agricultural land (Tenge, 2004). Similar soil erosion rate (50 to 200 tonnes per hectare) was reported by Garrity (1995) cited in Mercado (2005) in sloping uplands of Southeast Asia where rapid population growth was also reported to be the main cause, and cereals productivity was reduced to 200 to 500 kilograms per hectare per year (Fujisaka *et al*, 1995).   In the west Usambara highlands, several incidences of soil erosion have been reported to cause negative impacts like declining crop yields, increased food insecurity and reliance on food aid, poor nutrition and increased dependence on forest resources for livelihoods (Mowo *et al*., 2002).

2.3 Soil Conservation Technologies

Soil conservation technologies can generate both private and public benefits and thus constitute a potentially important means of generating “win-win” solutions for addressing poverty and food insecurity as well as environmental issues. In terms of private benefits to farmers, by increasing and conserving natural capital including soil organic matter, various forms of biodiversity, water resources SCTs can generate increased crop productivity, cost decreases and higher stability of production (Pretty, 2008; 2011). Soil conservation practices contribute to improving soil fertility and structure, adding high amounts of biomass to the soil, causing minimal soil disturbance, conserving soil and water, enhancing activity and diversity of soil fauna, and strengthening mechanisms of elemental cycling (Woodfine, 2009).

Soil conservation is about solving the problems of land degradation, particularly soil erosion through using physical and biological technologies (Sanders, 2004). Young (1989), Cooper (1997), Altieri (1995), Branca *et al*. (2011), WOCAT (2011) and Sanders (2004) observed that the technology package which contains the combination of different soil conservation practices including physical and biological practices in a farm plot maximizes the effectiveness in soil erosion control. Celestino (1985) for instance, reported that, the combination of barrier hedges with trees on grass barrier strips contributed in large in curbing soil erosion in the Philippines. Trees like *Grevillea robusta*, banana and avocado were used with other mechanical practices to constitute the technology package. This study too is conceptualizing the effectiveness in soil erosion control in the study area when a plot is invested with a diversity of soil conservation technologies.

Sander (2004) categorized soil conservation technologies into two major groups namely Biological and Physical or Mechanical. Biological practices of soil conservation involve the use of cover crops and its residues while application of physical or mechanical structures in the soil conservation fall under physical or mechanical practices such as bench terraces, cut-off drains, contour ridges and check dams.

2.3.1 Biological soil conservation technologies

Biological measures of soil conservation can be used when ensuring that there is sufficient vegetation, either living or dead, left on the surface to protect the soil from the effects of wind and water (Sanders, 2004).

a) Tree and cover crops

The benefits of growing the appropriate crops and trees on specific soils are important. Crops and trees help reduce the erosive forces of water and wind by means of their canopy intercepting rain, and acting as a windbreak. Root systems stabilize the soil and reduce losses (Stone, 1997). Tree-vegetable intercropping offers option to landowners to increase farm income and minimize soil erosion. In fact, growing trees and vegetables together appears to be more lucrative than growing trees only as the tree volume in the tree-vegetable system becomes greater than that of the tree treatment alone (Dano and Midmore, 2004).

b) Grass barrier and crop strip

Planting of the crop across, rather than with the slope, can reduce soil loss by 25%. Strip cropping which alternate hay and grain strips is an erosion control measure that can be used on long, smooth slopes where forages are part of the rotation. Strip cropping across the slope can reduce soil losses by 50% when compared to up-down slope cropping (Stone, 1997). Contour strip cropping will reduce soil losses even further.

Strip cropping, ideally, involves alternating strips of forage and a row crop on the contour. In situations where forage is not being grown, cereal crops are a reasonable substitute to be alternated with corn or soybeans. The strips are usually of grass, which has been planted or left to grow naturally in narrow strips along the contour at intervals across the slope of a field. The grass strips act in the same way as crop residue barrier; trapping the moving soil, slowing down moving water, and encouraging it to sink into the soil (Sanders, 2004; Prinz and Malik, 2004).

c) Mulching

Mulching is temporary soil stabilization or an erosion control practice where materials such as grass, hay, wood chips, wood fibres, straw, or gravel are placed on the soil surface. In addition to stabilizing soils, mulching can reduce the speed of water runoff especially over post-fire hillslope areas. When used together with seeding or planting, mulching can aid in plant growth by holding the seeds, fertilizers, and topsoil in place, by helping to retain moisture, and by insulating against extreme temperatures (Bautista *et al*., 1996; Napper, 2006; Robichaud *et al*., 2000; Wagenbrenner *et al*., 2006).

Agricultural straw and wood shreds mulch are often used alone in areas where temporary cover crops cannot be used because of the harsh climate. Mulching can provide immediate, effective, and inexpensive erosion control. On steep slopes and critical areas such as waterways, mulch matting is used with netting or anchoring to hold it in place (Bautista *et al*., 2009; Robichaud *et al.*, 2010; Yanosek *et al*., 2006).

2.3.2 Mechanical soil conservation technologies

Mechanical soil conservation measures include a wide variety of conservation practices and structures such as cut-off drains, bench terraces, contour ridges, fanya juu and check dams but, in essence, most of them aim to either reduce the length or the slope of the land. By doing this, the movement of water over the surface is stopped or slowed down to a velocity that will not cause erosion. Water is encouraged to be absorbed by the soil or is led off to an area where it can be safely dispersed (Sanders, 2004).

a) Bench terraces

Bench terraces are a series of level or virtually level strips running across the slope at vertical intervals, supported by steep banks or risers, and can be categorized into irrigated or level bench terraces and upland bench terraces. Level bench terraces are used where crops, such as rice, need flood irrigation and impounding water while the later are used mostly for rain-fed crops or crops which only require irrigation during the dry season (FAO, 2012).

For cultivation on slope lands, bench terraces are one of the most effective measures for erosion control and crop production (Cheng, 2002). The benches are made of a sub vertical riser reinforced with stones or plants, and a terrace with a slight reverse slope, with a possibility of irrigation and drainage down the slope. The benches create flat areas and suppress sheet erosion as well as increase the available crop water. They make irrigation possible and allow investment in steeply sloping land leading to greater productivity (Prinz and Malik, 2004).

b) Cut-off drain

A cut-off drain is like a contour ditch but has a slight slope (about 1%), so water drains slowly away. Cutoff drains are useful to protect fields from uncontrolled run-off and to divert water away from gullies. They are also effective in draining steep slopes while sometimes permitting irrigation of pasture through overspill and tying (Prinz and Malik, 2004; UM, 2009). Contour drains should be no longer than 50m, 15-30 cm deep and installed on a slight grade to prevent silting. Contour drains however present difficulties with other cropping operations such as spraying and harvesting (DPIPWE, 2012).

c) Contour ridges

The practice is among the simplest form of mechanical erosion control that consists of the cultivation of the land by ridging on or close to the contour instead of up and down the slope or round and round the field. When this is done, each furrow acts as a small dam, catching the water as it runs down the hill and encouraging it to soak into the soil. This simple conservation measure may be enough by itself to prevent the runoff of water and erosion where slopes are gentle and the rainfall intensities are low (Sanders, 2004; Prinz and Malik, 2004).

d) *Fanya juu* ("throw (earth) upwards")

A *Fanya juu* (in Swahili) is a physical structure which comprises embankments (bunds) which are constructed by digging ditches and heaping the soil on the upper side to form the bunds which are usually stabilized with grass strips (WOCAT, 2007). *Fanya juu* has been adapted and widely used in Africa especially in Kenya, Tanzania, Uganda, and in Ethiopia. It is the structure made of soil and/or stone with a basin in the lower part (Hurn, 1993). The structure would eventually lead to the development of bench terraces over a period of time if properly maintained (Million, 2003; Prinz and Malik, 2004). The end result is a creation of better growing conditions for the crop, both immediately, because of an increase in the amount of moisture available, and in the long term, because the soil is conserved (Hailu *et al*., 2012).

e) Surface roughening

Surface roughening is a temporary erosion control practice. The soil surface is roughened by the creation of horizontal grooves, depressions, or steps that run parallel to the contour of the land. Slopes that are not fine-graded and that are left in a roughened condition can also control erosion. Surface roughening reduces the speed of runoff, increases infiltration, and traps sediment. Surface roughening is appropriate for all slopes (WS, 1992).

