FARMERS' RESPONSE TO CATCHMENT MANAGEMENT TECHNOLOGIES: A CASE OF TENDE AND KIBUON CATCHMENTS IN SOUTH WEST, KENYA

MULWALE ATHANASA CATHERINE

Previous Degrees:

Bachelor of Science in Agriculture and Human Ecology Extension

Egerton University-Kenya

Master of Science in Community Studies and Extension

Egerton University- Kenya

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Kisii University, Kenya

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Mulwale Athanasa Catherine _DAN/50032/15_Sign.________________Date______

RECOMMENDATION

This thesis has been submitted for examination with approval as University supervisors

Prof. Samson Maobe

Department of Agricultural Education and Extension,

Kisii University

___________________________ Sign.__________________ Date_____________

Dr. Washington Adede Ochola

Department of Agricultural Education and Extension

Kisii University

___________________________ Sign.____________________ Date___________

Prof. Evans Basweti

Department of Agricultural Education and Extension

Kisii University

___________________________ Sign.__________________ Date___________

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DEDICATION

I dedicate this thesis to my late parents: Athanasa Mulwale and Colleta Ilahalwa Mulwale for laying a strong foundation for my education, my husband Konariko Pamphil Mayabi and my children: Manfred Makhanga Mayabi, Georginah Khati Mayabi and Gregory Stower Mayabi for providing a suitable environment to study and my dear brother and sisters for their prayers and encouragement in the course of the study.

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ABSTRACT

Globally catchment degradation has become the most serious form of natural resource degradation which impacts negatively on environment, food security and nutrition. Integrated Land and Water Management Project in Kibuon and Tende (ILWMKTP) was implemented in the study area from 2009 to 2014 and focused on improvement of land productivity and water quantity by using soil and water conservation technologies. The study determined farmers' response on catchment management technologies disseminated during project implementation. This research was crucial since it established the level of technology uptake in the catchments. The study was conducted in Homa Bay, Nyamira and Kisii Counties which were selected purposively since they implemented ILWMKTP project. This study was an *ex post facto* research design that adopted cross sectional survey approach and combined qualitative and quantitative data collection procedures to gather data from farmers and staff who implemented the programme. Farmers in the catchments practice mixed farming by rearing livestock and growing of maize, fruits, vegetables and legumes. Target and accessible populations were 9,475 and 370 farmers respectively selected proportionately through simple random sampling procedures. Interview schedule, a questionnaire and a research test were used in data collection. The research test developed was used to collect data on farmers' attitude towards catchment management technologies. Data collected was analyzed using SPSS through which descriptive and inferential statistics were used. There was a significant difference in the level of erosion before and after project implementation for example T-test on rill erosion before (M =4.37, SD = 0.654) and after (M = 3.511, SD = 1.151) t (369) = 12.442, p = 0.000. Farmers had different levels of knowledge, skills and attitude on technologies for example knowledge on use of cover crops, Kibuon K2 reported more (3.74 mean) compared to Mogusii T3 which had a mean of 3.15. Kibuon K1 reported a higher mean (2.93) on technology uptake compared to Isanta T2 which had a mean of 2.23. Data aggregation on use of integrated project extension approach in dissemination indicated more use of technologies not used before project implementation for example terraces had 1539 scores before and 1051 scores after. The research findings indicated more degradation before project implementation in the two catchments. Farmers had different levels of knowledge, skills and attitude on catchment management technologies. They constructed different numbers of technologies based on their knowledge, skills and attitude. Implementation of integrated project extension approach in disseminating different catchment management technologies was at different levels of implementation. Farmers needed more sensitization on catchment degradation to accept it as a critical problem. There was need for continuous farmers' trainings to enhance technology uptake in the catchments.

TABLE OF CONTENTS

CHAPTER FIVE

APPENDICES

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ANOVA:	Analysis of variance
Dr.:	Doctor
Fig.:	Figure
Kibuon K1:	Kibuon Sub catchment
Kibuon K2:	Kabondo Sub catchment
Kasipul K3:	Kasipul Sub catchment
Mt:	Metric tons
Pop. :	Population
Prof.:	Professor
Sig.:	Significant
Tende T1:	Tende 1 Sub catchment
Isanta T2:	Isanta Sub catchment
Tende T3:	Mogusii Sub catchment

