

**IMPACT OF SOIL EROSION CONTROL PRACTICES ON HOUSEHOLD FOOD
SECURITY AND INCOME. A CASE OF EAST USAMBARA HIGHLANDS,
TANZANIA**

BY

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ABSTRACT

The study was conducted to assess contribution of soil and water conservation practices on household food security and income in East Usambara highlands, Tanzania. Purposive sampling procedures were used to obtain six representative villages. In each village, 40 respondents were randomly selected leading to a sample size of 240 respondents. Structured and non-structured interview questions were used to collect data. Data collected by using questionnaires were supplemented by field observations and secondary data. Collected data were analysed using statistical package for social science software. Results indicated that five soil erosion control practices were introduced in the study area by various projects. These include agro-forestry, contour farming, planting crops in rows across the slope, application of animal manure and deep tillage. Contour farming was practiced by most farmers (56%) followed by agro-forestry. Preference for contour farming was based on multiple benefits that farmers get beside soil erosion control per-se. Significant proportion of farmers in the study area (74.8%) are aware of the soil erosion problem, consequences and control measures. Results also indicated that group approaches such as group discussions, demonstrations and field days were used to disseminate SWC technologies. These are considered to be among the most effective dissemination approaches. Results further indicated that there was substantial increase in yield following introduction of SWC technologies although this increase was far below potential yields. Significant proportion of households in the study area (87.5%) is food secure for most time of the year. The introduced SWC practices significantly ($P < 0.001$) correlated with annual income and crop yields pointing to possibility of enhanced food security and household income. It is therefore recommended that introduction of SWC technologies should also consider “multiple benefits” that farmers are likely to get beside erosion control. It is further recommended that extension services should be improved in order to increase the rate of implementation of SWC technologies. Technologies should be productive-enhancing and conservation effective.

DECLARATION

I, Anthony Justin Senkoro do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation has not been submitted for a higher degree award in any University.

.....

Anthony Justin Senkoro

(M.A Candidate)

.....

Date

The above declaration is confirmed by

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Professor G.G. Kimbi

(Supervisor)

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Date

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DEDICATION

I dedicate this work to Almighty God, my parents, Zefania Mbonea Senkoro and Navoneiwa Zefania who laid the foundation for my education.

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LIST OF ABBREVIATIONS

ABLH	-	Association for Better Land Husbandry
AGRA	-	Alliance for Green Revolution in Africa
AHFSI	-	Aggregate Household Food Security Index
AHI	-	African Highlands Initiatives
C	-	Degree celcius
cm	-	centimeter
DALDO	-	District Agricultural and Livestock Development Office
EEC	-	European Economic Community
ESRF	-	Economic and Social Research Foundation
EUADECP	-	East Usambara Agricultural Development and Environment Conservation Project
EUFCP	-	East Usambara Forest Conservation Project
FAO	-	Food and Agriculture Organization
FFS	-	Farmers Field Schools
FGD	-	Focus Group Discussion
FINIDA	-	Finland International Development Agency
ha	-	hectare
IFAD	-	International Fund for Agricultural Development
IFPRI	-	International Food Policy Research Institute
IITA	-	International Institute for Tropical Agriculture
IRWH	-	In-field Rain Water Harvesting
IUCN	-	International Union for Conservation of Nature
K	-	Potassium
km	-	kilometer
m	-	meter
MAFS	-	Ministry of Agriculture and Food Security
MDDP	-	Muheza District Development Programme
mm	-	millimeter
N	-	Nitrogen
na	-	Not applicable
NGO	-	Non Governmental Organization
NO ₃	-	Nitrate
NSGRP	-	National Strategy for Growth and Reduction of Poverty
NSS	-	National Soil Service
P	-	Phosphorus
SECAP	-	Soil Erosion Control and Agro-forestry Project
SPSS	-	Statistical Package for Social Science
SUA	-	Sokoine University of Agriculture
SWC	-	Soil and Water Conservation
ton	-	Metric tonne
Tshs	-	Tanzanian shillings
UN	-	United Nations
UNESCO	-	United Nations Educational, Scientific and Cultural Organization
URT	-	United Republic of Tanzania

USD - United States of American Dollar

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Tanzania is among the developing countries where soil erosion is one of the major threats to agricultural production (Kaihura and Stocking, 2003). Since its fast growing population largely depends on agriculture for its income and subsistence, soil conservation ought to be given a priority (URT, 1997). Pressure on the land is increasing and the challenge is to sustain land productivity without destroying its quality (Kuntashula *et al.*, 2006).

Different soil and water conservation (SWC) measures have been developed and promoted to minimize soil erosion in Tanzania (SECAP, 1998; AHI, 2000). Soil and water conservation measures that have been promoted include bench terraces, “fanya juu”, “fanya chini”, grass strips, cut-off drains and micro contour lines. These conservation measures are expected to reduce soil loss from water erosion, retain more moisture and nutrients and eventually increase crop yields. “Fanya juu” are ditches within a field located at a specified intervals formed by throwing the excavated soils on the upper part of the ditch while “fanya chini” are ditches whereby the excavated soils are kept below the ditch.

In East Usambara mountains of Tanzania, low yields of crops and livestock production is a core problem. Major reasons are attributed to soil erosion due to inappropriate land management practices. Most farmers in the area carry out farming practices with minimum soil and water conservation practices (Kimbi and Ngeti, 2003; Reyes, 2008).

Soil erosion results into loss of essential plant nutrients, water and other important soil components. Erosion can cause permanent and irreversible loss of soil productivity. Most of the farmers in East Usambara mountains are aware of the soil degradation problem.

Prior to the currently introduced technologies (before 1980s) farmers used to practice a number of strategies to control soil erosion. These included crop residues management, trash bands, short periods fallow, mulching, mixed cropping and shifting cultivation. Similar situation was also reported by Pfeiffer (1990) who indicated that in West Usambara mountains farmers practised “effective soil conservation and soil fertility preserving methods like multi-storey agro-forestry, mixed cropping and green manuring. However, due to high population pressure, more farms were opened up in the mountainous areas leading to increased soil erosion and over time such practices could no longer contain the problem. Soils on most of the steep slopes have lost their productivity due to soil erosion, leading to food shortages (Cox *et al.*, 2003). Soil degradation due to soil erosion is the major contributor to nutrients losses, because most of the soil nutrients are in the top 5-10 cm of the soil (Nkonya *et al.*, 2004).

Since 1980s, the government of Tanzania in collaboration with Non- Governmental Organisations (NGOs) and various donors have been addressing land degradation problem in East Usambara mountains. In 1987 European Economic Community (EEC) and International Union for Conservation of Nature (IUCN) in collaboration with the government of Tanzania established the East Usambara Agricultural Development and Environment Conservation Programme (EUADECP). The programme aimed at conserving forest catchments and agricultural land by introducing contour strips planted with guatemala grass (*Tripsacum laxum*) and agro-forestry. In 1991 the government of Tanzania in collaboration with the government of Finland through Finland International Development Agency (FINIDA) introduced the East Usambara Forest Conservation Project (EUFCP). The aim of the project was to conserve forests and control erosion on arable land by planting contour strips and provide tree seedlings to the farmers in order to

reduce pressure on forest resources. In the year 2000, Muheza District Development Programme (MDDP) with the support from Irish Aid introduced Contour Farming Project in East Usambara Mountains. The objectives of this project were to control runoff water and soil loss from the agricultural lands and to improve soil fertility using locally available nutrients sources such as farm yard manure and crop residues. This project was broadly targeted to improve household food security and income.

Soil erosion is the major problem that affects crop yields leading to low income of the small scale farmers and subsequently food insecurity. According to FAO (2004) food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. The definition indicates direct relationship between agricultural production, food security and income. In order to address food security and income which generally depend on increased agricultural production, more efforts should be directed to the improvement of appropriate land management practices. Improved soil erosion control measures should aim at increased agricultural production hence improved household income and food security.

1.2 Problem Statement

Although efforts by most projects in East Usambara mountains were on soil and water conservation measures, little is established about the contribution of the introduced soil erosion control technologies on household food security and income. This study was therefore conducted to assess the impact of the introduced soil erosion control technologies on household food security and income.

1.3 Justification

The Ministry of Agriculture, Food and Cooperatives Policy insists on soil erosion control measures in order to increase agricultural production for household food security and income (URT, 1997). This study was therefore in line with Tanzania agricultural policy (URT, 1997) and National Strategy for Growth and Reduction of Poverty (NSGRP) (URT, 2005b) both of which emphasize on soil conservation measures for sustainable agriculture and poverty reduction. The generated information therefore will be useful to policy makers and other beneficiaries, in terms of development of strategies related to SWC technologies.

1.4 Objectives

1.4.1 Main objective

This study investigated the impact of the introduced soil erosion control technologies on food security and income at household level in East Usambara mountains of Tanzania.

1.4.2 Specific objectives

- i. Analysed the introduced SWC technologies.
- ii. Assessed farmer's awareness on soil erosion control measures.
- iii. Assessed approaches used to introduce SWC technologies.
- iv. Assessed the impact of the introduced soil erosion control technologies on yields of major agricultural products.
- v. Examined the contribution of the introduced soil erosion control technologies on household food security and income.

1.5 Hypothesis

Null (H₀):

Soil erosion control technologies have no impact on household food security and income in East Usambara highlands, Tanzania.

Alternative (H₁):

Existing soil erosion control technologies have impact on household food security and income in East Usambara highlands, Tanzania.

1.6 Research Questions

- i. Are farmers aware on soil erosion and the introduced soil erosion control measures?
- ii. What are the effects of soil erosion on crop production?
- iii. What are methodologies used to introduce soil and water conservation technologies in the study area?
- iv. What are the factors contributed to adoption of soil and water conservation technologies?
- v. What are the impacts of the introduced soil and water conservation technologies on household food security and income?

1.7 Conceptual Framework (CF):

In the conceptual framework it have been assumed that the household characteristics, technical aspects, farm characteristics and institutional factors will influence implementation of soil erosion control technologies leading to increased food security and income

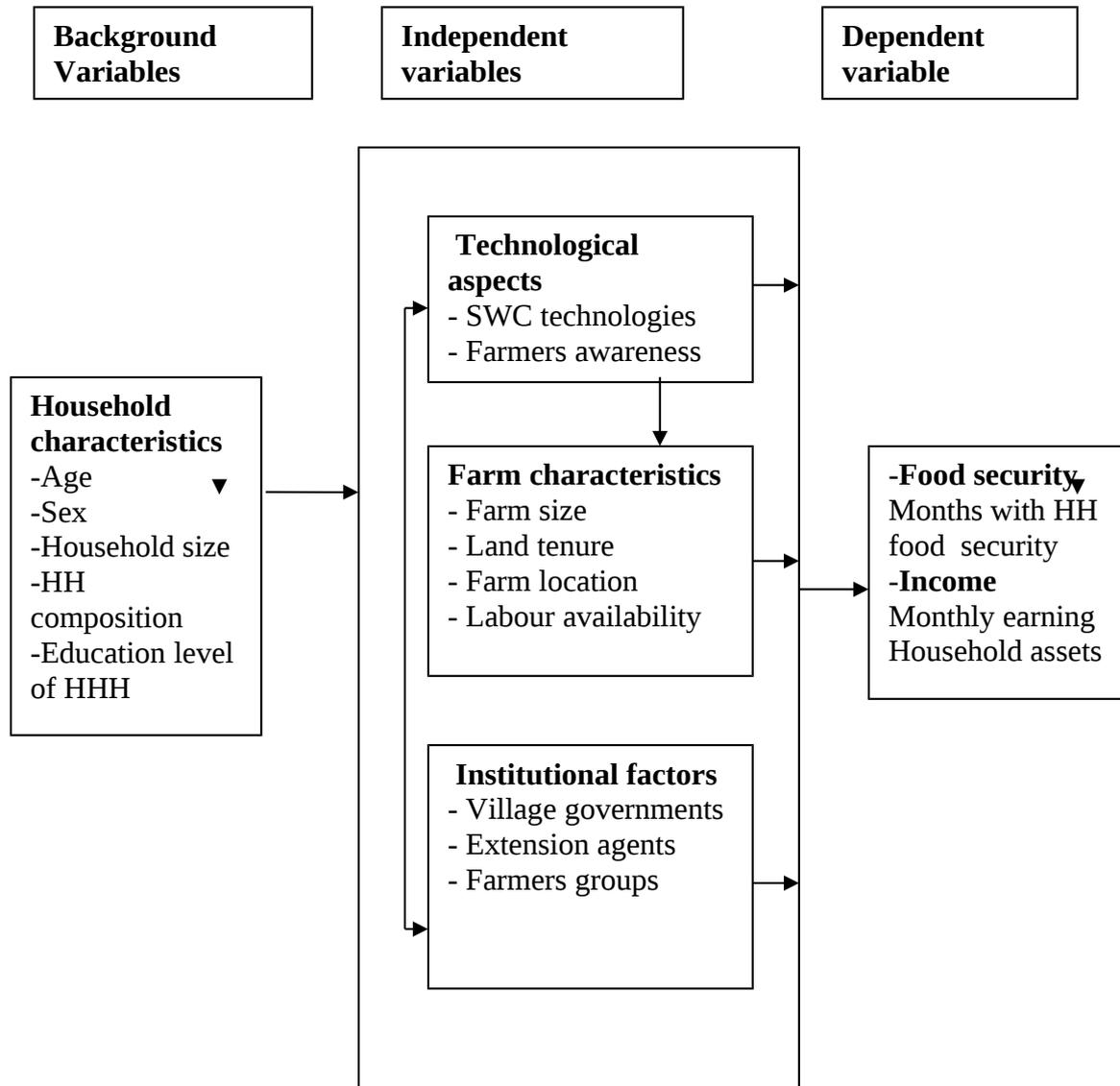


Figure 1: Conceptual framework illustrating the impact of soil erosion control technologies on household food security and income

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Overview

Soil erosion is defined as the wearing away, detachment or physical removal and transportation of top soil from one place and its deposition to another by various agents including striking and moving water, blowing winds, strong waves, snow and the forces of gravity (Abrol and Oman, 2002). According to Hellin (2006) soil degradation is any process that reduces the current and/or future productivity of soils. Erosion generally means destruction/deterioration of soil capacity to support crop growth (Edward, 2005). Soil and land degradation is a real threat to achieving sustainable agriculture.