To slow erosion, roughening should be done as soon as possible after the vegetation has been removed from the slope. Roughening can be used with both seeding and planting and temporary mulching to stabilize an area (Cooper, 1997). For steeper slopes and slopes that will be left roughened for longer periods of time, a combination of surface roughening and vegetation is appropriate. Surface roughening also helps establish vegetative cover by reducing runoff velocity and giving seed an opportunity to take hold and grow (Young, 1989).

2.4 Adoption of Soil Conservation Technologies and Agricultural Productivity

Duff *et al.* (1990) noted that researchers use a variety of measurement criteria in studying the adoption of soil conservation measures. Ervin and Ervin (1982) measured adoption using a number of soil conservation practices used by farmers over the recommended practices. On the other side, Lin (1991) measured adoption as percentage of total land under recommended conservation technology. Other measurement criteria for adoption used by researchers include intention to adopt; use of a particular practice; ownership of an implement or set of implements used for implementation of technology; amount of residue cover left on the soil surface; erosion problem recognition or perception; attitude towards soil conservation or conservation practices; expenditure on conservation practices; effectiveness of soil erosion control; and amount of pollution control achieved (Duff *et al*., 1990). Basing on the adoption measurements explained by Duff *et al*. (1990), the study therefore conceptualized the number of soil conservation technologies in measuring the level of adoption of soil conservation technologies in the study area.

Appropriate soil conservation practices are very site-specific in nature (Madden and Dobbs, 1988; Kassie *et al*., 2011). Thus, there can be great variability of results in erosion control, crop yields, and farm profits from adopting and implementing any number of conservation practices or systems on the variable conditions of the landscape (Zantinge *et al*., 1986; Madden and Dobbs, 1988; Henderson and Stonehouse, 1988; Stonehouse *et al*., 1988).

Difficult environmental conditions in farming on higher slopes result in lower agricultural yields, declining soil fertility and land degradation (Tabo *et al*., 2007). This pushes farmers to look for better land from marginal areas such as forest land in order to feed the ever increasing human population (Rukangira, 2011; Kangalawe *et al*., 2005; Muganyizi, 2009; Majule, 2010). However, Boyd *et al*. (2000) and FAO (2009) noted that improved soil and water conservation technologies when used lead to higher yields and greater resilience in a piece of land hence contributing to improved food security particularly in rural livelihoods.

FAO (2009) further observed that soil and water conservation technologies add better plant nutrient content, increased water retention capacity and better soil structure, potentially leading to higher yields and greater resilience, thus contributing to enhancing food security and rural livelihoods. Studies done in different countries appreciate contribution of adoption of SCTs to agricultural productivity. The study by Zikhali (2008) found that adoption of contour ridges led to a positive impact on land productivity in Zimbabwe. Shively (1998; 1999) reported a positive and statistically significant impact from the adoption of contour hedgerows to yield in the Philippines. Results by Kaliba and Rabele (2004) also found a positive and statistically significant association between wheat yield and short- and long-term soil conservation measures in Lesotho. However, the contribution of adoption of SCTs to farm productivity is not clear in the West Usambara highlands and therefore the study intended to come up with clear information on this.

Duff *et al*. (1990) reported that, past research attempting to find solutions to land degradation in general, and soil erosion in particular, has been sectoral. Francis and Clegg (1988) added, if real progress is to be made in reducing the impacts of soil erosion what is needed is an integrated perspective within which to conceptualize variables and explore possible solutions. The integrated approach would include the biological, economic, social and political dimensions for analysis. Barbier (1987) and Hallberg and Logan (1988) comment that drawing on ecological concepts, agricultural production needs to be studied and managed as a system rather than by component parts.

2.5 Social and Institutional Factors Influencing Adoption of Soil Conservation Technologies

Bentley and Leskiw (1983) point out three broad categories of factors which influence land management practices and farm productivity; 1) factors within the domain of the farmer, 2) within the public domain, and 3) external or natural factors and that they operate at varying scales of influence. These three components cannot be addressed in isolation, but rather an attempt should be made to break down sectoral interests and approach the issue in a comprehensive manner (Lowitt, 1985). The situation is not known as to what social and institutional attributes influence adoption of soil conservation technology package among farming households in the West Usambara highlands. Prager and Posthumus (2010) assert that there is no evidence in the studies that either economic factors or social factors are superior in explaining adoption decisions and investment. Rather, it is always a mix of personal, socio-cultural, economic, institutional and even environmental variables that explain the behaviour.

2.5.1 Social factors

Personal characteristics of farmers like age, household size, education, farming experience and marital status are hypothesized to be influencing the decision-making process of an individual farmer on the level of adoption of soil and water conservation technologies similar to what Ervin and Ervin (1982) asserted.

a) Farmer's age

Culver and Seecharan (1986) and Bultena and Hoiberg (1983) found that younger farmers are more likely to perceive the soil erosion problem and hence conservation measures will be identified as profitable, and that the risk associated with adopting new practices is therefore justified. The study by Green and Heffernan (1987) observed that age is positively related to adoption, but negatively related to a farmers' perception of the extent of soil erosion. However, Christensen and Norris (1983) and Mengstie (2009) observed age being directly related to the implementation of BMPs of pollution control. They posit that this anomaly is related to the larger financial constraints that face younger farmers. Other researchers contend that, age does not significantly influence the effort put into other conservation practices apart from conservation tillage (Norris and Batie, 1987).

b) Household size

Household size on the other hand was expected to have a positive impact on conservation efforts. The larger the family size, the higher the probability that future generation will farm the land and reap the long-term benefits of conservation investments (Garcia, 2001). Likewise, larger family size would indicate more labour that could possibly be available for the construction of soil conservation structures (Abu, 2011).

c) Education

Evidence from literature suggests that, educational level has a positive relationship with the use of soil conservation technologies (Duff *et al*., 1990). Education is expected to have a positive effect on adoption since higher levels of education could be associated with greater information on conservation measures and the productivity consequences of erosion, and greater management expertise (Garcia, 2001). While in their models, Ervin and Ervin (1982) put forward that education is significantly related to the level of adoption and investment of soil conservation technologies among farmers.

d) Farming experience

There has been little discussion of the role of experience or years of farming in literature to date (Duff *et al*., 1990). However, the study by Christensen and Norris (1983) found that, farmers with more experience were more likely to adhere to traditional practices and therefore, less likely to adopt BMPs. On the other hand, Pampel and van Es (1977) found out that years' of farming were positively related to the adoption of environmental practices, but not to the adoption of commercial practices. It is expected in the study area that years of farming had a positive influence on the level of adoption of soil conservation technologies in the study area.