Approximately 40% of the world's agricultural land is seriously degraded due to soil erosion and associated forms of land degradation (FAO, 2003). Globally, productivity of land has declined by 50% due to soil erosion which corresponds to an annual loss of 75 billion tons of soil (FAO, 2003). The situation is worse in developing countries where individual farm holdings are usually small. Most of the small farmers are poor and many of them are forced to farm small plots of land on steep hillsides due to increased population pressure (Lal, 2001). In Africa yield decrease due to soil erosion ranges from 2% to 40%, with a mean loss of 8% (Abrol and Othman, 2002). If current trends of soil degradation continue, the African continent might be able to feed just 25% of its population by the year 2025 (von Braun *et al.*, 2004). About 60% yields loss due to soil erosion was reported to occur in mountain and semi-arid areas of Tanzania (Johansson, 2001). Usambara Mountains are among the areas affected by soil erosion in Tanzania, with an estimated annual soil loss of fertile top soil of about 25 tonnes per hectare and consequently reducing crop yields (Tenge, 2005).

2.2 Types and Forms of Soil Erosion

There are two main types of soil erosion, geological soil erosion and human induced soil erosion. According to Hudson (2002) soil erosion which is accelerated by human activities is known as man-made or accelerated erosion. Accelerated soil erosion is one of the major threats to sustainable agricultural production in many parts of the East African Mountains (Ovuka, 2000). Geological soil erosion is the gradual removal of soil by natural processes acting over a very long time (Thomas *et al.*, 2003).

Major agents of soil erosion are water and wind. Soil erosion by water occurs in humid areas where rainfall exceeds infiltration capacity of the soil. Wind erosion is common in the arid and semi-arid areas with dry and bare soils (Tavakoli, 2006). Soil erosion by wind can cause serious damage to soils. Wind erosion occurs in three forms: surface creep, siltation and suspension (Twomlow and Bruneau, 2000). Surface creep occurs when large particles of coarse sand are pushed by wind along the surface. Siltation is the action in which fine and medium sand particles are rolled over the surface by direct wind pressure and sometimes the particles are lifted in the air. Suspension occurs when very fine particles are easily carried by wind to high levels and over long distances (Refahi, 2004).

Soil erosion process mainly involves three phases. The first process involves the detachments of individual soil particles. The second process is transportation by erosive agents such as striking and running water and blowing winds through mass movements. The third one is deposition which occurs when sufficient energy is no longer available to transport the soil particles (Mupangwa *et al.*, 2005).

Soil erosion occurs when there is no sufficient soil cover such as grass and organic matter (Glover, 2005). Water is the main agent of soil erosion in the humid areas where rainfall exceeds infiltration capacity of the soil (Ning, 2004). Water which will not infiltrate the soil starts to accumulate on the surface and moves down the slope carrying soil particles. Top fertile soils, rich in plant nutrients and organic matter are eroded leaving behind infertile sub-soils. Organic matter is important as it maintains plant nutrients in the form that is fairly readily available to plants (Kaihura and Stocking, 2003). Organic matter also maintains soil structure and stabilizing aggregates. Organic matter also promotes infiltration hence reduce the potential for erosion (Gachimbi, 2002). Soil conservation must aim at maintaining soil organic matter.

Deposition of soil material occurs when the force of striking and moving water diminishes due to either reduced volume of water or change of the topography. The severity of soil erosion depends upon materials supplied by detachment and the capacity of the eroding agents to transport the soil (Suresh, 2000).

There are five forms of soil erosion by water. These include; sheet erosion, rill erosion, gully erosion, slip erosion, stream bank erosion and sea shore erosion. Sheet erosion is essentially uniform removal of a thin layer or sheet of soil from a given area of land after the soil has been detached by the impact of falling raindrops (Nyathi *et al.*, 2003). Water which carried soil particles move uniformly down the slope. Rill erosion is the detachment and removal of soil from well defined small channels which are few centimetres wide and deep (Motsi *et al.*, 2004). Rill erosion results from a concentration of surface flow. As the volume of run-off water increases, the rills grow into gullies.

Gully erosion is the channel erosion that washes so deep into the subsoil that the ground cannot be easily smoothed by ordinary tillage methods (Thomas *et al.*, 2003). Slip erosion, sometimes known as land slide occurs due to instability formed in large masses of soil as a result of saturation and moisture pressure, aided by gravitational pull causes a big mass of soil and rock slips down slope. Stream bank erosion occurs when rivers and streams meander and change their courses by cutting the banks and depositing the soil elsewhere (Abrol and Oman, 2002). This type of erosion becomes more serious during heavy rains when rivers flood and streams move faster due to rain water. Sea shore erosion is caused by striking action of strong waves.

2.3 Causes of Soil Erosion

Human activities or factors responsible for soil and land degradation include deforestation, cultivation on marginal lands and excessive grazing with high stocking rates (Woltering, 2005). Due to population pressure, even steep slopes and marginal lands have been cultivated and fallow periods have become shorter and eventually abandoned (Reyes *et al.*, 2005). Soil degradation in steep lands is exacerbated by land and labour shortages, which in turn determine farmers' receptivity to soil conservation programmes. According to Erickson *et al.* (2000) the major causes of soil degradation are poor land husbandry and unsustainable agricultural practices.

Land use/cover, soil type, slope, slope length, rainfall amount and intensity influence the rate of soil erosion (Thomas *et al.*, 2003). Land cover is important in terms of protecting the soil from kinetic energy of the rain drops which detach the soil particles. Land cover can be maintained either by planting cover crops or through use of crop residues as mulch (Misana *et al.*, 2003). However, in some places crop residues are used for other purposes

such as thatching materials for houses, fuel wood and fodder. Phiri *et al.* (2006) reported that most farmers use crop residues as fodder instead of using it for mulching. Slowing the water movement on the slopes by regulating the vegetative cover ensures that water is available for plants for a longer time.

Soil properties such as texture and structure are important determinants of soil erosion (Gachimbi, 2002). Sandy soils are easily detached by rain drops than clay soils. Loose soils are easily eroded than soils with stable aggregates. Steep slopes are more sensitive to rapid soil erosion through run-off water (Taigbenu *et al.*, 2005). The only way to reduce soil erosion in hilly areas is to decrease the rate at which water moves down the slope. SWC practices on arable land are the pre-requisites for reducing the speed of run-off water. It is recommended to leave very steep slopes under natural vegetation. Severity of soil erosion increases as the length of the slope increase (Lal, 2001). The longer the slope length, the higher the soil erosion. Slope length can be reduced by construction of soil and water conservation measures such as terraces and contour strips (Manyatsi and Ndelela, 2006). These structures reduce the speed of run-off water and increase infiltration rate.

Soil erosion involves the expenditure of energy in all phases from breaking down soil aggregates to run-off. The amount of erosion, however, depends upon a combination of erosivity, which is the power of the rain to cause erosion, and erodibility, which is the ability of the soil to resist the rain (Singh, 2003). Storm rains in the tropics are with high intensity which strikes on the soil and detaches soil particles. The amount of rainfall if exceeds the infiltration rate, then water starts to accumulate on the surface resulting to run-off.

Indicators of land degradation used to assess land degradation include soil nutrient levels, evidence of observed soil erosion features and crop performance assessment by farmers (Gachimbi, 2002). Replenishment of plant nutrients could come in the form of organic manures, inorganic fertilizers or biomass transfer through agro-forestry or short fallow or integration of these technologies. In order to increase farm incomes and ensure food security, intensification and diversification of crop enterprises is important due to small land holdings in some areas.

2.4 Effects of Soil Erosion

2.4.1 Loss of soils and nutrients

Soil erosion has in many years resulted into depletion of the top fertile soil and destruction of soil properties, hence reducing soil productivity leading to food insufficiency (de Villiers *et al.*, 2006). This situation increases production costs for agricultural crops. Worldwide it is estimated that soil degradation has affected 1,966 million hectares. This represents 15% of the total land area and 38% of the agricultural land. Furthermore, it has been suggested that, approximately 12 million hectares of arable land are destroyed and abandoned annually because of unsustainable farming practices (Hellin, 2006).

Nitrogen (N) and phosphorus (P) are the main limiting nutrients in crop production. Reyes (2008) reported that about half of the N, P and K losses in Africa are due to erosion and leaching. Soil fertility depletion is considered as a biophysical limiting factor affecting food security. Resource poor farmers are the most affected ones since most of them depend on annual crops that succumb more to soil erosion than perennial crops. Stocking (2003) estimated that in Zimbabwe, soil erosion carries away an average of 1.6 million tons of N, 15.6 million tons of organic matter and 0.24 millions tones of P each year.

In Usambara mountains, the effects of indiscriminate cultivation started becoming evident in the 1930's, during which soil erosion started to become a major problem in the area. As a result, soil conservation schemes were established. The schemes aimed at introducing various conservation practices. Johansson (2001) observed that farms opened in up slope areas in West Usambara in 1964 resulted in increased crop yields in the first years. However, in the subsequent years crop yields decreased due to soil erosion and poor agricultural practices.

Tenge (2005) revealed that annual soil loss in Usambara mountains was approximately 25 tons per hectare. However, other previous studies indicated annual soil loss of 100 tons per hectare (Pfeiffer, 1990; Kaswamila, 1995). The variation could be due to differences in estimation techniques. Nevertheless, the important issue is the effect of soil erosion on crop yields and its consequences on household food security and income. The aim for soil conservation practices is to reduce soil erosion in order to ensure increased crop production, improved household food security and income.

2.4.2 Decrease in crop yields

Soil degradation caused by soil erosion is the major contributor to nutrients losses because most of the scarce soil nutrients are in the top 5-10 cm of the soil (Nkonya *et al.*, 2004). The relationship between soil loss and productivity is obvious (von Braun *et al.*, 2003). Crop production is expected to decline due to decreased levels of soil nutrients caused by erosion.

Globally, land productivity has declined by 50% due to soil erosion (FAO, 2004). In Africa productivity has declined by 16%. Of the degraded soils, 58% are in dry lands and

42% in humid areas. In Tanzania, it has been estimated that the yields of any given crop are only 20% to 40% of the potential yields due to various reasons including soil erosion (Uliwa and Fischer, 2004). Reyes (2008) reported that the average cardamom yields decreased by 22% in 10 years in the East Usambara highlands, from year 1995 to year 2005. Similar studies were also conducted in other parts of Tanzania at farm level which all indicated that there is a serious problem of declining soil fertility and this affects crop productivity (Nyathi *et al.*, 2002; Kaihura and Stockings, 2003). The issue at stake for many farmers is that soil degradation exacerbates an already precarious struggle for food security.

2.5 Soil Erosion Control Practices

Soil conservation is defined as the specific use and protection of land, including wise choice of land use and pursuit of necessary measures of soil management and erosion control. According to Heinrich (2001) soil conservation technologies can be grouped into two categories; mechanical/physical and biological measures.

2.5.1 Physical soil conservation measures

Structures for soil conservation on crop land are permanent features formed from earth, stones or masonry that are designed to protect the soil from run-off water and erosion and to retain water where it is needed (Manyatsi and Vilane, 2001). The most common conservation structures include: cut-off drains, water ways, tie ridges, terraces, retention ditches, graded and non-graded channels/drains (Kabambe, 2006).

Soil conservation drains are of different types depending on the intended purpose. For example, graded channels are constructed with recommended gradient aimed at deviating

excess water out of the farm with the speed which will not cause erosion. These channels are suitable in areas with high rainfall. Contour bands are another type constructed with zero gradient aimed to reduce the speed of run-off water, trap the soil particles and allow water to infiltrate in the soil (Floor, 2000). Contour bands are suitable in areas with moderate rainfall. Tie ridges are constructed in such a way that the channels are tied to allow water collection and increase water infiltration in order to improve moisture content in the field. Tie ridges are practiced in arid and semi-arid areas which experienced less amount of rainfall (Kangalawe, 2006).

Cut off drains are constructed on the upper part of the field. The cut-off drains are bigger in size compared to field drains aimed to evacuate the excess water coming from the outside of the field and safely dispose to the waterways (van der Zaag, 2005). Bench terraces are level or nearly level steps constructed on the contour and separated by embankments known as risers. They can be used on slopes of up to 55% provided that the soils are deep (Shiferaw and Bantilan, 2004). Waterways are natural or constructed structures used for safely disposal of run-off water collected from the fields through drains. The waterways are left with natural vegetation in order to increase roughness which reduces water velocity. Van Zyl (2006) emphasized that physical soil conservation measures should be properly constructed otherwise they may cause much damage than without soil conservation measures.

2.5.2 Biological soil conservation measures

Soil and water conservation measures such as live barriers, cover crops, agro-forestry, mulch and contour strips constitute biological conservation methods. Covering the soil with growing plants or plant residues has been shown to provide soil erosion protection,

especially on sloping land (Glover, 2005). Slow decomposition of plant residues on the soil surface increases organic matter and total nitrogen contents in the top 5 to 15 cm soil stratum while protecting soil from erosion.

Retention of residues on the surface has been found to increase the soil nitrate (NO_3) concentration by 46%, the N uptake by 29% and the crop yields by 37% (Mandal *et al.*, 2004). With permanent soil cover, zero tillage and a rotation of crops with green manure, crop yields in Brazil improved by a factor of 5.5 in just two years (Hellin, 2006). Farmers can improve yields by using sufficient organic mulch in the fields. This improves moisture retention capacity, suppresses weeds and decrease soil erosion.

Agro-forestry refers to land use practices where trees are integrated with crops and livestock on the same land management unit (Place *et al.*, 2005). Trees have benefits such as timber, firewood, building materials and fruits, on top of that trees reduces soil erosion, increase organic matter and bring to the surface the plant nutrients which are found beyond crop root zone (Bonifasi, 2004; Swallow *et al.*, 2006). Many biological practices are aimed at maintaining and improving soil quality and productivity. Recently, more attention has been directed to the use of cover crops to protect the surface of soil from the impact of high intensity rain drops (Anderson *et al.*, 2001).

2.5.3 Soil conservation technologies developed/promoted in Tanzania

Different soil and water conservation measures have been developed and promoted in most parts of Tanzania to minimize soil erosion (SECAP, 1998; AHI, 2000). These include bench terraces, “fanya juu”, “fanya chini”, grass strips, cut-off drains, infiltration ditches, agro-forestry and micro contour lines (AHI, 2000). “Fanya juu” are ditches within

a field located at a specified intervals formed by throwing the excavated soils on the upper part of the ditch while “fanya chini” the excavated soils are kept below the ditch. These soil and water conservation measures are expected to reduce soil loss from water erosion, retain more moisture and nutrients, the effect of which increases crop yields (Phiri *et al.*, 2006).

A range of indigenous soil and water conservation measures have evolved over the centuries. These include planting-pits which are dug out with a traditional hoe and organic matter is sometimes added to improve soil fertility (Wedum *et al.*, 1996).

Malley *et al.* (2004) describe an indigenous “ngoro” manual cultivation practice that is used on steep slopes in parts of southwest Tanzania. The “ngoro” conservation system consists of a matrix of pits with surrounding bund walls. Grass is cut prior to cultivation and is normally laid out in a 1.5 m x 1.5 m square. Soil is then dug from the middle of each square and is placed on top of the grass to form four bunds surrounding each pit. Crops are subsequently planted on these bund walls. The decomposing plant residues provide nutrients to the developing crops. In East Usambara Mountains, farmers also practice indigenous soil and water conservation measures such as trash lines/bands and mulching (Newmark, 2002).

2.6 Farmers Awareness on Soil Erosion and Control Measures

Resource-poor farmers are probably more desperate than their governments and any number of soil conservation experts about the land’s quality because their livelihoods are intimately dependent on the maintenance of its productivity (Kuntashula *et al.*, 2006). In managing land to meet family livelihood requirements, farmers therefore have to consider

a wide range of influences including risks and opportunities for profit. In this context, farmers are embedded in a range of social, economic, cultural and political relationships that affect their access to property and labour, and their decision-making power within their communities and households with respect to livelihood options (Matata *et al.*, 2001).

Farmers are commonly faced with a range of adverse agro-ecological, social and economic conditions including erratic rains, low soil fertility, fluctuating market prices for agricultural products and labour shortages (Angelson and Kaimowitz, 2004).

Complex and diverse livelihood and farming systems reduce vulnerability and enhance security. Farmers perceive an increase in soil erosion and a decline in soil fertility as the main constraints to crop production (Gachimbi *et al.*, 2003; Thomas *et al.*, 2003). Other studies showed that farmers do not identify soil erosion as a cause of reduced productivity even though they are aware of the factors that favour erosion. There is a direct relationship between soil loss and productivity, but many times farmers are not identifying soil erosion as a reason for soil degradation, farmers just complain that the yields are declining (Olson *et al.*, 2004). Farmers tend to believe that low soil productivity is caused by lack of soil moisture; however, they fail to understand that there is a direct relationship between soil erosion and moisture deficiency in the soil. Soil erosion removes the top soil rich in organic matter and leave behind the subsoil with low water holding capacity. Unless the soil will be added with organic matter in the form of farm yard manure or compost the soil productivity will remain low.

Hellin (2006) in Honduras revealed that farmers, in general, understand the causes of land degradation and acknowledge that their agricultural practices can contribute to the

degradation process. Local people know far better than development planners do how to strategize to get the best from difficult circumstances (Paudel and Thapa, 2004). These strategies interfere with each other in ways that force the farmer to make compromises on the optimum technical management of most of the farming system. Pfeiffer (1990) in West Usambara highlands, Tanzania, concluded that farmers in the past practised “effective soil conservation and soil fertility preserving methods like multi-storey agro-forestry, mixed cropping and green manuring. Another critical factor explaining farmer’s lack of concern about soil loss is that they are masters in survival and have learnt how to cope with the problem. What is clear is that many farmers have developed practices that alleviate the detrimental consequences of soil erosion. Farmers can mask the effects of erosion by growing crops that are less demanding and/or by increasing levels of inputs such as irrigation and fertilizers (Abrol and Oman, 2004).

Liwenga and Kangalawe (2006) observed that the role of local knowledge in managing water scarcity for agricultural production in dry lands of central Tanzania is an indication of farmer’s awareness on SWC technologies. The study revealed that local innovations in water management have contributed on household food security and poverty reduction. The innovations include, moisture tapping through sand river cultivation and exploiting of small ‘wetlands’ (mbuga) within the dry lands. These innovations increased crop yields in the areas with soil moisture constraints.

Understanding the true complexity of farmers’ livelihoods can therefore; help researchers and development practitioners to develop soil conservation technologies and approach that better compliment farmer’s complex livelihood strategies. There is a need to engage active

farmer participation at all stages of project development and implementation (Altieri, 2002).

2.7 Common Extension Approaches Used to Disseminate Agricultural Technologies

Dissemination of agricultural technologies requires the use of different extension approaches. Dissemination is essentially the process by which knowledge, ideas and skills are introduced to farmers in order to bring about change in crop, livestock and other production practices and thus improve farmer's livelihoods (Matata *et al.*, 2001). Training is the basic method used to ensure that new innovations are introduced to the farming communities. Training aims at communicating information, knowledge and skills, exchanging opinions and experiences leading to removal of doubts and difficulties, and creating a desire to change (FAO, 2000). Taigbenu *et al.* (2005) found that information is a key variable and its availability is typically found to correlate with adoption of technologies. Extension services are a major source of technical information for farmers therefore contact or proximity to extension agents increases adoption of technology. Some studies identify farmers training through workshops, seminars, exchange visits and demonstrations as the major approaches that enhance adoption of technologies.

2.7.1 Workshops and seminars

Workshops are valuable ways of disseminating information to the community but also soliciting their views and feedback. These methods involve experts and farmers aiming at discussing the theme on the improvement of certain situation. The aim for conducting workshops and seminars is to exchange ideas, knowledge and skills (Rodgers, 2003). Group discussions can also be arranged to elaborate issues and clarification is given whenever necessary. Matata *et al.* (2008) observed that workshops and seminars are the major training approaches to enhance the adoption of technologies.

2.7.2 Exchange visits, study tours and demonstrations

Study visits are important as they create awareness on the part of farm operators as an obvious pre-requisite to adoption (Mahboubi *et al.*, 2005). With proper planning and follow up, study visits are very effective instructional techniques in the learning process (Kimbi and Ngeti, 2003). Study visits support the learning theory that individuals learn better through examples. The principle function of study visits is to make participants aware of innovations away from their immediate home area, which may be useful (Van den Ban and Hawkins, 1988). Usually they will have to be followed up by other methods until farmer's interest is developed and converted into action.

Farmer's knowledge and experience are considered when they are involved in the process of technology development and implementation (FAO, 2005). Johansson (2001) reported the achievement whereby farmers adopted new crops introduced and green manuring initially established in project demonstration plots. There are two types of demonstrations; these are method and results demonstration. Method demonstration is a practice used by extension agents to train farmers by showing how to do a particular innovation so that farmers they can do on their own (FAO, 2003). The demonstrated technology should be adequately evaluated. Method demonstration should include what the farmers want to see and what is needed by them at that particular time (FAO, 2002). Results demonstration is a way of showing farmers the value of an improved technology (FAO, 2004). This is done by showing and comparing improved and non-improved technologies so that farmers may see and choose the best practice. Demonstrations have spill-over effects within and outside the localities as they influence non-adopters to adopt the innovations.

2.7.3 Farmers field schools (FFS)

Farmer's field schools are characterized by learning-by-doing, learning-by-using, experimentation and peer learning. It has been hypothesised that they are more effective and efficient than traditional extension approaches in stimulating adoption of knowledge – intensive technologies such as SWC (Rusike *et al.*, 2004). Farmers field schools uses group building exercises, experiments and trials, look-and-learn visits. Farmers learn by doing, and the curriculum is largely selected by farmers, based on problems they commonly face (Bwalya, 2005). Rusike *et al.* (2006) concluded that FFS improves farmers understanding of new technologies, their capacity to effectively use the technologies and make better decisions and improve adoption rate.

2.8 Factors Likely to Affect Adoption of SWC Technologies

Adoption is defined as the degree of use of a new technology in long run equilibrium when a farmer has full information about the new technology and its potential (Grepperud, 2003). Therefore, adoption at the farm level describes the realization of farmer's decision to apply a new technology in the production processes. A particular technology is adopted when the anticipated utility from it exceeds that of non-adoption (Douthwaite *et al.*, 2001). Since utility is not observable, change in utility can be inferred from farmer's decision of adopting or not adopting a technology (incidence of adoption) or adopting some continuous choice over a predefined interval (Kazianga and Masters, 2001). Factors influencing adoption of new agricultural innovation can be divided into three major categories: farm and farmers associated attributes, attributes associated with the technology ((Mose *et al.*, 2000)) and the farming objective.

In the first category, factors discussed include human capital represented by the level of education of the farmer (Glover, 2005), the risk and risk management strategies (Pannel,

2003), the institutional support system such as marketing, research and extension services and transportation (Hazell *et al.*, 2007), availability of production factors and factor endowment such as farm size, number of livestock owned (Heirich, 2001) and the level of off-farm income and income sources (Tshiunza *et al.*, 2001).

The second and third categories depend on the type of technology and it is important when farmers access to different types of technical innovations (Gray and Moseley, 2005). Therefore, the influence of each exogenous variable on adoption responses is unique and specific to the study area. These characteristics make adoption studies site specific and often incomparable (Mulenga, 2006). Farmer- adoption is often quantified in terms of the number of farmers who have adopted a particular technology and/or the length of SWC measures established.

Much less attention has been directed at the impact of the technologies on productivity. Soil conservation technologies will be attractive to farmers if they will offer sufficient and obvious benefits, especially increased productivity to compensate the farmers for increased labour input (Tiffen, 2003). Farmer's interest in soil conservation technologies will be enhanced if recommended technologies can be shown to reduce soil and water losses and contribute to increased productivity. A cost benefit analysis of soil conservation technologies reveals vastly different returns from different technologies with a large part of these differences due to the varying labour demands that each technology requires (Angelsen and Kaimowitz, 2004). In terms of soil conservation techniques, the lowest labour requirements are for biological systems and the highest requirements tend to be for terraces. Investment on soil conservation has to be justified on the grounds of maintaining food production and providing an economic return on investment.

Livestock are important in implementing SWC technologies. Keeping cows may encourage planting grasses along macro-contour-lines which will be used as fodder but at the same time conserve soil and moisture for improving crop yields. Livestock and livestock products are the source of income which could be used for implementing SWC measures (hiring of labour and expand farm size). Dairy cattle keeping in East Usambara highlands contribute 20% of the income of the farmers (URT, 2006). The study by Woytek *et al.* (1988) reveals that the ownership of dairy cows given to farmers on credit was found to be major incentive for macro-contour-lines establishment in West Usambara Tanzania. Almost two thirds of the heifer credit receivers were high adopters of basic soil erosion control and agro-forestry measures.

Nkonya (2004) revealed that SWC practices such as terraces and contour strips also tend to remove land from production. From the farmer's perspective reduction in land area for growing crops may be seen as a sacrifice. However, the reduction of land due to soil conservation measures will be compensated from the high yields obtained from the conserved land. Katila (2008) points out that farmer with small plots of land, who are struggling to produce sufficient food, cannot afford to take land out of food production to put it under physical conservation structures.

Much has been written about the link between land tenure and the adoption of soil conservation technologies or better land management practices (Murray and Bannister, 2004 and Chomba, 2004). Lack of tenure is a disincentive to the adoption of these technologies. Evidence comes from the Vietnam (Fahlen, 2002) and Niger (Gruhn *et al.*, 2000) Iran (Rezvanfar *et al.*, 2009). The study by Msikula (2003) revealed that land tenure systems have placed constraints on the long term investment in land that would be vital for increasing the agricultural productivity. Farmers tend to fear to invest on the land which

does not belong to them. As farmers participate in programmes, they gain self-confidence, pride and the satisfaction of having made significant achievements. The confidence that comes from this process of empowerment, increases farmers ability to learn and experiment skills that are vital in an increasingly globalise world that places a premium on adaptability and responsiveness (Ellis and Seeley, 2001). However, knowledge and preferences of farmers have not been adequately considered in planning and implementation of soil and water conservation programmes (Ellis-Jones and Tongberg, 2000). Consequently, the adoption by farmers of the most recommended soil and water conservation measures is minimal and soil erosion continues to be a problem (Tejwan, 2004).

Fernandes (2000) on the slopes of Mount Kilimanjaro Tanzania revealed that young people migrate to urban areas, which leads to labour shortages on the farms. The young and educated rural population continue to migrate to urban areas looking for employment and other styles of living. It is unlikely that such old peasant farmers are going to be bothered by construction of soil conservation structures. This issue of aging rural population is likely to have an even more serious effect on soil conservation in those areas where the migrants cut all their ties with the rural areas. The success of any soil conservation programme in terms of farmer adoption rests partly on the credibility of the extension agents and their ability to communicate with farmers. In order to be successful, soil conservation has to be supported enthusiastically by farmers and practices need to be farmer-friendly in terms of being easily adopted and offering tangible benefits (Matata *et al.*, 2008). This requires a bottom-up and farmer-first approach that matches conservation activities to the needs and wishes of the farming community.

2.9 Household Food Security and Income

2.9.1 Overview

FAO (2004) has defined food security as physical and economic access by all people at all times to sufficient, safe and nutritious food to meet their dietary requirements for productive and healthy life. The concept of food security is complex; it has a wide range of aspects from global food balance to nutritional adequacy of an individual. Food and Agriculture Organization has recently incorporated the three elements of its broadened concept of food security which are availability, stability of supply and access into an index of household food security. The Aggregate Household Food Security Index (AHFSI) calculates the “food gap” between the undernourished and average national requirements, the instability of the annual food supply and the proportion of undernourished in the total population. The index ranges from 0 to 100 with 100 representing complete, risk free, food security and zero reflecting total famine. FAO (2002) categorized the food security situation with an index rating below 65 as “critical” while ‘low’ food security ranges between 65 and 75.

2.9.2 Food Insecurity

Food insecurity has been described as a condition in which people lack basic food intake to provide them with the energy and nutrients for fully productive lives (FAO, 2003). The stages of food insecurity range from food secure situation to full-scale famine. Food insecurity can be categorized as either chronic or transitory. Chronic food insecurity translates into a high degree of vulnerability to famine and hunger (Cox *et al.*, 2001). Chronic hunger is not famine. It is similar to under nourishment and is related to poverty which exists in poor countries. Food insecure people are those individuals whose food intake falls below their minimum energy requirements. They also exhibit physical

symptoms caused by energy and nutrients deficiencies resulting from inadequate or unbalanced diet (von Braun *et al.*, 2004).

2.9.3 Food Security Situation

Worldwide around 852 million people are chronically hungry due to extreme poverty, while up to 2 million people lack food security intermittently due to varying degree of poverty (FAO, 2001). Of the 39 countries worldwide that face food emergencies, 25 countries are found in Africa. Sub-Saharan Africa has the highest prevalence of under nourishment and has shown little progress in reducing this in the last 30 years.