2.5.2 Institutional factors

Ervin and Ervin (1982), Christensen and Norris (1983), and Norris and Batie (1987) noted that institutional factors such as farm distance from the nearest market, land tenure, technical assistance, technical training, policy implementation and cooperative membership are among the determinants that influence farmer's decision on the adoption of appropriate soil conservation technology package. The study as well is in line with what these authors assert.

a) Policy implementation

A wide range of policies may impact on decisions to invest in the SWC (Duff *et al*., 1990; Pender and Gebremedhin, 2007). Conservation policies including National environmental policies (which may include elements dealing directly with erosion and conservation issues); land tenure and planning policy; and forestry, agriculture and livestock policies (including those favour incentives) may have direct or indirect influence on the level of adoption of SWC technologies and crop productivity through implementation of various land management programs (Boyd *et al*., 2000; Rukangira, 2011).

b) Land tenure

The impact of farmer's land tenure circumstances on the use of soil conservation technologies is inconclusive at present (Duff *et al.*, 1990). Kabubo-Mariara *et al*. (2010) found out that tenure security is important in determining the likelihood and intensity of adoption and therefore, it is important to consider whether household plots are owned, rented out or rented in. Research findings reported by Boyd *et al.* (2000) explained that land ownership has some influence on the adoption of SWC practices since most farmers feel secure under the customary land rights, and tenure is not a constraint in most cases. However, a few farmers who rent land particularly young people and new immigrants regard insecure tenure as a constraint to the adoption of SWC technologies.

c) Technical training

Duff *et al* (1990) assert that, little work has been done to assess the importance of technical training on adoption. Its importance depends upon the complexity of the soil conservation practice or technology being considered. Nowak (1983) and Pattanayak *et al* (2002) noted the importance of farm management skills in the adoption of soil conservation technologies since technologies place additional demands on farmers' managerial skills in an already risky occupation of the agricultural sector.

d) Extension service

Access to information on resources of new inputs and technical advices as part of extension service is believed to have a contribution towards the optimal use of scarce resources and improved conservation technology and *vice versa* (Tizale, 2007; Rukangira, 2011; Pattanayak *et al*., 2002). Various studies in developing countries including Ethiopia reported a strong positive relationship between access to information and technical advices about soil conservation technologies disseminated by extension agents and the adoption behaviour of farmers (Tizale, 2007; Kassie *et al*., 2011; Culver and Seecharan, 1986; Christensen and Norris, 1983; Yao and Garcia, 2002). However, there is inadequate information about the access of extension services on land management in the study area.

e) Market distance

The distance from the farm plot to the homestead and nearest market can be an incentive for, or constraint to putting in soil conservation structures (Pattanayak *et al*., 2002; Mengstie, 2009). The closeness of the farm plot to market centre allows better access for marketing of farm products, giving an incentive for increasing production and hence stimulating adoption of SCTs. One way of increasing productivity of farms in the highly erodible uplands is to construct proper soil conservation structures. Therefore, the longer the distance of the farm plot to nearest market centre, the lower the level of adoption and investment of soil conservation technologies and vice versa (Garcia, 2001; Bayard *et al*., 2006).

f) Conservation motivation

The dissemination of subsidies, either from the government or other partner organizations in various forms such as conservation inputs (construction implements, tree seedlings and tree seeds) and irrigation infrastructure support provide an incentive to adopt soil conservation technologies (Connolly and Hilts, 1987; Kassie *et al*., 2011). However, in many cases, farms that receive any form of subsidy are thought to have initially conformed to the government's conservation requirement or the NGOs development program (Garcia, 2001).

g) Cooperative membership

Membership in a farmers' organization or local cooperative supported by either government or NGOs is thought to enhance adoption (Pattanayak et *al*., 2002; Pender and Gebremedhin, 2007). Local cooperatives and farmer organizations are often used as a medium for the promotion of government and NGO programs. Lack of access to extension services due to non-membership in such organizations is frequently cited as an impediment to the adoption of soil conservation technologies (Garcia, 2001).

h) Demonstration plots

The most effective measures of soil erosion control need to be demonstrated so that farmers can see and understand exactly on how SCTs can work in controlling soil erosion (TRIC, 1982). It is important to carefully select farmers who are to participate in the program such as Farmer's Field Schools (FFS) if a farm demonstration program is to be effective. Demonstration farms have been used as one means of farmers being able to learn from other farmers the effective adoption of soil conservation technologies based on participatory research, farmers' knowledge and experience (Duff *et al.,* 1990; Rukangira, 2011).

2.6 Theoretical Framework for the Adoption of Soil Conservation Technologies

There are several theories explaining the choice and use of soil conservation technologies. These theories differ only in paradigms but all explain the adoption of soil conservation technology (Duff *et al.,* 1990). Some of these theories are the Traditional Adoption-Diffusion model (Rogers, 1983), Economic Constant model (van Kooten, 1986) and Ervin and Ervin (1982) theoretical framework.

This study opted the 1982 Ervin and Ervin's theoretical framework in explaining the level of adoption of SCTs and farm plot improvement on crop productivity in hillside farming households of the West Usambara highlands. According to the theory, the adoption and use of soil and water conservation technologies can be modeled as a decision-making process with three consecutive stages namely; perception of the soil erosion problem; a decision to adopt soil and water conservation technologies; and investment in soil conservation technologies. These three stages are simultaneously influenced by social, institutional, physical and economic factors.

The theory further states that the adoption could be triggered by four groups of farmer’s characteristics through drawing inferences concerning the relationship between crop productivity and soil quality. The decision to adopt soil conservation leads to another array of decisions over what type(s) of soil conservation technology were convenient to employ.

Among others, Ervin and Ervin (1982) theoretical framework shows the interplay of age of a household head, gender, education, farming experience, tenure status, extension service, subsidies, technical trainings, distance to the nearby market centre, demonstration plot, and cooperative membership as social and institutional factors in guiding the level of adoption and investment of soil and water conservation technologies. Moreover, the model shows the number of soil conservation technologies adopted and their effectiveness in soil erosion control.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Description of the Study Area

3.1.1 Topography and population

The West Usambara highlands are located in the North Eastern part of Tanzania and constitute a portion of the Eastern Arc Mountains. About 80% of the population of Lushoto district in Tanga Region is found in the West Usambara highlands. (Mwihomeke and Chamshama, 2001). Lushoto District, where the study was conducted, lies between latitudes 4^{o} 05’ and 5^{o} 00’ and longitude 38^{o} 05’ and 38^{o} 40’ with altitudes ranging from 600 meters to 2300 meters above sea level (Minderhoud, 2011). The district is characterized by the hill slope ranging from 18% to 60% while annual rainfall ranges between 800mm and 1400mm (Mowo *et al*., 2002; Minderhoud, 2011). Lushoto District has a population of 492 444 people in which 230 236 are males and 262 205 are females (URT, 2013). The famous tribes found in Lushoto District are Sambaa, Pare and Mbugu.

The major soil types in the Lushoto District are reddish-brown soils such as Humic, Haplic and Chromic Acrisols, Luvisols and Lixisols in the mountainous uplands and Fluvisols and Gleysols in the valley bottoms (Meliyo *et al*., 2002). Agriculture is the main economic activities of people in Lushoto District where horticultural activities are carried out mainly in valley bottoms while paddy production is dominant in plain land areas. The major horticultural crops grown include Irish potatoes (*Solanum tuberosum*), cabbage, carrots, tomatoes as well as other varieties of fruits.

3.1.2 Justification for the study area

Lushoto district was selected for the study due to the following reasons:

a) High rate of soil erosion reaching 100 t/ha/year (Lyamchai *et al*., 1998; Minderhoud, 2011) which reduces crop productivity on hillside farm areas (Mwihomeke and Chamshama, 2001; Minderhoud, 2011)

b) Promotion and dissemination of soil conservation technologies to farmers by conservation projects such as SECAP, AHI and TIP in collaboration with TAFORI for adoption from early 1980s (Mowo *et al*., 2002).

3.2 Study Design

On the basis of the nature of the study objectives, a cross-sectional study design was opted. The study design used allows data to be collected at one point in time and generates data for description and determination of relationships between variables while taking into consideration limited time and available resources (IDRC, 2003).