Three quarters of the world's poor live in rural areas and earn their living from agriculture (FAO, 2003). In Africa, widespread and abject poverty and hunger are getting worse. Nearly half the population of Sub-Saharan Africa lives below the international poverty line, a higher percentage than in any other regions. Improving poor performance of Africa's stagnating agricultural sector is the key to solving the problems of hunger and poverty since this sector is at the heart of food security (Roman, 2003). The International Food Policy Research Institute (IFPRI) in a 2001 report estimated that for each one percent rise in agricultural productivity, poverty would be reduced by 0.6 percent. Therefore, a direct relationship exists between agricultural productivity, food security and income.

In Tanzania, 18.7% of the people live below the food poverty line (NBS, 2002). Food availability in rural areas depends on production; therefore if crop production fails due to unpredictable climate people in rural areas will suffer more than the urban people who depend on purchasing food (Amani, 2004). Poverty reduction is a major objective of economic development in Tanzania. Since independence in 1961 the government has been

striving to eradicate poverty. Currently, the government introduced the National Strategy for Growth and Reduction of Poverty (NSGRP) which focus on attaining Tanzania Development Vision 2025 aiming at improving people's livelihood. More efforts will be directed to provision of social services as well as improvement of production sectors such as agriculture. The ultimate goal is to attain social well-being of the people, ensure food security and poverty reduction (URT, 2002).

2.10 Impact of SWC Measures on Household Food Security and Income

Several studies have been conducted world wide to assess the impact of soil erosion control measures on household food security and income. For example, the International Fund for Agricultural Development (IFAD) funded soil and water conservation project in Niger, for a seven year period (1990-1996). The results indicated that water harvesting contributed to the rehabilitation of degraded land and also increased household food security.

Hamilton (1997) reported that the Association for Better Land Husbandry (ABLH) worked with resource poor farmers in central and western Kenya using participatory approaches to promote double-dug beds on small areas of their holdings. This enabled them to grow a new range of crops with better market prospects. The overall impact was increased food security, nutrition and cash income.

The study conducted by Mwakalila (2006) on the contribution of indigenous knowledge of SWC on poverty alleviation in semi-arid areas indicated that SWC practices in Magu, Tanzania resulted into an increase of rice production by 6 to 7 tons per hectare. The

increased production has improved food security at household level and income leading to poverty alleviation.

Kangalawe and Lymo (2006) conducted a study on the local knowledge and its role in sustainable agriculture in the southern highlands of Tanzania. The results revealed that there was an increase in maize production when 'ngoro' pits technology was practiced. The 'ngoro' system involves in-situ composting in tied-ridges, run-off interception and water storage between the pits for crop growth. Under the 'ngoro', the crop yields are generally higher and productivity is sustained over longer periods of time than flat cultivation under similar landscape and environmental conditions.

Kanyama-Phiri (2006) reported the increase in maize yields of up to 3 tons per hectare after implementation the technology of green-manuring in Malawi. Green manuring of herbaceous and shrubby legumes involving velvet beans (*Mucuna puriens*), sun hemp (*Crotalaria juncea*) and lab lab (*Lablab purpureus*) resulted into improvement of soil fertility.

Botha *et al.* (2006) found that the application of the in-field rainwater harvesting (IRWH) technique in rural communities in South Africa increased productivity. The technology combines the advantages of water harvesting, no-tillage, basin tillage and mulching. The water conservation technique has the ability to reduce total run-off to zero and also reduce evaporation to a considerable extent, resulting in increased plant available water and therefore increased yields. Intensive field experiments on-station and on-farm demonstrated over a period of six seasons showed that IRWH could increase maize and sunflower yields between 30% and 50% compared to conventional tillage.

Few studies on the impact of SWC on food security have however been conducted in East Usambara mountains. For example, the study conducted by Reyes (2008) indicated that improved agro-forestry systems in East Usambara Mountains increased food production. However, no quantification on yields increase from other SWC practices and contribution to the improvement of household food security and income were indicated.

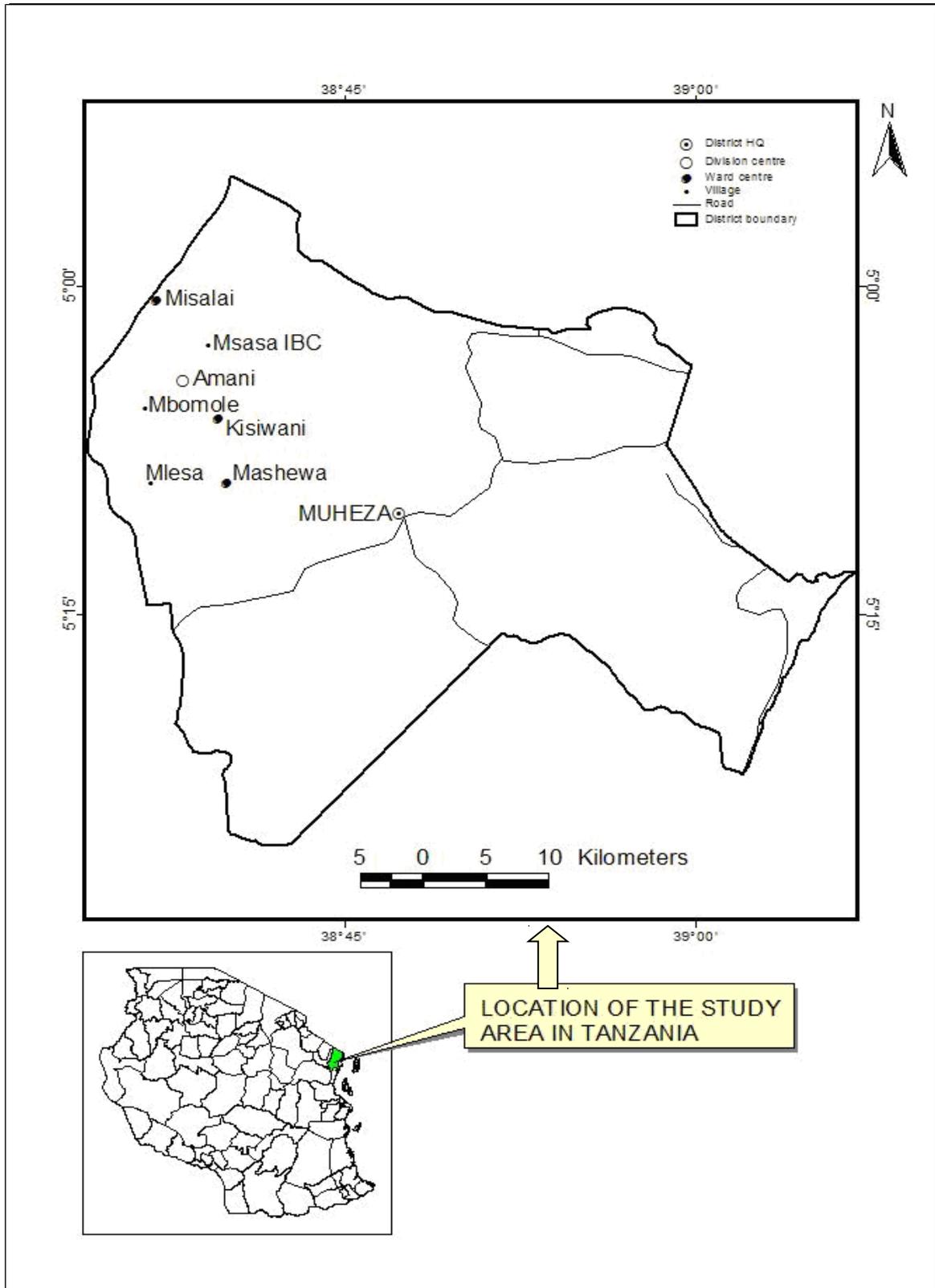
CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Description of the Study Area

The study area is located in Amani division in Muheza district, Tanzania. Amani is part of the East Usambara Mountains. These mountains are range of low mountains close to the coast in the north-eastern corner of Tanzania (Fig. 2). The East Usambara Mountains are one of chains of isolated mountains stretching in a great arc around eastern Tanzania. They cover an area of 1 300 km² between 4° 48' and 5° 13' S and 38° 32' and 38° 48' E. The area experience high rainfall and exceptionally low temperatures on their upper slopes due to its close proximity to the sea (EUCAMP, 2002). The area experiences bimodal rainfall pattern (long rains season from March to June and short rains season from October to December). Mean annual rainfall in the lowland around the mountains varies from 1 000 to 1 300 mm to the south and east, to less than 600 mm in the north. The temperature ranges from 25° C and 20° C.

Soils of the East Usambaras have been described by National Soil Service (1986) and found that the rock at both high and low altitudes is rather uniform and belongs to the Precambrian Usagara system, consisting mainly of biotite-horneblende-garnet gneiss, with much quartz. There are local occurrences of granulite, amphibolite and pegmatite. Rock outcrops are found on summits around the plateau edges and on the escarpments, where there are some very large boulders.



Source: Agricultural Research Institute (ARI) Mlingano (2008)

Figure 2: Location of the study area

The soils are generally deep to very deep (often 1 m to 5 m), usually red or brightly coloured, sandy clays or sandy clay loams. The forest soils are Ferralsols, according to the FAO/UNESCO (1993) system of classification. Soils at higher altitudes have been described as being highly leached and acidic with little inherent fertility, likely to be due to continuous agricultural activities (Johansson, 2001).

Major cash crops grown in the study area are cardamom, cloves, cinnamon, black pepper, tea, sugarcane and banana. Major food crops include banana, maize, beans, yams, sweet potatoes and cassava. Different types of livestock are kept. These include cows (local and cross breed), goats, pigs and chicken.

3.2 Research Design

The research design of the study was cross sectional survey. This method involves collection of information by asking questions to a representative sample of the population at a single point in time (Robert and Tripez, 2005). The design is useful for descriptive purposes as well as for determination of relationship between and among variables (Bailey, 1998).

3.3 Sampling Techniques and Procedures

Six villages namely; Kisiwani, Msasa, Mlesa, Mashewa, Misalai and Mbomole were purposively selected for the study based on the fact that SWC technologies were introduced by various projects in those villages. Two villages (Msasa and Kisiwani) were purposively selected to represent the higher and medium altitudes with different climatic conditions. Msasa village is located at higher altitude 1300 m above mean sea level and Kisiwani village is located at lower altitude 900 m above mean sea level. A list of farmers

practising soil and water conservation measures was obtained from the village and used as a sampling frame. Random sampling was undertaken whereby representative sample of farmers was included in the sample units. A sample size for each village was 40 respondents. This procedure was used to obtain 240 respondents who were then interviewed to collect the desired information. Bailey's (1998) observed that regardless of population size, a sample should not be less than 30 respondents in which statistical data analysis is to be done.

3.4 Data Collection Methods and Instruments

3.4.1 Primary data

Several methods were used for primary data collection. These included household questionnaire survey, focus group discussions with the key informants using checklist of questions and physical observation. The aim was to cross check and verify information obtained through these different methods based on the objectives of the study. A reconnaissance survey was conducted in order to get basic information related to the study objectives.

3.4.2 Household questionnaire

The main instrument used for data collection was a structured questionnaire designed to address specific objectives of the study. Pre-test of the questionnaire was conducted prior to household survey. The pre-test was done in the village with similar conditions to the study area. The purpose of pre-testing was to check the validity of the instrument. Based on the results of the pre-testing, the questionnaire was adjusted accordingly. Open and closed-ended questions were included in the household questionnaire. Data were collected

from 240 households as representatives of the farmers in the study area. The household questionnaire is attached as Appendix I.

3.4.3 Focus group discussions (FGD)

Focus group discussions were conducted with key informants guided by a checklist of open ended questions. The key informants considered were the village leader's representatives, farmers and extension workers. Groups of twenty members from each village were invited for discussions. The purpose of FGD was to obtain details and clarification of the collected data from household surveys. A checklist (Appendix II) was used to guide the discussions based on the objectives of the study.

3.4.4 Physical observations

Few selected representative fields were visited to assess the existing technologies and different management practises. Field observations were done in order to verify and supplement the information collected during household surveys and focus group discussions. Documentation was mainly through photographs.

3.4.5 Secondary data

Additional information was obtained from various reports in projects, DALDOs reports (Muheza district), Sokoine University of Agriculture (SUA) and village government offices. Consultations with government and project officials such as District Agricultural and Livestock Development Office (DALDO, Amani Nature Reserve, East Usambara Forest and Catchments Conservation Project were carried out in order to complement information collected through other methods.

3.4.6 Data analysis and presentation

The data collected were edited, summarized and coded. Analysis was done using the statistical package for social science (SPSS). Descriptive statistics (means, standard deviation, frequencies, cross tabulations and correlation) were used to analyse and summarise the findings. Data were presented in tables, figures and plates.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Household Characteristics

Different household characteristics were considered in this study based on their importance on the implementation of soil erosion control technologies and objectives of this study. These characteristics included, age, sex, marital status, household size, education level, income, labour, farm size, land tenure and farm location.

4.1.1 Age and Household Size

Results in Table 1 indicate that the majority of the respondents (34.5%) were in the age of between 41 to 50 years whereas 26% were in the age group of 31 to 40 years. About 12% were in the group of 51 to 60 years. Significant proportion (17.8%) of the respondents was above 60 years old. Only 9.9% of the respondents were in the age group of 18 to 30 years pointing to the likelihood of youth migration to urban areas. Generally, the results indicate that significant proportion of the respondents were in the active age for agricultural activities. Age influences experience, wealth and decision making, all of which have effect on the adoption of technologies. Rezvanfar, *et al.* (2009) observed that age is likely to have an impact on the adoption of best practices in agriculture. They pointed out that old farmers are not likely to effectively contribute to agricultural activities. Fernandes (2000) observed that young people migrate to urban areas which may lead to labour shortages resulting to low implementation of SWC practices.

Table 1: Age and household size in the study area

Characteristics	Proportion of the respondent in the study villages						
	Msasa n = 40	Kisiwani n = 40	Misalai n = 40	Mbomole n = 40	Mlesa n = 40	Mashewa n = 40	Average n =240
(%).....						
Age (years)							
18 - 30	6.8	12.1	13.0	4.5	0.0	23.1	9.9
31 - 40	18.2	18.2	26.1	36.4	26.7	30.8	26.0
41 - 50	18.2	54.5	26.1	36.4	33.3	38.5	34.5
51 - 60	13.6	6.1	17.4	13.6	20.0	0.0	11.8
61+	43.2	9.1	17.4	9.1	20.0	7.7	17.8
Household size (No. of people)							
1 to 2	2.3	15.2	21.7	0.0	20.0	23.1	13.7
4 to 6	36.4	72.7	34.8	63.6	60.0	46.2	52.3
7 to 9	36.4	12.1	34.8	31.8	20.0	15.4	25.1
10+	25.0	0.0	8.7	4.5	0.0	15.4	8.9

More than 50% of the total respondents had households with 4 to 6 people while 25.1% of the total respondents had households with 7 to 9 people. About 14% of the households had 1 to 2 people whereas 8.9% of the households had more than 10 people (Table 1). The average number of people in the household in the study area was 6 people. This implies that most of the households had number of people below the average suggesting low labour availability for implementation of SWC practices. The findings are in line with other studies (Mbaga-Semgalawe and Folmer, 2003) who observed that insufficient labour has a negative effect on the implementation of SWC technologies. Kangalawe (2006) observed that labour shortage resulted to construction of 'ngoro' pits with small dimensions and low quality compared to pits which were constructed using adequate labour force.

4.1.2 Sex, marital status and education level

Table 2 shows sex and marital status of household heads in the study area. The highest proportion of household heads interviewed was male (70%) whereas women respondents constituted 30%. This suggests that the majority of the households in the study area are male headed. According to Johansson (2001) in most cases males are the ones who make major decisions such as use of income despite of the fact that women contribute significantly to agricultural production.

Results in Table 2 also indicate that most of the respondents (89%) were married while 5.4% were widows. About 3% were divorced and 3% were not married. Married farmers are likely to be more productive due to increased labour force. According to Bwalya (2005) married farmers have wider spreading of labour throughout the year hence enhanced implementation of SWC practices.

Table 2: Sex and marital status

Sex		Marital status	
n = 240		n = 240	
.....(%).....		
Male	70	Married	89
Female	30	Widow	5.4
		Divorced	2.6
		Not married	3
Total	100		100

Results in Table 3 indicate that about 76% of respondents have primary education, 1.3% has no formal education, 1.5% has tertiary education and 21% have secondary school education. Results therefore suggest that most of the farmers in the study area have modest level of education. Education level has influence on the implementation of soil erosion control technologies.

Table 3: Education level in the study area

Education level	Proportion of the respondent in the study villages						
	Msasa IBC n = 40	Kisiwani n = 40	Misalai n = 40	Mbomole n = 40	Mlesa n = 40	Mashewa n = 40	Average n = 240
(%).....						
Tertiary	2.3	0.0	0.0	0.0	6.7	0.0	1.5
Secondary	6.8	3.0	13.0	9.1	0.0	92.3	20.7
Primary	90.9	93.9	87.0	86.4	93.3	7.7	76.5
Informal	0.0	3.0	0.0	4.5	0.0	0.0	1.3

Educated farmers can easily adopt new innovations and access information and services. The study by Lucila *et al.* (1999) in the Philippine highlands and Pali *et al.* (2002) in Uganda revealed that education influenced implementation of soil and water conservation measures. Low education level can be a barrier for agricultural development, since education normally has a significant influence on household's income strategies, land management and labour use (Nkonya *et al.*, 2004). The study by Glover (2005) revealed that adoption of technologies increased with the education level of the farm household head. Rezvanfar *et al.* (2009) also observed that education correlates positively with the adoption of SWC measures. It is generally agreeable that access to information sources and communication channels may increase awareness about the effects and consequences of sustainable soil conservation practices among farmers.

4.1.3 Household Income

Results in Table 4 indicate that the majority of the respondents (39%) had income of less than Tshs 470 000 per year, (20%) had income ranging from Tshs 471 000 to 500 000 per

year, 18.5% had income between Tshs. 501 000 to 700 000 per annum and 15.5% had income ranging from Tshs. 701 000 to 1 000 000 per year. Only 8% of the respondents had income of more than Tshs 1 000 000 per year. Generally, the results suggest that most farmers in the study area earn low income compared to average per capital income of 430 USD (Tshs 541 800) (World Bank, 2008). Results indicate significant variation in terms of income in the study area. For example, Kisiwani village (located at low altitude) 66.7% households had low income of less than Tshs 470 000 per year compared to Msasa village (located at high altitude) which had 12% of respondents who earned income of more than Tshs 1 000 000 per year.

Table 4: Household income in the study area

Average annual income (Tshs)	Msasa n = 40	Kisiwani n = 40	Misalai n = 40	Mbomole n = 40	Mlesa n = 40	Mashewa n = 40	Average n = 240
%.....						
< 470 000	25	66.7	47.8	45.5	20	30.8	39
471 000 – 500 000	24	8	21.2	18.5	24.3	24.2	20
501 000 – 700 000	21	11.3	12	15	28.7	23	18.5
701 000 – 1 000 000	18	10	13	14	15.4	13.6	15.5
> 1 000 000	12	4	6	7	11.6	8.4	8

The observed variation in household income could be due to the fact that farmers in high altitude areas grow cash crops (perennial crops) and keep dairy cattle while the farmers in low altitude mostly grow annual crops such as maize and beans. Farmers in low altitude areas mainly produce food crops which are used for home consumption and little surplus for the market. This has impact on the implementation of SWC practices due to the fact that income has a bearing on investment and adoption of innovations. High income increases risk aversion behaviour among farmers. These findings are in line with those of Tiffen (2003) who observed that economic factor promotes adoption of agricultural technologies. Increase in overall income may affect land use decisions taken by a farmer. It increases the ability of households to hire labour which result into intensification of

agricultural production (AgREN, 2000). Intensification of land use needs improvement of crop husbandry by investing in more labour or other inputs, such as fertilizers into the existing cropping systems. Also, income has influence on the size of the farm the farmer can operate (Scherr, 1999). High income enables farmers to expand the farm for agricultural production. The ability of the farmer to invest in agricultural production depends on the income obtained from the farm. Angelsen and Kaimowitz (2004) observed that willingness of the farmer to invest in soil improvement activities is closely associated with the overall economic profitability of farming.

4.1.4 Household labour force and farm size

Results in Figure 3 indicate that about 70% of the average households had 1 to 2 people for farm activities and about 5% of average households had more than four people. About 25% households had 3 to 4 people involved in farm activities. The results suggest insufficient labour force for agricultural activities.

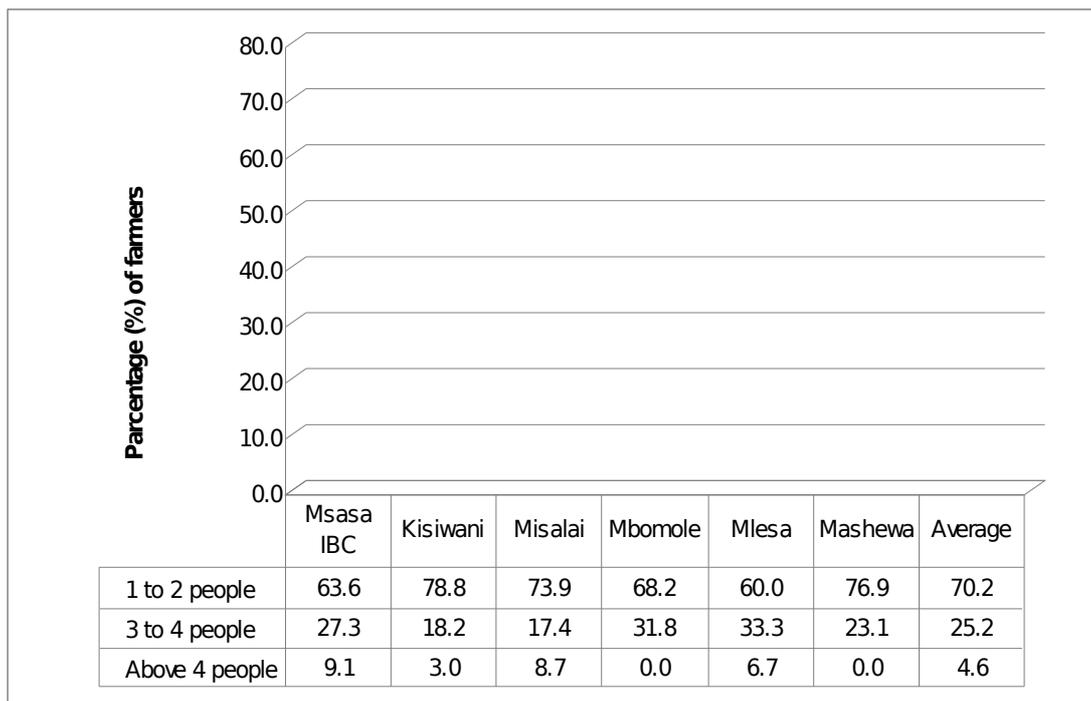


Figure 3: Household labour force in the study area

Labour availability has the implication on the implementation of SWC practices. Labour availability in East Usambara highlands is a major constraint to increased agricultural production. Cultivation is normally done by family members and labour shortage is often the reason why improved agricultural practices are not adopted (Douthwaite *et al.*, 2001). However, farmers with high income hire labour to supplement family labour force.

The results in Figure 4 indicate that about 61% of the average households own more than 2 hectares of land while about 3% of the average households have less than one hectare. About 23% households have 1.1 to 2 hectares of land and about 13% households have 0.6 to 1 hectares of land. The average farm size per household is about 3.5 hectares.

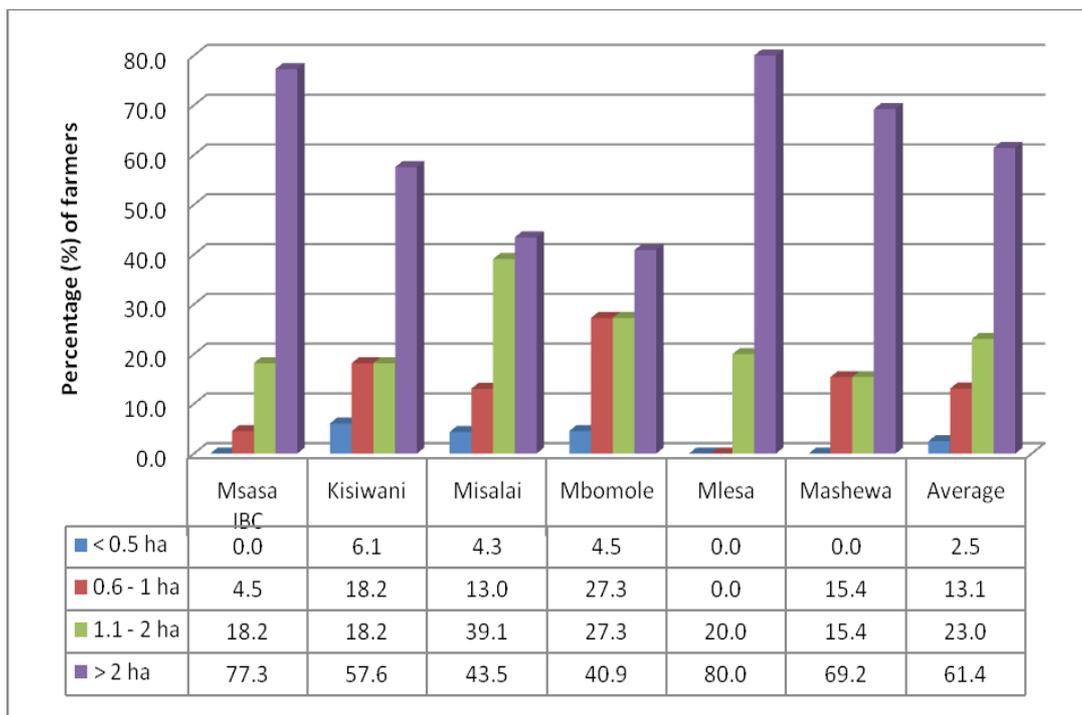


Figure 4: Household farm size in hectares in the study areas

These results suggest that the households with large farm size are likely to implement SWC technologies regardless of the reduction of farm sizes by conservation measures, while farmers with small farm size are more likely to be reluctant to implement SWC

practices. Shiferaw (2005) observed that one of the farm structural factors related to the adoption of SWC practices is farm size. Other factors include income, farm profitability and land tenure.

However, planting of vegetative strips and multi-purpose trees provide other benefits such as fodder, manure and firewood which compensate the losses caused by reduction of land by SWC measures (Stroud, 2000).

4.1.5 Land tenure and farm location

Results in Figure 5 indicate that about 96% of the households own land whereas only 4% carry out farm activities in borrowed land. The results suggest the potential for most of the farmers to invest in long term SWC activities. Insecure land rights are often claimed as a barrier for adopting better land management practices (Katila, 2008). Farmers are not likely to invest on the land in which security is not assured. Land tenure systems have placed constraints on the long term investment in land that would be vital for increasing agricultural productivity (Msikula, 2003). It has been widely held that an enhanced sense of land ownership security results in more land investments, better land management and higher land productivity (Altieri, 2002).