3.3 Sample Size

A household was used as unit of analysis in which 100 households were chosen by the study as convenient sample size. Maas and Joop (2005) noted that the sample size of at least 30 respondents chosen at random is reasonably large in social science research studies to ensure normal distribution of the sample mean.

3.4 Sampling Procedure

The sampling procedure involved three consecutive stages to obtain the representative sample. By starting, two wards namely; Sunga and Rangwi which are in Lushoto District were purposively selected using the criteria of their location on hillsides. In the second stage, from the two selected wards two villages from each ward were chosen by simple random sampling. Therefore, four villages which are Mambo, Tema, Nkelei and Emao were involved in the survey. A lottery technique was applied in selecting villages. Again, simple random sampling was used in the third stage to obtain the sample size of 100 households in which 25 households were selected from each selected village. The table of random numbers was used in selecting households to obtain the representative sub-samples of households from respective villages. The study used the head of household either man or woman as the respondent.

3.5 Data Collection

The study collected qualitative and quantitative primary data by using qualitative and quantitative methods. The qualitative methods used were personal interviews, key informant interviews, focus group discussions and direct observation while a questionnaire survey was used for gathering quantitative data. Direct observation, personal interviews, focus group discussions and key informant interviews were used in collecting information concerning the relevance and preferences of integrating different soil conservation technologies on the hillside farm plot. This aimed at ascertaining whether farmers recognized the need for integrating different soil conservation technologies in their farm plots as an effective way of curbing the erosion problem and improving crop productivity.

Quantitative data were collected using a structured questionnaire comprised of both open and closed ended questions administered to household respondents (Appendix 1). Quantitative data involved information pertaining to the type and number of soil conservation technologies adopted by farming household, plot size under conservation intervention, crop productivity as well as social and institutional factors that govern farmer's decision-making on the choice of appropriate package of disseminated soil conservation technologies in the study area.

3.6 Data Analysis

Both qualitative and quantitative data were subjected to analysis process. Qualitative data from observation, personal interviews and key informants pertaining to the relevance and preference of farmers on integrating different soil conservation technologies in a farm plot were analyzed by using content analysis. On the other side, quantitative data were analyzed through the application of SPSS computer software in which descriptive and inferential statistics were determined. Descriptive statistics including percentages, means, minimum and maximum, standard deviations and frequencies as well as inferential statistics were presented in tables and figures.

The variation of adoption of soil conservation technology was determined using the Indices of Adoption (IA). In this regard, **Composite Index of Adoption (CIA)** as well as maximum and minimum index of adoption were computed. According to Yila and Thapa (2008), the Indices of adoption reflect the range of technologies adopted but not the intensity of their use. With reference to Barungi and Maonga (2011), the composite index of adoption (CIA) is computed as follows:

$$CIA = \frac{IA_1 + IA_2 + \ldots\ldots\ldots\ldots\ldots\ldots IA_{100}}{N} \qquad (1)$$

$$IA_i = T_i / T \qquad (2)$$

Where;

IA_i denotes the Index of Adoption of SCTs for i^{th} household

T_i denotes the total number of SCTs adopted by the i^{th} household

T denotes the total number of SCTs available for adoption

N is the sample size

The expression (T_i /T) represents the index of adoption for i^{th} household

Inferential analyses were carried out by using **Chi-square**, **Paired-Samples t-test**, and **Multiple Linear Regression**. While Paired-samples t-test used in the study to identify if there was a significant difference in the average crop productivity from the same cultivated hillside farm plot before and after adoption of soil conservation technologies. Chi-square also used in identifying associations between respondent's education level and extension visit, farmer's age and years' farming as well as a relationship of crop productivity before and after adoption of SCTs.

Similar to Namwata *et al.* (2010) and Agwu *et al*. (2008), and Enujeke and Ofuoku (2012), the multiple linear regression was used in the study to identify social and institutional factors influencing adoption of the number of soil conservation technologies among households in hillside farm areas.

Equation number three represents the multiple linear regression model;

$$Y_i = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + \beta_{12} X_{12} + \beta_{13} X_{13} + \varepsilon_i \quad (3)$$

Whereby;

- Y_i is the number of soil conservation technologies influenced by X_i
- X_1 to X_{13} are determinants for adoption of SCTs
- β_1, β_2, β_3.....................β_{13} are coefficients that measure a corresponding change in Y_i brought by a unit change in X_1, X_2, X_3…….X_{13}
- β_0 and ε_i are intercept and error term respectively

Variables which stand for Xs and Y which used in regression model and corresponding indicators appear in Table 1.

Table 1: Explanation of variables used in the multiple linear regression model.

Variables	Indicators
Dependent variable	
Technology adoption	• Number of adopted SCT technologies
Independent variables	
Marital status	• 1 if married, 0 otherwise
Age	• Years since respondent was born
Education	• Years spent in school
Experience	• Years spent in farming activities
Technical training	• 1 if attended, 0 otherwise
Extension service	• Number of contacts in year 2012
Tenure	• 1 if the land owned, 0 otherwise
Conservation programs	• 1 if have contribution, 0 otherwise
Market distance	• Walking minutes
Subsidies	• 1 if provided, 0 otherwise
Cooperative membership	• 1 if has a membership, 0 otherwise
Irrigation infrastructure	• 1 if has access, 0 otherwise
Demonstration plot	• 1 if exposed, 0 otherwise

A detailed explanation of all variables, indicators and level measurements used by the study has been presented in Appendix 3.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Background Information of the Respondents

The study collected data from household respondents from four villages of Mambo and Tema (Sunga ward) and Nkelei and Emao (Rangwi ward). In order to understand the background of the respondents, personal characteristics including age, marital status, sex, household size, farming experience and education level of respondents were studied. Such characteristics are important in determining the level of adoption of soil conservation technologies of individual farmer in the study area.

4.1.1 Age of respondents

Based on age distribution of respondents, it was found that the average age was 47.52±13.972 years while the maximum and minimum age was 78 and 22 years respectively. The age group of 40 – 49 years constituted the majority (29.6%) of the respondents (Table 2). The age of respondents is important in the adoption process of soil conservation technologies in the study area (Boyd *et al*. 2000; Christensen and Norris, 1983; and Mengstie, 2009).

Table 2: Distribution of respondents according to age groups

Age group	Frequency	Percent
20 – 29	10	10.2
30 – 39	17	17.3
40 – 49	29	29.6
50 – 59	17	17.4
60 – 69	15	15.3
70 – 79	10	10.2
Total	**98**	**100**

4.1.2 Sex and marital status of respondents

The study involved a total of 44 females and 54 males. Married respondents constituted the majority (89.8%) and the remaining (10.2%) were widowed (Table 3). Among other factors, the marital status of a household head can determine the level of adoption of soil conservation technologies in the study area since it can be associated with agricultural land ownership. The study by Leavens and Anderson (2011) found out that the marital status of the farmer has an implication on land ownership since widows and unmarried females often suffer the consequences of land ownership and technology information.

Table 3: Distribution of respondents based on sex and marital status

Variable	Frequency	Percent
Sex		
Female	44	44.9
Male	54	55.1
Total	**98**	**100**
Marital status		
Married	88	89.8
Widow	10	10.2
Total	**98**	**100**

4.1.3 Household size and education

In this study, it was found that the household size ranged from 1 to 14 members while the average household size was 5.84±2.162 members. The household size of 6-10 members constituted the majority (52%) of respondents (Table 4). Based on respondent's education, majority (87.8%) of the respondents had primary school education while 4.1% had secondary school education. However, 8.2% of the respondents had no formal education (Table 4). Farmers with higher level of education have higher level of adoption of soil conservation technologies than those with low level of education. Enujeke and Ofuoku (2012) similarly noted that formal education is important to enhance adoption of soil conservation technologies and innovation of agricultural technologies.

Table 4: Distribution of respondents according to household size and education level

Variables	Frequency	Percent
Household size		
1 – 5	45	45.9
6 – 10	51	52.1
11 – 15	2	2
Total	**98**	**100**
Education		
No formal education	8	8.2
Primary education	86	87.7
Secondary education	4	4.1
Total	**98**	**100**

4.2 Household Level of Adoption of Soil Conservation Technologies in the West Usambara Highlands

Under household level of adoption of soil conservation technologies, types of technologies used by farmers and variation of adoption were studied. Furthermore, the study assessed the size of hillside household farm plot which is under household land management intervention.

4.2.1 Types of soil conservation technologies adopted by farmers

The study collected data concerning the types of SCTs which were used by farmers based on the seven disseminated SCTs in the study area. It was observed that at least each technology was used in the study area (Table 2).

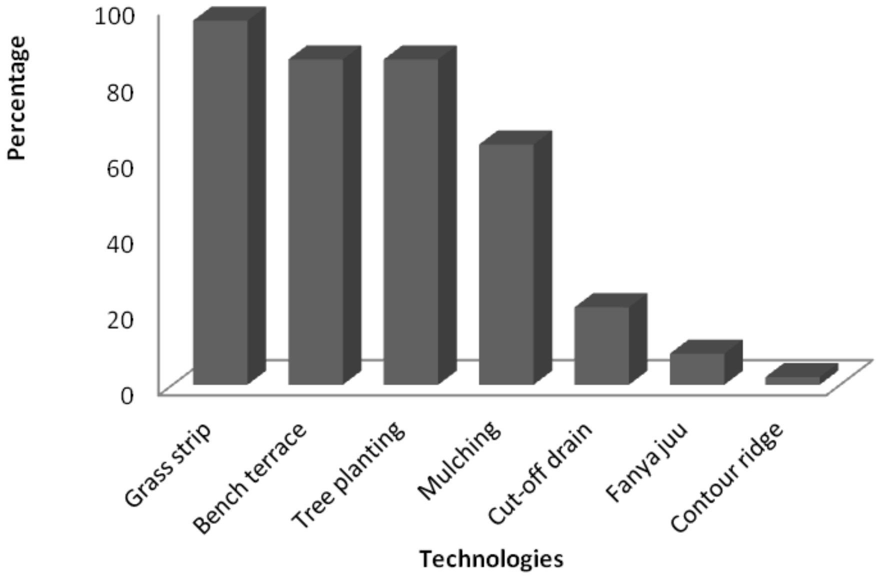

Figure 2: Farmers' response to the adoption of disseminated soil conservation technologies

As shown in Figure 2, grass strip technology dominated by Guatemala and Napier grass was the most popular (95.9%) soil conservation technology followed by multipurpose tree (85.7%) (*Grevillea robusta* (Grevillea), *Pinus patula* (Pines), *Musa spp*. (Banana tree) and *Persia Americana* (Avocado)). Also bench terrace stabilized by grass strips and trees was used by the majority of farmers (85.7%) in the study area. One-fifth and three-fifths of the surveyed farming households used cut-off drain and mulching respectively in integration with other soil conservation technologies. On the other hand, it was found that contour ridges and *fanya juu* were the least used soil conservation technologies in the study area. However, through interviews, farmers appreciated soil conservation technologies as being relevant in their farm plots because they demonstrated effectiveness in soil erosion control by improving crop productivity. During focus group discussions, farmers explained that bench terraces were very effective in controlling soil erosion and therefore once bench terraces were invested by the farmer, the need for other mechanical methods such as *fanya juu* and cut-off drains become less important.

In addition, it was also found that there was variation in farmer's preference on soil conservation technology adoption (Fig. 2). Therefore, technology use differed among farmers in the study area. Similar findings were reported by Mutuma *et al.* (2010) in Kenya that bench terraces were the most popular used soil conservation technologies while the findings are contrary to those reported by Barungi and Maonga (2011) in the highlands of Southern and Central Malawi who observed contour ridges and terraces being the most and least adopted soil conservation technologies respectively. Such differences in technology use justify that the application of the type of soil conservation technology is a site specific and therefore technology use should not be generalized among different regions.

4.2.2. The variation of adoption of soil conservation technologies among adopters

The Composite Index of Adoption (CIA) which is the average of the Index of Adoptions (IAs) of farming households was used by the study to identify variations of adoption of soil conservation technologies among farming households. According to Paudel and Thapa (2004) cited in Barungi and Maonga (2011), the calculation of this index helps to understand the variation in technology adoption and thus contributing to the formulation of policies for effective implementation of land management programmes.

The study identified the CIA of 0.520±0.148. The minimum and maximum Index of adoption (IA) stood at 0.14 and 0.86 respectively. However, the results gave the interpretation that all surveyed households were adopters (minimum IA>0) since each household managed to use at least a single type of disseminated SCTs while the majority managed to adopt above the average number of the disseminated SCTs (CIA>0.5). Generally, CIA ranged between 0 (when there is no adoption) and 1 (when each farming household adopted all disseminated technologies). Therefore, based on the study findings, there was a medium adoption of SCTs in the study area. The CIA identified in the study area was close to that reported by Mutuma *et al.* (2010) who found the CIA of 0.528±1.463 (minimum IA=0. 14; maximum IA=0. 79) but was larger than the CIA of 0.120±0.112 (minimum IA = 0; maximum IA = 0.429) reported by Barungi and Maonga (2011) in the highlands of Central and Southern Malawi where the majority of farmers adopted a small number of technologies and some farmers found as non adopters. Such variations in CIA can be accounted by the fact that the soil erosion problem is an area specific and adopters have different socio-economic and institutional characteristics that determine their capabilities for technology adoption. Therefore, the adoption level of soil conservation technologies should not be generalized among adopters of different geographical location.

The revealed CIA generally depicts that farmers were aware of the seriousness of the soil erosion problem and appreciated the effectiveness and relevance of the disseminated technologies in addressing the erosion problem that face their agricultural plots in hillsides. When interviewed, respondents realized the importance of integrating different SCTs in their farm plots as a way of maximizing the effectiveness of soil erosion control in hillside agricultural lands.

The findings reported by Young (1989), Cooper (1997), Altieri (1995), Branca *et al*. (2011), WOCAT (2011), Sanders (2004) and Celestino (1985) declare similarly that the integration of different soil conservation technologies contributes effectively in curbing the soil erosion problem once properly used by farmers in hillside agricultural plots and results into improved crop productivity.

Table 5: Variations of adoption based on the number of soil conservation technologies per household hillside farm plot

Number of adopted SCTs	Frequency	Percent of adopters
1	3	3.1
2	9	9.2
3	29	29.6
4	39	39.8
5	14	14.3
6	4	4.1
Total	**98**	**100**

Based on descriptive statistics, the majority (39.8%) of farming households in the study area had adopted the package of 4 soil conservation technologies per plot while very few (4.1%) were using the package of 6 technologies per plot. However, 58.1% of farming households adopted more than 4 of the available seven technologies (Table 5).

According to the Ward Agricultural Extension Officer (WAEO), one of the two key informants was asked to give his views on the general level of adoption in SCTs. He stated that almost each farming household was possessing hillside agricultural plot(s). He added that each household was at least applying a type of soil conservation technologies disseminated in the study area but the overall farm coverage was small and technologies were less integrated. Small coverage of technologies was a result of owning fragmented and scattered plots by most of the farmers. On the other hand, another key informant, the Chairperson of Tema-Nkelenge Farmers' Irrigation Association added that following the prolonged drought periods which contributed to the drying of irrigation infrastructures, particularly dams, and the plots on hillside with irrigation infrastructures were no longer prioritized by farmers since they became less profitable and therefore less effort was directed towards conservation. Farmers are now concentrated in the valley bottoms where moisture lasts for some months after the end of the rain season. In view of this, farming activities were now exceeding the carrying capacity of the available agricultural land.