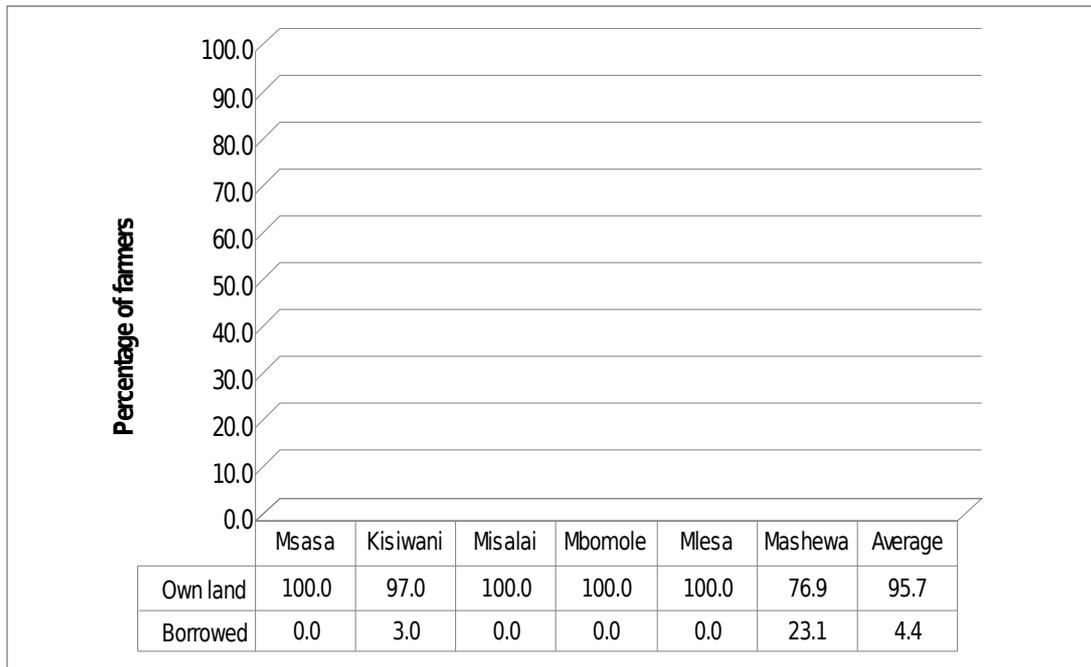


Figure 5: Land ownership in the study area

Land ownership if not assured could lead to low interest and awareness towards investment on SWC measures. Farmers who borrow land for crop production will not bother to invest in SWC practices. Results in Figure 6 indicate that 40.7% of the farms are located at the distance less than 0.5 km, while 36.7% of farms are located within one kilometre from homesteads. About 17% of farms are located at the distance between 1 to 2 km and 6% of farms are located at the distance 3 km and above. Generally, the results suggest that most farms are at close proximity to the homesteads. Distance from homesteads to the farms has the implication on the implementation of SWC technologies. Farmers who walk long distances from their homesteads are not likely to carry out farm activities effectively. The study by Ryan and Spencer (2001) observed that long distances between farms belonging to the same farmer hinder better land management. Pannel (2003) reported that farmers carry out SWC activities as part time job during the evening, making it more difficult to walk to the fields that are located far away from the homesteads.

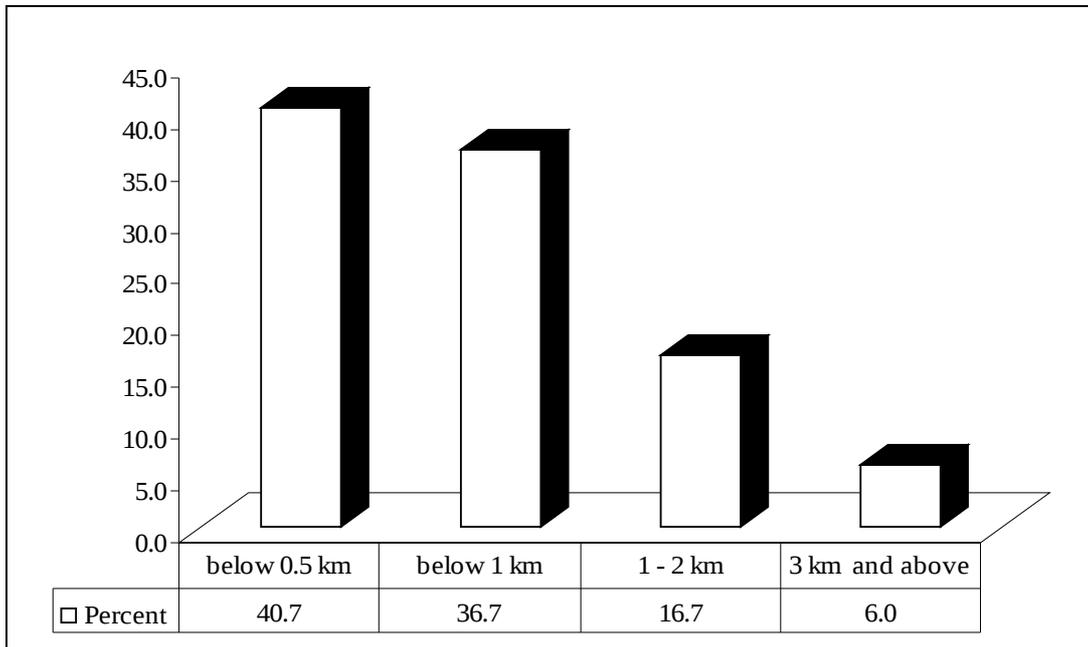
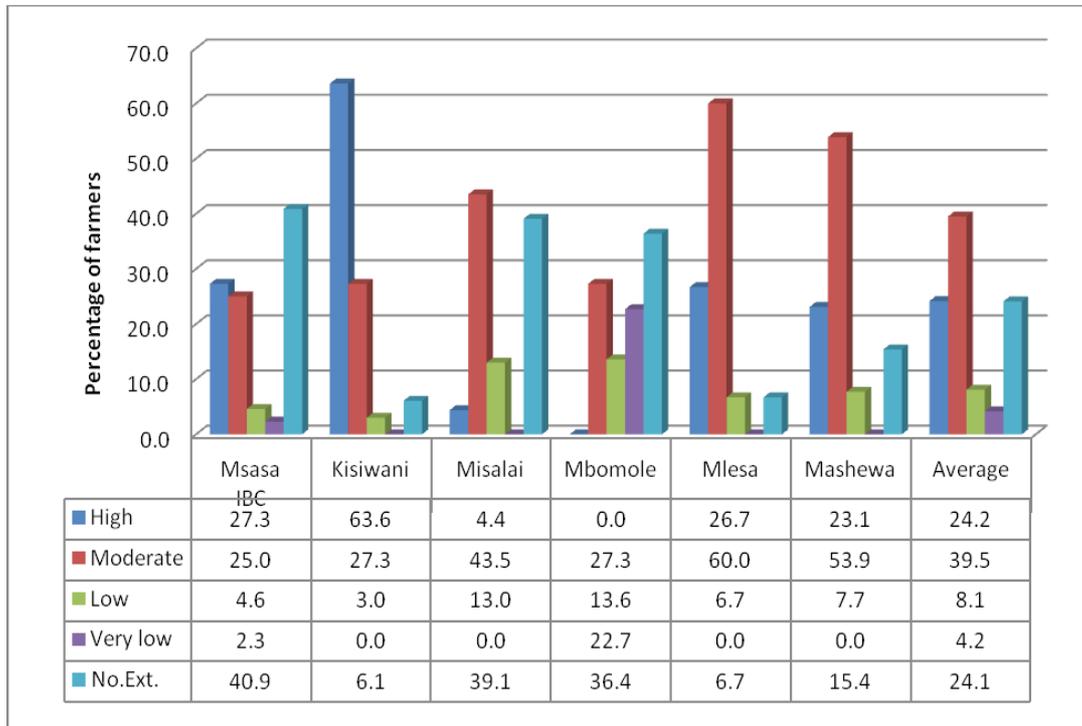


Figure 6: Location of the farms from homestead in the study area

4.2 Assessment of Extension Service Delivery

Results in Figure 7 indicate responses on farmer's assessment of extension services. About 40% of respondents receive moderate extension services. Significant proportion of respondents (24%) indicated that they were not receiving any extension services. Extension services were quite poor in Msasa, Misalai and Mbomole villages where more than 35% of respondents indicated that they were not accessing extension services. Generally, the results suggest inadequate extension services in the area. Meaningful implementation of land management technologies will largely depend on effective extension service delivery.



No. Ext. = No extension services

Figure 7: Contribution of extension services to implementation of soil erosion control technologies

According to District Agriculture and Livestock Development Office report (DALDO, 2008) Muheza district has a total of 100 villages but has only 33 village extension workers. The study area had 18 villages with only 5 village extension workers. According to agriculture policy (URT, 1997) each village in Tanzania is supposed to have an extension worker. Based on the agriculture staff available in the district there is a deficit of 67 village extension workers. Different strategies should be employed to ensure that extension packages reach most farmers. There is a direct link between extension services and implementation of SWC technologies. The study by Nkonya *et al.* (2004) suggests that majority of households who implemented SWC measures had close contacts with extension agents. Extension services are major source of technical information for farmers. Lambin *et al.* (2003) observed that most of the farmers lack information and

encouragement to change their traditional cultivation systems. In most cases there are gaps in knowledge and often research findings, projects and extension services fail to reach the majority.

4.3 Soil Erosion Control Technologies Existing in the Study Area

Different soil erosion control technologies were identified in the study area. These include agro-forestry, contour farming, planting crops in rows, application of animal manure and deep tillage (Table 5). Deep tillage/cultivation refers to digging deep (25 – 30 cm) into the soil during land preparation and leaving large soil clods on the surface. Agro-forestry refers to land use practices where perennial trees are integrated with crops and animals on the same land management unit (McNeely, 2004). Contour farming refers to carrying all farming operations across the slope.

Table 5: Soil erosion technologies existing in the study area and percentage of farmers implementing the technologies

SWC technologies	Msasa n = 40	Kisiwani n = 40	Misalai n = 40	Mbomole n = 40	Mlesa n = 40	Mashewa n = 40	Average n=240
(%).....						
Agroforestry	20.5	0	39.1	22.7	0	15.4	16.3
Contour farming	70.5	87.9	34.8	18.2	93.3	30.8	55.9
Planting in rows	6.8	6.1	17.4	36.4	6.7	30.8	17.4
Manuring	2.3	0	4.3	4.5	0	0.0	1.9
Deep tillage	0	6.1	4.3	18.2	0	23.1	8.6

Survey results indicate that contour farming ranked highest with 56% of the households implementing the technology whereas 16.3% of the households implementing agro-forestry. Results in Table 5 also indicate that only 2% of households use manure for purposes of crop production as well as control of soil erosion. There was a significant variation among the villages with regard to soil erosion control practices. For example, in

Mlesa village about 93% of households implement contour farming whereas only 18% of households implement the practice in Mbomole village (Table 5).

Planting crops in rows across the slope (micro contours) is highly implemented in Mashewa village with 30.8% households implementing the practice and least implemented in Kisiwani village (6.1%). Results in Table 5 also indicate that deep tillage/cultivation is implemented in Mashewa with 23% households implementing the practice whereas 18.2% households implement the technology in Mbomole village.



Plate 1: Field planted with sugar cane for soil erosion control in Mbomole village

The observed variations could be attributed to variation in crops grown which could also be associated with differences in climatic conditions. According to Rodgers (2003) implementation of soil erosion control technologies depends on various factors, such as crops grown, labour availability, farm location and farm size. Perennial crops such as

cloves, black pepper, banana and cardamom perform well under agro-forestry system (Garrity, 2004), while annual crops such as maize and beans grow well under contour farming (Angima *et al.*, 2002). In any case, farmers tend to adopt soil erosion control practices that have “immediate” benefits to them such as contour strips planted with grasses which can also be used as animal feed. Kabambe (2006) found that vetiver bunds proved to be the most effective soil-erosion-control technology due to its well developed roots system. Vetiver grass also has advantage of providing thatching materials. Heirich (2001) observed positive relationship between profit and adoption index. Selection of plants to be grown in contour strips should therefore be based on effectiveness of soil erosion control as well as farmers preference based on tangible benefits.



Plate 2: Field with contour strips planted with sugar cane in Kisiwani village

Focus group discussions were conducted in two representative villages of Msasa and Kisiwani in order to confirm the information collected from the other methods. Msasa village represented high altitude area while Kisiwani village represented low altitude area.

Table 7: Soil erosion control technologies preferred in the study area – Pairwise ranking, Kisiwani village

Technology	Contour farming	Deep tillage	Agro forestry	Manure	Plant crops in rows	Terracing	Score	Rank
Contour farming		Contour farming	Contour farming	Contour farming	Contour farming	Contour farming	5	1
Deep tillage			Deep tillage	Deep tillage	Deep tillage	Deep tillage	4	2
Agro forestry				Agro forestry	Agro forestry	Agro forestry	3	3
Manure					Plant crops in rows	Manure	1	5
Plant crops in rows						Plant crops in rows	2	4
Terracing							0	6

Discussions with farmers revealed that agro-forestry allow planting of different crops on the same plot which reduces risks in case of failure of some crops. It is also the best method of utilizing labour taking into consideration labour shortage in most of the households.

Responses in Kisiwani and Msasa villages on preferences for contour farming could be due to the fact that this technology require less labour compared to other technologies such as terraces. The findings are in line with other studies (Kaswamila, 1995; Kimbi and Ngeti, 2003) who observed that contour strips planted with grass require less labour during establishment and maintenance compared to other SWC practices. Most small holder farmers look for short term and immediate tangible financial benefits from SWC investment. Soil and water conservation such as improved fallows, have medium to long term benefits, unlike application of inorganic fertilizers that has immediate and direct benefits within the same season (Munthali *et al.*, 2006). It is for this reason that most of the soil and water conservation technologies are adopted slowly because they do not have immediate financial benefits.

Field observations revealed that almost all farmers who practice contour farming use crops such as sugar cane, pineapples and fodder crops that can also be used as animal feed. Sugar cane and pineapples fetch attractive market prices hence contributing to enhanced household income. The findings are consistent with the study by Angelson and Kaimowitz (2004) who observed that farmer's willingness to invest in soil improvement is closely associated with the overall economic profitability of farming.

Responses observed for planting in rows and agro-forestry could be attributed to proper land utilization through crop intensification and diversification. Trees such as *Grevillea robusta* were planted for soil improvement due to shading and provision of mulch. The specie competes less with the adjacent agricultural crops compared to other tree species available for farmers due to its deep rooting system (Muchiri, 2001). Johansson (2001) observed that about 55% of farmers in Lushoto district planted trees for purposes of obtaining firewood and building poles while 30% is for soil conservation and other purposes.

Low application of manure could be attributed to the bulk nature and low nutrient contents of manure which implies that farmers must apply huge amounts of manure. In order to improve the quality of manure, farmers should store and handle manure properly. Kimbi and Semoka (2004) observed that proper storage and handling of animal manure before application minimize nutrient losses. Boesen and Friis-Hansen (2001) observed that farmers are less likely to apply animal manure in distant farms due to increased transport cost.



Plate 3: Trash bands one of the traditional methods of controlling soil erosion in Mashewa village

4.4 Farmers Awareness on Soil Erosion and Soil Control Practices

Results in Table 8 indicate that 65% of the interviewed farmers are moderately aware of the SWC practices. About 3% of farmers are at very low level, 22% of farmers are at low level and 10% of farmers are at high level of awareness. Generally, the results show that most of the farmers in the study area are aware of soil erosion and control measures. The high level of awareness could be attributed to efforts from projects and other development agents through different methods which were used to create awareness. Discussions with farmers indicate that some of the methods used to create awareness in the study area included village meetings, use of extension workers in dissemination of information, training through workshops, study tours/visits, seminars, group formation and field days.