Similar observations to the above have been reported by Napier and Camboni (1988), Nowak (1983) and Barrows and Gardner (1987) who found that attitudes toward a proposed soil conservation program were significantly influenced by a number of factors related to the perception of soil erosion problems including believing that soil erosion problems had high priority and no internalized costs of soil conservation programs were incurred since an individual farmer usually avoided risky activity.

4.2.3 Household hillside plot size under soil conservation intervention

The study assessed information pertaining to household farm plot size on the hillside which is currently under soil conservation intervention and revealed that the majority of households in all surveyed villages operated at most half an acre (Table 6). The overall 11.3% of the surveyed households were found to be operating farm plot size of more than an acre which is under sustainable land management while not exceeding 2 acres. The overall minimum and maximum farm plot sizes under soil conservation intervention were 0.06 acres and 2 acres respectively, while 0.54±0.45 acre was the overall average farm plot size under conservation management in the study site.

Table 6: Distribution of respondents based on household hillside farm plot sizes which are under conservation intervention

Village	**Acres under soil conservation**						
	0.01-0.5	0.51-1.0	1.01-1.5	1.51-2.0	Min	Max	Mean
Mambo(n=25)	64	4	28	4	0.13	2.00	0.78±0.56
Tema(n=25)	76	16	4	4	0.17	1.75	0.57±0.42
Nkelei(n=25)	84	16	0	0	0.06	1.00	0.38±0.29
Emao(n=23)	82.6	13	0	4.4	0.10	2.00	0.42±0.41
Overall(n=98)	76.5	12.2	8.2	3.1	0.06	2.00	0.54±0.45

The highest household average land size in the hillsides which is under soil conservation intervention was observed in Mambo village (0.78±0.56 acre) followed by Tema village (0.57±0.42 acre). However, each surveyed household in Nkelei village was found to possess not more than one acre (Table 6).

When interviewed, most farmers admitted to have fragmented plots which are mostly scattered and located very distant from home. They further explained that they devoted their conservation efforts on the hillside plots which were nearby their home surroundings and those in valley bottoms since other physical soil conservation technologies such as bench terraces and *fanya juu* were labour intensive. However, the farmers admitted that they had been farming even in other plots with no conservation measures. Bebbington(1999) noted that conditioning variables related to human asset such as availability of labour force are important since they give a farmer the capacity to act effectively by investing soil conservation technologies

The above findings concur with the reality that despite some efforts undertaken by farmers in the adoption of the disseminated soil conservation technologies in the study area, the coverage of agricultural land was still low as most of the hillside farm areas were left by farmers without any conservation initiatives and hence highly susceptible to soil erosion and experienced low crop productivity.

4.3 Contribution of Soil Conservation Technologies and Crop Production in Hillsides

Based on Irish potatoes (*Solanum tuberosum*), the study observed an increase in the average crop productivity from the same cultivated land in all four surveyed villages following the application of SCTs (Table 7). Each village was observed to have a significant ($p<0.001$) increase in Irish potato productivity at 5% level of significance since farmers decided to invest on soil conservation technologies in their farm plots (Table 7). High standard deviation of the average crop productivity indicates that despite the significance in improvement of crop productivity, there was high variation in yields per acre between the surveyed households.

Moreover, according to Irish potatoes farm plot productivity distributions of 1-1000 kg/acre, 1001-2000 kg/acre, 2001-3000 kg/acre, and above 3000 kg/acre, the Chi-square test revealed a significant association between the Irish potato productivity before and after the adoption of soil conservation technologies in three surveyed villages of Mambo ($\chi^2_{(3)}$ =10. 931; p=0. 012), Nkelei ($\chi^2_{(9)}$ = 19.767; $p<0.019$), Emao ($\chi^2_{(9)}$ = 20.969; $p<0.013$) and the overall study area ($\chi^2_{(9)}$ = 55.237; $p<0.001$) at 5% level. Therefore, there was a significant change in Irish potato productivity between these two periods.

Table 7: Contribution of SCTs to Irish potato productivity (kg/acre) based on selected villages of Lushoto District

Village name	Average productivity before adoption	Average productivity after adoption	t-value	p-value
MAMBO (n=25)	874.98±389.81	1767.04±1085.74	5.345	<0.0001
TEMA (n=25)	1018.08±474.53	3384.89±1813.25	7.778	<0.0001
NKELEI (n=25)	1386.52±1267.95	2632.88±1874.66	6.504	<0.0001
EMAO (n=23)	1396.61±1117.47	2665.48±1820.10	6.136	<0.0001

Note: Figures added and subtracted (±) are the standard deviations

The patterns of averages of crop productivity observed in all villages depict the improvement of productivity since farmers decided to invest on soil conservation technologies in their farm plots. Hence, soil conservation technologies are effective in curbing soil erosion and contribute significantly to the improvement of soil fertility in hillside farm plots.

Significant crop performance observed in the study area following the application of recommended SCTs is similar to that reported by Shively (1999) on the hillside farms in the Philippines, Dutilly-Diane *et al*. (2003) in Burkina Faso and Niger, Dosteus (2011) cited in Branca *et al.* (2011) in the Uluguru mountains in Tanzania, Verchot (2007) in Malawi, and Posthumus (2005) in Peru based on specific crops and environmental conditions. Therefore, the adoption of soil conservation technologies has significant contribution to crop productivity on the hillside farm plots of the West Usambara highlands.

4.4 Social and Institutional Factors Influencing Adoption of Soil Conservation Technologies.

The study assessed social and institutional factors characterized by farming households which influence the adoption of a number of soil conservation technologies on the hillside agricultural plots. The social factors studied included marital status, age of household head, education of household head as well as household size and farming experience. On the other hand, the institutional factors studied were agricultural subsidies, farm plot distance to the nearby market centre, land tenure, extension visit, conservation programs, cooperative membership, demonstration plot, irrigation infrastructure and technical training. Such factors were also explained by 1982 Ervin and Ervin's soil and water conservation theory being essential determinants for the adoption of soil conservation technologies.

Based on access to extension services, only 10.2% of the surveyed farmers had contact with an agricultural extension agent at least once in the year 2012 for soil conservation advice while the majority (89.8%) of farmers did not consult extension officers (Table 8). The study found a significant association between the access to extension visit and farmer's level of education (χ^2 (2) = 7.899; p = 0.019) at 5 % level of significance and this gave the fact that more educated farmers had good access to extension compared to uneducated farmers.

Table 8: Distribution of respondents based on selected institutional factors affecting the level of adoption of soil conservation technologies (n=98)

Variable	Frequency	Percent of responses
Technical training		
Had attended training	58	59.2
Had not attended training	40	40.8
Extension service		
Had a contact with extension agent	10	10.2
Had no contact with extension agent	88	89.8
Tenure		
Plot owned	97	99
Plot not owned	1	1
Cooperative membership		
Cooperative member	37	37.8
Not a cooperative member	61	62.2
Demonstration plot		
Visited a demonstration plot	18	18.4
Never visited	80	81.6
Irrigation infrastructure		
Had access	38	38.8
Had no access	60	61.2
Subsidies		

Had access to a kind of subsidies	30	30.6
Never access subsidies	68	69.4

According to the above observation, farmers are sensitive in recognizing and processing information pertaining to agricultural extension packages. Based on skills pertaining to the application of soil conservation technologies, 59.2% of the surveyed farmers had attended a kind of soil conservation training at least once while the rest (40.8%) did not (Table 8). Moreover, only 18.4% of the surveyed farmers reported that they had either participated or visited demonstration plots to learn about land management practices. The rest (81.6%) did not due to the absence of demonstration plots nearby their localities (Table 8).