Table 8: Farmers awareness on soil erosion control technologies

Level of awareness	Name of villages						Average n = 240
	Msasa n = 40	Kisiwani n = 40	Misalai n = 40	Mbomole n = 40	Mlesa n = 40	Mashewa n = 40	
 (%).....						
High	11.4	9.1	8.7	0	20	7.7	9.5
Moderate	61.4	78.8	47.8	77.3	80	46.2	65.3
Low	18.2	12.1	43.5	22.7	0	38.5	22.5
Very low	9.1	0.0	0.0	0	0	7.7	2.8

The observed variation in the level of awareness among the villages could be attributed to factors such as farmer's willingness, lack of knowledge, availability of extension workers and individual efforts by extension workers.

Rodgers (2003) suggests four components for a planned social change program to be successful. There must be an awareness of the problem and awareness that the solution exists, a felt need by the audience to solve the problem, commitment or willingness to allocate resources to solve the problem and the capacity to make the solution a reality. The ability to obtain and use the assistance available from soil conservation agents depends on the understanding levels of the farmers. Concomitant with the creation of awareness is an effort to create a need for solving the problem and willingness to allocate resources, usually money and time. There is a significant correlation between level of awareness and adoption of technologies. Pannel (2003) contend that access to information sources and adequate number of extension agents may increase awareness about the effects and consequences of sustainable soil conservation practices among farmers. In most cases, extension agents conduct educational programs to create awareness on soil erosion problems and latest technologies for controlling soil erosion. Glover (2005) observed that

awareness on new technologies is high if farmers are regularly supported by extension agents. Reyes (2008) concluded that despite a high level of literacy in the East Usambara Mountains about 93% of the information is delivered orally.

Communication between individuals is generally more effective when they have similar customs and beliefs. In a study that involved 540 villages in Tanzania it was observed that similar ethnic backgrounds and shared social activities contributed to a faster adoption of fertilizer use (Isham, 2002).

Okunade (2006) observed that characteristics of change agents such as competency, credibility, communication ability and confidence were identified as factors which influence level of awareness. Characteristics of extension agents go a long way to affect the decision of the adopters. Marshall (2004) observed that relationships between farmers and advocates for innovation including scientists, extension agents, private companies and other farmers may influence awareness.

4.5 Approaches Used to Introduce SWC Technologies

Results in Table 9 indicate that the majority of farmers (42%) accessed SWC technologies through meetings and group discussions whereas 20% of farmers received information through field days. About 10% of farmers were reached through study visits/tours whereas 21% of farmers received skills and knowledge through demonstrations. Only 7% of farmers were reached through workshops and seminars. The results imply that most of farmers accessed SWC information through group approaches such as meetings and field days. These approaches are not only effective in terms of reaching many farmers at a time but they are also cheap in terms of resource utilization such as time and money.

Table 9: Responses of farmers on effectiveness of approaches used to introduce SWC technologies

Approach used	Number of farmers	Percent
Meetings/ group discussions	100	41.6
Study visits/tours	24	10
Workshops and seminars	16	6.7
Field days	48	20
Demonstrations	52	21.7
Total	240	100

Matata *et al.* (2008) observed that group methods such as meetings, demonstrations, field trips and campaigns are the most effective information dissemination methods. Group discussions enhance the process of adoption through transferring knowledge from an expert to the group. The audience gets adequate time to ask questions, relate the new information with what they already know and the possibility of adoption is high. Bwalya (2005) suggests that learning through groups enable members to sit together and share ideas and experiences on the farming practices. Study visits/tours/ excursions are also preferred by farmers as they learn by seeing what other farmers achieved and they will practice the innovations after coming back to their localities. With proper planning and follow up study visits are very effective instructional techniques in the learning process. Johansson (2001) observed that farmer's excursions to other catchments enable them to see SWC practices and talk to other farmers about their experiences.

Field days and demonstrations are very effective methods for disseminating agricultural technologies. Farmers learn through 'seeing and doing' thus making them remember for quite a long time. Farmers are convinced to adopt new technology as a result of discussing with other farmers and seeing their results. Erickson (2003) observed that SWC practices which were mostly adopted in Lushoto district in Tanzania were through demonstrations and field days.

4.6 Crop Yield Trends and Improvement

Table 10 indicates information on crop yield trends in Muheza district for a period of 10 years. Generally the results indicate gradual increase in yields of selected crops and milk suggesting improvement in soil productivity. This could be attributed to increased soil fertility due to reduction of soil erosion emanating from practicing soil erosion control measures. In any case, the observed increase in yields of the selected crops is far below potential yields. For example, potential yield of maize is 8 tons/ha (Msuya *et al.*, 2008) whereas that of cassava is 10 tons/ha (IITA, 2007) and beans is 2 tons/ha (AGRA, 2009).

This suggests that efforts should be intensified in terms of improvement of land productivity. Improvement strategies should include, but not limited to; reduction of soil erosion using various strategies as indicated before, application of animal manure, management of crop residues and practicing agro-forestry.

Table 10: Crop yields in Muheza district (tons/ha)

Crop/year	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08
maize	1.5	1.49	1.51	1.52	1.53	1.54	1.53	1.53	1.54	1.54
cassava	5	5.2	4.85	5.1	5.2	4.98	5.0	5.2	4.99	5.0
beans	1.0	0.9	0.85	1.0	1.2	0.8	0.9	1.0	0.95	1.0
cardamom	0.3	0.3	0.4	0.42	0.41	0.3	0.4	0.45	0.5	0.51
cloves	0.3	0.4	0.38	0.37	0.4	0.37	0.39	0.5	0.54	0.56
banana	10.0	10.1	10.2	10.5	10.0	10.6	10.7	10.5	10.6	10.7
black pepper	0.53	0.65	0.62	0.74	0.56	0.53	0.50	0.54	0.53	0.54
tea	1.35	1.13	1.3	0.81	0.81	1.43	1.4	1.42	1.4	1.38
oranges	9.3	9.4	9.5	10.0	9.3	8.9	8.8	8.9	9.1	9.3
Milk										
(Lt/cow/day)	5.5	6.0	6.5	7.0	6.5	7.5	7.0	8.0	8.5	8.0

Source: DALDO Muheza District (2008)

Results in Table 11 indicate that there was increase in yields following the introduction of SWC technologies. As stated earlier, the magnitude (after 10 years) is below potential yields. In any case, there is evidence that there is a long term benefit in terms of reduced soil erosion and increased land productivity. The observed increase in yields points to a possibility of increased household income and increased food security.

Other studies have showed significant increase in crop production when SWC technologies were implemented. Mariki (2004) found that minimum tillage (sub-soiled) improved maize productivity ranging between 4.7 to 5.5 ton/ha compared to conventional non-sub-soiled tillage ranging between 0.9 to 1.1 ton/ha. The study by van Roode (2002) also indicated that there is enormous potential to increase crop yields when SWC measures are implemented. Mwape *et al.* (2003) observed that water harvesting improved maize grain yield by 82% and up to 30% economic gain when compared with conventional systems. Results from the study by Reyes (2008) on the spice crops under agro-forestry system showed that intercropping cardamom and black pepper with *Grevillea spp* resulted to increased yields.

Table 11: Yield of selected crops grown before and after implementation of SWC technologies (after 10 years of implementation)

Type of crop Maize (ton/ha)	Crop yields in the study area					
	Msasa	Kisiwani	Misalai	Mbomole	Mlesa	Mashewa
Before	0.5 -0.75	0.75 - 1.2	0.5 - 0.8	0.75 -1.2	0.3 - 0.5	0.8 - 1.2
After	1.0 - 1.5	1.5 - 3.7	1.5 - 2.5	1.5 - 2.5	0.9 - 1.5	1.6 - 2.5
Beans						
Before	0.5	0.25 - 0.40	0.25 - 0.40	na	0.2 - 0.25	0.25 - 0.40
After	1	0.5 - 1.0	0.5 - 1.0	na	0.4 - 0.5	0.5 - 1.0
Sugarcane						
Before	3.0 - 4.0	2.0 - 3.0	4.0 - 5.0	3.0 - 5.0	5.0 - 6.0	0.7 - 1.0
After	6.0 - 8.0	4.0 - 6.0	8.0 - 10.0	6.0 - 10.0	10.0 - 12.0	1.4 - 2.0
Tea						
Before	1.0 - 1.5	na	2.0 - 3.0	1.5 - 2.0	1.0 - 1.5	na
After	3.0 - 4.0	na	4.0 - 6.0	3.0 - 4.0	2.0 - 3.0	na
Black pepper						
Before	na	0.2 - 0.3	na	na	na	0.25 - 0.5
After	na	0.4 - 0.6	na	na	na	0.7 - 1.25
Milk litres/cow/day						
Before	5	5	5	6	6	na
After	10	10	10	12	12	na

na = not applicable

Source: Villages Government records, Msasa, Kisiwani, Misalai, Mbomole, Mlesa and Mashewa (2008)

4.7 Field Visual Observations

Field visual observations were conducted in few selected farmers fields to confirm the SWC technologies implemented by farmers and growth vigour of crops under different technologies. Soil erosion control technologies observed in the fields included: contour strips planted with sugar cane, pineapples and fodder grass, agro-forestry with indigenous and exotic tree species such as *Grevellia spp.*, crops planted in rows across the slopes and fields in which manure was applied. Different contour plants were planted for the purpose of reducing the speed of run-off water and stop the movement of soil down the slope. Plate 4 indicates fields planted with contour strips and agro-forestry.



Plate 4: Fields with contour strips and agroforestry in Kisiwani village

Generally visual observations indicated that crops in the fields where soil erosion control technologies were introduced are doing better in terms of vigour as compared with fields where SWC practices were not carried out. Crop patterns were well maintained at recommended spacing and crops were planted on micro-contours which followed macro-contour-lines.

Visual observation were consistent with previous results which indicated that crop performance where SWC technologies were practiced was much better compared to where

they were not practiced. Ngatunga (2006) reported that construction of water barriers such as cut-off drains, live fences, agro-forestry and use of manure improved agricultural productivity in Lushoto district. Mlipha (2005) observed that conservation tillage resulted into sustainable production of food. The study by Reyes (2008) revealed that application of manure to cardamom in East Usambara highlands resulted into an increase in crop yield twice as much compared to fields where manure was not amended.

4.8 Assessment of Food Security Situation

4.8.1 Dietary situation at household level

Results in Table 12 indicate that about 75% of the households have improved their diet following increase in crop production hence improved food situation after introduction of SWC practices in the study area. Discussion with farmers revealed that due to improvement in land productivity most farmers were able to grow diverse types of crops including keeping dairy cattle. Under this situation it is expected that dietary situation at household level will improve.

Table 12: Dietary improvement at household level after implementation of soil erosion control technologies

Nutritional level	Msasa n = 40	Kisiwani n = 40	Misalai n = 40	Mbomole n = 40	Mlesa n = 40	Mashewa n = 40	Average n = 240
(%).....						
Very good	9.1	33.3	0.0	13.6	0.0	0.0	9.3
Good	47.7	60.6	91.3	63.6	80.0	53.9	66.2
Satisfactory	38.6	6.1	8.7	22.7	20.0	38.5	22.4
Un-satisfactory	4.6	0.0	0.0	0.0	0.0	7.7	2.1

Phiri *et al.* (2006) observed that development of appropriate SWC technologies lead to an increase in availability and quality of food. According to Kennedy and Bouis (1993) nutrition security refers to access to a nutritionally adequate diet. Food and nutrition security are based on the key determinants; availability, accessibility and utilization. Munir *et al.* (2007) concluded that nutrition security is only effective when there is adequate utilization of dietary.

4.8.2 Number of meals taken per day

Results in Table 13 indicate that most of the households in the study area (92%) are capable of taking three meals per day. These results are consistent with the earlier ones (Table 11 and 12) which suggest that there was increase in crop production. The results are also in line with those of Rosegrant *et al.* (2005) who observed that availability of sufficient food for all people can be achieved through improvement in crop production because there is a direct relationship between food availability and consumption.

Table 13: Number of meals taken per day after implementation of SWC technologies

Number of meals	Msasa n = 40	Kisiwani n = 40	Misalai n = 40	Mbomole n = 40	Mlesa n = 40	Mashewa n = 40	Average n = 240
%.....						
Above three	9.1	0.0	0.0	0.0	0.0	0.0	1.5
Three	86.4	97.0	95.7	86.4	86.7	100.0	92.0
Two	4.6	3.0	4.3	13.6	13.3	0.0	6.5

Gebremedhin (2000) indicated that food and nutrition security indicators refers to how much food is available for a household, number of meals eaten daily, diet diversity and general appearance of an individual. The Muheza district reports (DALDO, 2001; 2003)

indicated that the study area produce sufficient food hence does not receive relief food compared to other areas in the district. According to FAO (2003) a household is considered food secure when its occupants do not live in hunger or fear of starvation. Families with the financial resources to escape extreme poverty rarely suffer from chronic hunger, while poor families not only suffer the most from chronic hunger, but are also the segment of the population most at risk during food shortages and famine.

4.8.3 Periods of food insecurity

Results in Table 14 indicate that about 48% of households are food insecure for less than three months in the year. About 10% of households are food insecure for 4 to 6 months whereas about 3% of households are food insecure for more than six months in a year.

Generally, the results indicate that a significant proportion of households (87.5%) are food secure for most time of the year. The results are in agreement with those indicated in Tables 11, 12 and 13. According to URT (2004) the key indicators of rural poverty include insufficient food and vulnerability to famine where about 30% of the population in rural areas are food insecure for more than four months every year.

Table 14: Periods in months with food insecurity

Months	Msasa n = 40	Kisiwani n = 40	Misalai n = 40	Mbomole n = 40	Mlesa n = 40	Mashewa n = 40	Average n =240
.....%							
> 6	6.8	0	0	9.1	0	0	2.7
4 to 6	13.6	9.1	8.7	27.3	0	0	9.8
< 3	59.1	57.6	34.8	36.4	33.3	69.2	48.4
Sufficient	20.5	33.3	56.5	27.2	66.7	30.8	39.1

Food insecurity leads to nutrition insecurity (malnutrition) because the amount and quality of nutrient required for effective body function is limited (FAO, 2005). Households that are more likely to experience food insecurity are female headed ones with children, those

with income below the poverty line. There is therefore a need to improve household's nutrition and health in food security management activities.