Regarding the role of conservation partners in the study area, this study found that 35.7% of the surveyed farmers appreciated sufficient contribution of conservation programs that are implemented by the government and other conservation partners to their soil conservation efforts. Such contributions were in terms of training on sustainable agriculture and farm inputs provision. Soil conservation inputs provided were Guatemala and Napier grass, Tree seeds and Construction tools such as spades. SECAP and PADEP under the District Agricultural Department and TIP were among the conservation projects that were mentioned to be supporting farmers. However, the majority (64.3%) of the surveyed farmers did not recognize sufficient contributions of conservation programs in their land management efforts (Table 8).

Being the means of mobilization among farmers for easy access to extension services, credit and training on sustainable land technologies, the study found that about one-third of the surveyed farmers in the study area had either formal or informal cooperative membership. The majority (two-thirds) of farmers had no affiliation to any kind of cooperative union (Table 8). Such situation accelerated poor access to conservation services including extension services and technical training among the unorganized farmers and hence, reduced their chance to the effective soil conservation. The observation was contrary to that reported by Enujeke and Ofuoku (2012) in Edo State Nigeria whereby a large number (71.7%) of respondents was lacking affiliation to cooperatives and farmer's associations. On the other hand, 38.8% of the surveyed farming households had access to irrigation infrastructures including dams and irrigation channels while 61.2% depends entirely on rain-fed agriculture (Table 8).

On the other hand, it was also found that 99% of the farming households owned agricultural land either through purchase or inheritance from parents and relatives while the rest had the access to use the farm plots from their fellow villagers (Table 8). Moreover, 69.4% of the surveyed households had never received any kind of agricultural or soil conservation subsidies except a few (30.6%) respondents who had been provided with some subsidies by TIP, SECAP and PADEP (Table 8). Subsidies were provided to steer the process of adoption by encouraging farmers. Subsidies were in the form of tree seeds (e.g. *Grevillea robusta*), tree seedlings, fertilizer, exotic grass (e.g. Guatemala and Napier) as well as construction tools such as hand hoes, spades and machetes. A similar approach was also reported by Kassa (2003) in Ethiopia where regional government was playing a role in subsidizing farmers with agro-inputs as an incentive in boosting the conservation process since most farmers were lacking collaterals required by banks for loan access. Other researches by

Napier and Camboni (1988) revealed that favorable attitudes towards a proposed soil conservation program were related to the perception that the adoption of soil conservation practices was not risky and therefore the farmer would be encouraged to adopt.

With regard to farming experience, a half of farming households were found to have experience of not more than 20 years in farming activities (Table 9). The minimum and maximum years of farming were 2 and 53 years respectively while the average years of farming was 23.36±14.506 years. Farming experience is essential in farmer's decision making on the adoption of SCTs (Christensen and Norris, 1983).

Table 9: Distribution of respondents in relation to the farming experience and distance to the nearby market centre affecting the level of adoption of SCTs

Variable	Frequency	Percent of responses
Market distance (walking minutes)		
10 – 29	23	23.5
30 – 49	36	36.7
50 – 69	19	19.4
70 – 89	13	13.3
90 and above	7	7.1
Total	**98**	**100**
Farming experience (years)		
1 – 10	25	25.5
11 – 20	24	24.5
21 – 30	20	20.4
31 – 40	11	11.2
Above 40	18	18.4
Total	**98**	**100**

In this study, it was also found that the age of the farmer was significantly associated with his or her years of experience in farming activities ($\chi^2_{(20)}$ = 130.210; p<0.001) at the 5 % significance level. The findings imply that agriculture remains to be the farmer's day-to-day economic activity and hence application of soil conservation technologies is indispensable in the West Usambara highlands to ensure sustainability of agriculture. On the other side, the average distance of the farm plot to the nearby market centre was 46.15±25.22 walking minutes while 120 walking minutes and 5 walking minutes was the maximum and minimum distance respectively. However, 60.2% of the farm plots were within the walking distance of less than 50 minutes from the nearby market centre (Table 9). Farms which are near the market centre are most likely to receive high conservation efforts than those which are distant.

The findings revealed by the multiple linear regression model show that the model is significant fit to the data (F=2.984, p=0.004) at the 5 % level and presented a diversity of influences on the adoption of the number of soil conservation technologies led by social and institutional factors attributed among farming households (Tables 10). The ratio between Sum of Squares Regression (SSR) of 33.596 and Sum of Squares Total (SST) of 110.204 in the model revealed the R^2 equal to 30.5%. The calculated R^2 explains the variation of adoption of soil conservation technologies brought by social and institutional factors that govern individual farmers (Tables 10).

Table 10: Regression analysis showing social and institutional factors influencing household adoption of soil conservation technologies

Variable	B	S.E	t-value	p-value
(Constant)	3.098	1.330	2.329	0.022
Marital status	0.017	0.356	0.046	0.963
Age	0.100	0.014	0.742	0.460
Household size	0.002	0.051	0.038	0.970
Education	0.052	0.053	0.965	0.337
Farming experience	0.001	0.012	0.047	0.963
Technical training	0.669	0.261	2.562*	0.012
Subsidies	0.134	0.278	0.481	0.632
Land tenure	-0.835	1.024	-0.815	0.417
Conservation program	0.187	0.344	0.543	0.588
Market distance	-0.001	0.005	-0.159	0.874
Extension service	0.469	0.188	2.500*	0.014
Cooperative membership	0.200	0.333	0.600	0.550
Irrigation infrastructure	-0.206	0.267	-0.772	0.442
Demonstration plot	0.159	0.282	0.563	0.575

N=98; R^2 = 30.5%; *Significant at p<0.05

According to the multiple linear regression analysis, technical training (p=0.012) and extension service (p=0.014) were variables which were found to have a positive significance at the 5 % level in influencing the number of soil conservation technologies in the study area (Table 11). Similar findings were also reported by Kasse *et al.* (2012), and Enujeke and Ofuoku (2012) while different from that reported by Barungi and Maonga (2011) who observed sex of the household head and being widowed as positive significant determinants for the adoption of a number of soil conservation technologies in Central and Southern Malawi. Such a difference justifies the fact that the adoption of SCTs is area specific and therefore influencing factors should not be generalized among the adopters of different regions.

On the other hand, the age of a household head, household size, education, farming experience, conservation program, subsidies, cooperative membership, household head being married and demonstration plot were not significant determinants although they had positive influence on the adoption of a number of soil conservation technologies. Married head of household is often in favour of access and control over resources including control over agricultural land as well as access to extension services, credit and technical trainings compares to a single parent household headed by widows, divorced woman or unmarried woman (Ellis, 2007; Lymo-Macha and Mdoe, 2002).

Farmers' access to irrigation infrastructure, land tenure and distance of the farm plot to the nearby market centre were also not significant although showed a negative influence on the adoption of a number of soil conservation technologies. Land tenure demonstrated negative and insignificant influence on the adoption of technologies in the study area. This is associated with lack of land title deeds which add value to their farm plots since almost all farms were owned by inheritance from parents and relatives. Based on one of the key informants (the chairperson of one of the farmers' irrigation association), the dry-up of irrigation dams due to prolonged drought was the main cause of reduced adoption of soil conservation technologies in the surveyed areas with irrigation infrastructure. However, increase in farm plot distance to nearby market centres reduces the adoption of soil conservation technologies as it is associated with transportation implications of farm produce to the nearby market centre and inputs such as fertilizer to the farm plot. Pattanayak *et al*. (2002) and Mengstie (2009) assert that closeness of the farm plot to market centre allows better access to marketing of farm products, giving an incentive for increasing production and hence stimulating adoption of SCTs.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Although soil conservation initiatives have a long history in the West Usambara highlands, soil erosion problems still exist and contribute at large to yield failure.
This demonstrates that soil erosion control is a continuous process and adoption of disseminated soil conservation technologies by farmers is not a one-off process.

In the study area, it was found that at least each of the farming household applied at least one type among the seven disseminated soil conservation technologies and the majority used more than four technologies. This shows that farmers were aware of the seriousness of the soil erosion problem. The integration of grass strips, trees and bench terraces were popular soil conservation technologies in the study area followed by mulching, cut-off drain, *fanya juu* and contour ridges. Generally, there was a medium level of adoption of conservation technologies. Moreover, soil conservation technologies demonstrated significant contribution on crop productivity on the hillside farm plots. However, the coverage area under land management intervention was still small.

There were variations in the capacity of farmers to adopt the number of soil conservation technologies. Access to extension services and technical training to farmers had positive relation and significant to the adoption of the number of soil conservation technologies in the study area. However, other factors were not significant as far as the adoption of technologies is concerned.

5.2. Recommendations

To ensure effective control of soil erosion and improved agricultural productivity in the West Usambara highlands, this study recommends the following:

i. The government of Tanzania and other natural resources conservation partners should enable the extension agents to reach the majority of farmers; men and women who depend on hillside agricultural plots as well as having more programs on technical training which are relevant in land management for the effective adoption of soil conservation technologies.

ii. The government in collaboration with NGOs and CBOs should increase access to subsidies for the majority of farmers. Farmers should be sensitized to form and join cooperatives, land management programmes should be extended, and demonstration plots should be established in villages. Farmers will have more access to learn about land management practices, valuing their farms and consequently encouraged to take more actions towards the adoption of soil conservation technologies to conserve their hillside farm lands.

iii. Policy makers and other stakeholders are recommended to apply a joint implementation approach in addressing soil erosion problem since the problem is a cross-cutting issue.

iv. There should be a sustainable intensive land management campaigns. Such campaigns should take into consideration the importance and complexity of the mountain ecosystem.

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APPENDICES

Appendix 1: Questionnaire template for household respondent

Date …………………………………   Number…………..

A. ADMINISTRATIVE CHARACTERISTICS

i. Study location: Lushoto District, Tanzania

ii. Ward …………………..   iii. Village……………………….

v. Name of household respondent …………………………………….

B. SOCIAL AND INSTITUTIONAL CHARACTERISTICS FOR ADOPTION

i. Sex of the household respondent:

(a) Male   (b) Female   ( )

ii. Which is your position in a household?

(a)Husband   (b) Wife   (c) Other   ( )

If the answer is “other”, specify the relationship ……………………..

iii. Age of household respondent: …………. years old

iv. Are you married?

(a) Yes (b) No   ( )

v. Number of individuals residing in a household ………………….

vi. How many years did you spend in schooling? ....years.

Mention the highest level of formal education which you attained…………

vii. How many years have you been involving in farming activities? ……years.

viii. Have you ever attended any training on the application of soil conservation practices?

(a)Yes (b) No ( )

If the answer is (b) give reasons…………………………………………

ix. How many contacts per year have you been made with an extension officer for advice on soil conservation? ……………….contacts.

x. Is the farm plot used by your household for agriculture owned by you?

(a) Yes (b) No ( )

If the answer is (b), specify

…………………………………………………………

xi. Do you agree that the existing agricultural policy is sufficiently supporting soil conservation interventions?

(a)Yes (b) No ( )

If the answer is (b), specify………………………………………………

xii. How many minutes do you spend in walking from your farm plot to the market?.................................minutes.

xiii. Did you ever receive any kind of soil conservation subsidies to boost your conservation effort?

(a) Yes (b) No ( )

If the answer is (a), what kind of subsidies you received among the following list: (Please put a tick (√) in the bracket(s) corresponding to the kind of conservation subsidies received)

(a) Tree seeds ( )

(b) Tree seedlings ( )

(c) Construction implements ( )

(d) Other ( ) Specify ……………………………

Subsidies received from where? …………………………………………….

xiv. Do you a member of any formal or informal cooperative organization?

(a) Yes (b) No ( )

xv. Do you have an access to constructed irrigation infrastructures such as dams and traditional irrigation channels for agriculture?

(a) Yes (b) No ( )

xvi. Have you ever attended to any demonstration within your district to learn on what is practiced about land management?

(a) Yes (b) No ( )

If the answer is (b), specify……………………………………………

C. ADOPTION EFFORT OF SCT AND CROP PRODUCTIVITY

xvii. What are types of improved SCT adopted by the household among the available introduced and promoted technologies below?

(Please, tick (√) in the corresponding space of conservation technology if is adopted)

S/N	Available soil conservation practices	Adopted soil conservation technology
1	Bench terraces	
2	“*Fanya juu*” (throw(earth) upwards)	
3	Grass strips	
4	Cut-off drains	
5	Multipurpose trees e.g. Grevillea spp.	
6	Contour ridges	
7	Mulching	
TOTAL		

Xviii. What is your plot size in acres which is under soil conservation intervention?

. Xix.What is the average of crop productivity before and after adoption of soil conservation technologies SCTs in your farm plot?

Average Irish potatoes productivity before adoption of SCT in kg/acre	Average Irish potatoes productivity after adoption of SCT in kg/acre

Thank you for your cooperation

Appendix 2: Interview question for household respondent

i. Please, can you explain on the appropriateness of applying a number of soil conservation practices in a farm plot in relation to effectiveness in soil erosion control?

ii. Can you explain the relevance or irrelevance of the promoted soil conservation technologies in soil erosion control and improvement of crop productivity

Appendix 3: Questions for key informant

Basing on your long term experience in agricultural sector;

i. What can you comment about the general level of adoption of soil conservation technologies among farmers with reference to the available seven disseminated technologies namely; bench terraces, grass strips, multipurpose trees, mulching, cut-off drains, *fanya juu*, and contour ridges?

ii. Are the adopted packages of soil conservation technologies well integrated in farm plots operated by farmers?

Appendix 4: Description of variables and measurements for descriptive and inferential analyses

S/N	Variables	Description	Measurement
A. SOCIAL FACTORS			
1	Age	Age of household respondent since he/she was born	Years
2	Marital status	If respondent is married	1/0
3	Household size	Number of members in a household which eat in the same pot	Number of members
4	Education	Level of education of the household respondent	Years spent in school
5	Farming experience	Household head experience in farming activities	Years
B. INSTITUTIONAL FACTORS			
6	Technical training	If respondent ever attended any training on soil conservation technology	1/0
7	Conservation program	If implementation of conservation programs is sufficiently supporting soil conservation process to farming household	1/0
8	Extension advice	Exposure of farmer to agriculture extension services provided by extension officers or other institutions	Number of contacts in year 2012
9	Land ownership	If farm plot owned by the household	1/0
10	Farm to market distance	Distance of the farm plot from the nearby market	Walking minutes
11	Conservation subsidies	If respondent ever received any kind of soil conservation subsidies	1/0
12	Cooperative membership	If respondent has a membership in any formal or informal cooperative union	1/0
13	Irrigation infrastructure	If respondent had an access to irrigation infrastructures such as dams and traditional irrigation channels	1/0
14	Demonstration plot	If respondent ever visited or participated in any land management demonstration plot within a district	1/0
C. DEPENDENT VARIABLES			
15	Technology adoption	Number of soil conservation practices adopted by the household over available seven introduced ones	Number of technologies
	Type of technology	Kind of disseminated SCT adopted by farming household	Nominal
	SCT coverage	Farm plot size under soil conservation intervention	Acre
16	Crop productivity	Yields before and after adoption of SCT in the same farm plot.	Kg/acre