4.8.4 Coping strategies used by farmers to overcome food shortages

Different coping strategies used by farmers were identified. These include buying supplemental food, planting tolerant crops, reducing the number of meals per day and food storage. Perception of food crops is used as a coping strategy whereby farmers eat food which is available rather than food which they were used to eat, for example eating cassava instead of maize.

Results in Table 15 indicate that most households (51.3%) buy food to supplement whatever little is obtained from their fields, whereas 20% of households plant drought tolerant crops such as cassava, yams and sweet potatoes. Only 1.3% use reserve food. Very small proportion (0.4%) is forced to reduce number of meals taken per day. About 27% of households are food self sufficient throughout the year.

Table 15: Coping strategies to overcome food shortage

Strategies used	Name of villages						
	Msasa n = 40	Kisiwani n = 40	Misalai n = 40	Mbomole n = 40	Mlesa n = 40	Mashewa n = 40	Average n = 240
(%).....						
Buy food	59.1	42.4	60.9	72.7	26.7	46.2	51.3
Plant drought tolerant crops	25.0	39.4	8.7	4.6	20.0	23.1	20.1
Reduce meals	2.3	0.0	0.0	0.0	0.0	0.0	0.4
Store food (reserve)	0.0	0.0	0.0	0.0	0.0	7.7	1.3
Self sufficient	13.6	18.2	30.4	22.7	53.3	23.0	26.9

Generally, the results suggest that significant proportion of farmers in the study area do not face acute food shortage pointing to the possibility of enhanced food security. This is consistence with the previous results (Table 13 and 14) which indicated that farmers in the

study area are food secure. Mazur *et al.* (2007) observed that farmers use different coping strategies in response to food shortages. ESRF (2002) reported that farmers in Singida district involved in off-farm activities in order to get money to purchase food. They also found that most of the poorer farmers are involved in casual labour on farms as a way of survival. Yanda *et al.* (2001) observed that major expenditure of income was for purchasing food during critical period of food shortages.

4.9 Indicators of Household Income Improvement after Implementation of SWC

Practices

Results in Table 16 show some indicators of improved household income following implementation of SWC practices. Generally, the results suggest that most of the households were capable of investing into some basic activities such as construction of modern houses, paying for school fees for their children and hiring labour.

Table 16: Households income investments after implementation of SWC technologies

Households assets	Number of respondents	Percent
Constructed modern houses	93	39
Capable of paying school fees	88	36
Hiring labour	26	11
Capital for other enterprises	3	1
Others	2	1
Not applicable	28	12
Total	240	100

Brown and Funk (2008) observed that increased agricultural productivity enables farmers to grow more food crops, which translate into better diets and higher farm incomes. They also observed that with more money, farmers are more likely to diversify production and grow higher-value crops. Shiferaw and Bantilan (2004) observed that improved SWC practices will not only improve food security directly but also enhance farmer's income. In many instances, food is available but people lack the income and access to food.

Improving farmer's income will enable them to buy more food to feed many people affected by hunger and malnutrition. Delang (2006) suggested that there is high potential and need for increasing output and productivity through improved agricultural practices. Implementation of improved SWC measures is critical for the achievement and sustenance of food security.

Flora (2006) observed that income security is achieved when there is assurance or high degree of likelihood or receiving income at an adequate level on a regular basis that is needed to pay for basic life necessities. Farmers without adequate and regular income tend to work as casual labourers and leave their farms which leads to vicious circle of poverty. According to de Villiers (2006) improved SWC measures will enable smallholders to exploit comparable advantage and thus change from subsistence to commercial profitable systems. Lobell *et al.* (2008) observed that reducing hunger is characterized by rapid economic growth and especially rapid growth in agricultural sector. Addressing agriculture is a vital to achieving food security. Increasing agricultural productivity is a key to increased income and reduced food insecurity.

4.10 Correlation Between SWC Technologies, Income, Crop Yield and Food Security

Results in Table 17 indicate that there is a correlation between SWC technologies, income, crop yields and food security. The introduced SWC technologies significantly ($P < 0.001$) correlated with average income, whereas crop yields significantly ($P < 0.001$) correlated with average annual income and household income improvement/investment. The findings are consistent with those indicated in Tables 10 and 11 which indicated that there was increase in crop yields and food security following introduction of SWC technologies.

Table 17: Correlation between SWC technologies, income, crop yields and food security

Variables		Average annual income	SWC tech	HH income improvement	Number of meals	Crop yield
Average annual income	Pearson Correlation		0.234**			0.357**
	Sig. (2-tailed)		*	0.336***	0.021 ns	*
	N		0.004	0.000	0.797	0.000
SWC technologies	Pearson Correlation					
	Sig. (2-tailed)			0.283***	0.045 ns	0.034 ns
	N		240	240	240	240.
HH income improvement	Pearson Correlation					0.389**
	Sig. (2-tailed)				0.098 ns	*
	N				0.232	0.000
Number of meals	Pearson Correlation					
	Sig. (2-tailed)					0.058 ns
	N				240	240.
Crop yield	Pearson Correlation					
	Sig. (2-tailed)					0.483
	N					240.

***Correlation is significant at 0.001 levels (2-tailed).

ns = not significant

The results indicate that SWC practices had an impact on average annual income and household investment. AgREN (2000) observed that the decision to invest in SWC measures relates both to the assets available to households and the attractiveness of agricultural intensification as a livelihood strategy. Adoption of SWC practices represents a decision by households to intensify their agricultural production. This will result into improve output per unit area through capital investment or an increase in labour inputs.

Hatibu (2003) observed that innovations and technologies for small holder farmers are designed in order to promote food security at household's level through increased incomes and purchasing power. Improved SWC technologies leads to higher yields hence improved household food security. von Braun *et al.* (2004) concluded that there are strong and direct relationships between agricultural productivity, income and food security.

4.11 Farmers Suggestions on the Improvement of Implementation of SWC

Technologies

Several suggestions were given by farmers which aimed at improving implementation of SWC technologies. These were availability of extension services, availability and use of agricultural inputs, training and availability of credit facilities. Results in Table 18 indicate that about 34% of average households suggested that provision of extension services through village extension workers will improve the situation. Training of farmers through seminars, farmer's field schools and study tours were suggested by 36.6% of the average households. Other suggestions are indicated in Table 18.

Table 18: Farmers suggestions regarding improvement of the implementation of soil erosion control technologies

Suggestion from farmers	Msasa n = 40	Kisiwani n = 40	Misalai n = 40	Mbomole n = 40	Mlesa n = 40	Mashewa n = 40	Average n = 240
.....(%).....							
Availability of extension service	47.7	33.3	39.1	54.6	13.3	15.4	33.9
Availability& use of inputs	4.6	0.0	17.4	31.8	40.0	7.7	16.9
Training	22.7	51.5	34.8	9.1	40.0	61.5	36.6
Availability of credits	25.0	12.1	8.7	4.6	0.0	15.4	11.0
No suggestion	0.0	3.0	0.0	0.0	6.7	0.0	1.6

The results imply that farmers were ready to implement different technologies if they get external support in terms of extension services, training, inputs and credit facilities. Extension services are necessary for dissemination of new innovations and technologies to the farmers. FAO (2002) observed that availability of extension personnel is the most effective and efficient way of diffusing, assimilating and absorbing improved agricultural technologies for increased production, productivity and food security. Increasing agricultural productivity is also highly related with the availability and use of agricultural inputs such as fertilizers, pesticides, improved seeds and water for irrigation (Brown and Funk, 2008).

Farmers' training is one of the most effective for dissemination of technologies. Inadequate access to capital and credit facilities is commonly considered as a major constraint for increased household production and income (Dolan, 2006).

5.0 CONCLUSION AND RECOMMENDATIONS

The objective of this study was to assess the impact of the introduced soil erosion control technologies on household food security and income. Results indicated that technologies that were introduced in the study were agro-forestry, contour farming, planting crops in rows across the slope, manure application and deep tillage. Significant proportion of farmers (56%) implemented contour farming compared to other technologies. This was due to the multiple benefits that farmers get apart from soil erosion control per-se.

Results also indicated that effective dissemination methods such as group discussions, demonstrations and field days were used during introduction of the technologies. There was an increase in crop yields and household income following introduction of the SWC technologies. Results further indicated that most farmers in the study area (87.5%) are food secure for most time of the year. The introduced SWC technologies significantly ($P < 0.001$) correlated with household income and crop yields.

Based on the study findings the following recommendations are pertinent:

Introduction of technological packages to farmers should be based on farmer's conditions, knowledge and preference. This will contribute to high adoption of technologies. The introduced technologies should be productivity-enhancing and conservation-effective. This will result into sustainable agricultural production hence improved household food security and income.

Farmers and other stakeholders should be involved in all stages of the project. These stages include problem identification, planning, implementation, monitoring and evaluation. Involvement of farmers in all project stages will enhance awareness, empowerment and ownership of the project.

Extension services should be improved for effective dissemination of agricultural technologies.

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APPENDICES**Appendix 1: Questionnaire for household head****BACKGROUND INFORMATION**

Name of the interviewer.....

Date of interview.....

Respondent's number.....

Name of village.....

Name of ward.....

Name of division.....

Name of district.....

SECTION A**HOUSEHOLD CHARACTERISTICS**

1) What is your age?years

2) Sex of household head (tick)

a) Female b) Male

3) Educational level of household head (tick)

a) No formal education b) Primary school c) Secondary school d) Tertiary

4) Marital status of household head (tick)

a) Not married b) Married c) Divorced/separated d) Widowed

5) What is your family size (tick)

a) 1-2 b) 3-5 c) 6-9 d) > 10

SECTION B**FARM CHARACTERISTICS**

6) What is your total farm size? (tick)

- a) < 0.5 ha b) 0.6 - 1 ha c) 1.1 - 2 ha d) > 2 ha

7) How far is your farm from homestead? (tick)

- a) < 0.5 km b) 1 km c) 2 km d) 3 km and above

8) Do you own land (tick)

- a) Yes b) No

9) If No how do you get land for farm activities (tick)

- a) borrowing b) hiring c) others (specify)

10) What is the source of labour force (tick)

- a) Family b) Casual labour c) Labour in kind d) Others (specify)

11) How many household members are involved in farm activities? (tick)

- a) 1-2 b) 2.- 3 c) 4-6 d) > 7

12) Who decides on the use of farm products? (tick)

- a) Household head b) Family

SECTION C**ECONOMIC ACTIVITIES**

13) Are you keeping livestock? (tick)

- a) Yes b) No

14) If Yes how many? (fill the numbers)

a) Cows.....

b) Goats.....

c) Sheep.....

d) Chicken.....

e) Others (specify).....

15) Are you involved in off-farm activities? (tick)

a) Yes b) No

16) If Yes mention them

a)

b)

c)

d)

17) Is the income from off-farm activities used for soil erosion control? (tick)

a) Yes b) No

18) Are you receiving money from relatives (remittances)?

a) Yes b) No

19) Are you using remittances to invest in soil and water conservation practices? (tick)

a) Yes b) No

20) What is your average annual income? (tick)

a) Tshs 200 000 – 400 000

b) Tshs. 401 000 – 500 000

c) Tshs 501 000 – 700 000

d) Tshs. 701 000 -1 000 000

e) Tshs above 1 000 000

SECTION D**INSTITUTIONAL FACTORS**

21) Are you getting extension services/advice on soil and water conservation from the extension agents/workers? (tick)

- a) Yes b) No

22) What is the source of information?

- a) extension agents
- b) NGOs/CBOs
- c) village leaders
- d) others (specify)

23) What is your assessment about the level of the extension services that you received?

- a) Very high b) High c) Moderate d) Low e) Very low

SECTION E**TECHNOLOGICAL INFORMATION**

24) Are you aware of SWC technologies introduced in the village?

- a) Yes b) No

25) If Yes, what is your assessment about the level of your awareness?

- a) High b) Moderate c) Low d) Very low

26) How did you get the information about soil erosion control technologies? If different methods were used rank them according to importance (tick).

- a) From your neighbours
- b) Extension officer

- c) Study tours
- d) Field days
- e) Leaflets/reading materials
- f) Others (specify)

27) What soil erosion control technologies exist in the village? Mention them according to your preference.

- a)
- b)
- c)
- d)
- e)

28) Which soil conservation technologies are easy to implement? Mention them according to easiness.

- a)
- b)
- c)
- d)
- e)

29) How were the soil erosion control technologies introduced? Mention the approaches that were used according to preference. (tick)

- a) Village general meetings/group discussions
- b) Seminars/workshops
- c) Advice from extension officers
- d) Demonstration plots

e) Field days

f) Others (specify).....

SECTION F

AGRICULTURAL PRODUCTIVITY

29) What were the yields of crops before implementation of soil erosion control technologies?

a) maize (bags per acre)

b) beans (bags per acre).....

c) milk (litres/cow/day)

d) other crops (specify).....

30) What were the yields of crops after implementation of soil erosion control technologies?

a) maize (bags per acre).....

b) beans (bags per acre).....

c) milk (litres/cow/day).....

d) other crops (specify).....

SECTION G

FOOD SECURITY AND INCOME

31) What are the improvements on household food security? (Nutritional level) (tick)

a) very good b) good c) satisfactory d) un-satisfactory

32) Number of meals per day after implementation of SWC practices (tick)

a) above three b) three c) two d) less than two

33) Period (in months) of food insecurity during the year after practicing SWC (tick)

- a) above 6 months b) 4-6 months c) less than 3 months d) self sufficient throughout the year

34) Was the household income improved after implementation of soil erosion control technologies? (tick)

Possible indicators are:

- a) Construction of modern houses
- b) Paying school fees
- c) Hiring labour
- d) Capital for other enterprises
- e) Others (specify).....

SECTION H

FARMERS SUGGESTIONS

37) What should be done to improve implementation rate?

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THANK YOU FOR YOUR COOPERATION

Appendix 2: Checklist Questions for Focus Group Discussion

- 1) Are you aware of the introduced soil erosion control technologies by different projects?
- 2) Which soil erosion control technologies were introduced in the village?
- 3) What were the most preferred technologies?
- 4) Which approaches were used to introduce soil erosion control technologies?
- 5) What were the reasons for some farmers not implementing some of the technologies?
- 6) What are the benefits of soil erosion control technologies in terms of crop production and income?
- 7) What is the real situation on household food security for those farmers who implemented soil erosion control technologies?
- 8) What is the status of extension service delivery in the village?
- 9) What should be done to improve implementation of soil and water conservation?

THANK YOU FOR YOUR COOPERATION