LIST OF ACRONYMS

ABCG: Africa Biodiversity Collaborative Group

AWF: African Water Facility

CBO: Community Based Organization

CGIAR: Consultative Group on International Agricultural Research

FAO: Food and Agriculture Organization

GoK: Government of Kenya

H_0: Null hypothesis

ILWMKTP: Kibuon and Tende Integrated Land and Water Management Project

KALRO: Kenya Agriculture and Livestock Research Organization

KEFRI: Kenya Forest Research Institute

KEMFRI: Kenya Marine and Fisheries Research Institute

KOSFIP: Kimira-Oluch Smallholder Farm Improvement Project

NACOSTI: National Commission of Science and Technology Institute

OECD: Organization for Economic Cooperation and Development

SIDA: Swedish International Development Agency

TSS: Total Suspended Solids

WRUA: Water Resource Users Association

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Kenya is one of the Countries which have used a lot of resources to reduce catchment degradation. Through soil conservation programme, the Country was supported by Swedish International Development Agency (SIDA) to control degradation in the whole Country through catchment approach. The project was successful although later some technologies were abandoned in some catchments. This study was conducted in Kibuon and Tende catchments to examine farmers' response to catchment management technologies which were disseminated during implementation of Integrated Land and Water Management project. Catchment degradation is expanding affecting more than 20 percent of agricultural land, 30 percent of forest cover and 10 percent of grassland World -wide (Tamene, IKindu, Woldearegay & Aberra, 2014). Further it affects between 20 to 50 percent of land in Sub Saharan Africa occupied by 200 million people.

High population in the upper parts of Kibuon and Tende catchments contributed to intensive agricultural practices in hilly areas resulting in degradation. Across the world, economies are expanding, towns and improved services are spreading and growing populations are enjoying good standards of living in towns (Lenton & Muller, 2009). Further, farmers in the rural areas grow food for domestic and commercial purposes at the expense of the natural resources leading to exploitation of soil and water, causing catchment degradation. There was more degradation in Kibuon and Tende catchments where land was prepared with less regard to sustainable methods of land preparation and less use of soil conservation technologies. Water and soil are important natural resources for agricultural production which are critical in economic growth of any country (Heiner, Shames & Spiegel, 2016). Charcoal burning and brick making contributed to degradation in Kibuon and Tende Catchments. Social and economic activities by man have transformed half of the Earth's land surface making it susceptible to degradation (Hill, 2010). Due to catchment degradation in Kibuon and Tende catchments farmers were not able to realize land potential in terms of productivity. Catchment degradation has emerged as the most critical example of natural resource degradation impacting negatively on environment and socio-economic issues (Atnafe, Ahmed & Adane, 2015). Land productivity in some parts of Kenya is adversely affected by catchment degradation. Although World- wide, degradation is more common in developing countries (Mesfin, 2010; Desalegna , Erkosa & Prabha, 2012).

Soil erosion was a major cause of catchment degradation in Kibuon and Tende catchments. Degradation in other countries is caused by sedimentation of water courses, reservoirs, flash floods and reduced water quality (Darghouth, Ward, Gambarelli, Styger & Roux, 2008; Widomski, 2009; Adugna & Desta, 2012). Catchment management technologies have been piloted in many countries in the World as best solutions to water resource challenges but the uptake has been low in most catchments. Their implementation has not been successful in many areas due to various constraints encountered during implementation (Wamalwa, 2009).

Kibuon and Tende catchments are located on Eastern side of Lake Victoria in South West Kenya. They were characterized by soil and water degradation which resulted in reduced water base flow and productivity. Benefits of catchment management in any part of the world cannot be overstated. For that reason, an Integrated Land and water Management Project in Tende and Kibuon catchments was initiated and funded by African Development Bank (ADB) from 2009 to 2014 through African Water Facility to reduce degradation in the catchments. The project also aimed at increasing land productivity and improving water quality and quantity for the households living in the catchments. The two rivers originate in the highlands of Nyamira and Kisii Counties, and flow through Homa Bay County eventually draining into Lake Victoria.

The agricultural extension programme planning and implementation method used an Integrated Project Extension Approach in implementation of Integrated Land and Water Management Project (ILWMKTP) in Kibuon and Tende to promote catchment management technologies in the catchments. The approach is participatory, capital intensive intervention implemented within a time frame to achieve specific objectives. The approach uses demonstration method to disseminate technologies on farmers' farms. The farmers are supported to implement and encouraged to convince their neighbours to also implement those technologies and continue using them even at the end of the project. It is the most suitable approach for soil and water conservation measures among smallholder farmers who are not able to commit their limited resources to long term goals. Five years later, there was need to determine farmers' response to catchment management technologies which were disseminated in Kibuon and Tende catchments to assess the level of improvement in degradation. The improvement was expected to reflect in improved productivity and water base flow contributing to enhanced economic empowerment which was the goal for ILWMKTP project.

1.2 Statement of the Problem

Healthy catchments are important for conservation of water resources and if well managed they provide enough water for agriculture, industrial and domestic use. Declining farm productivity due to degradation needs to be reversed through widespread practice of technologies. Integrated Land and Water Management in Kibuon and Tende project used Integrated Project Extension Approach to disseminate catchment management technologies in the basins to control degradation. Despite the interventions, degradation was still evident, technology uptake was low hence the study.

1.3 Justification of the Study

Research findings were expected to contribute to new knowledge in management of catchment degradation. A strategy was developed on enhancing utilization of integrated project management approach in dissemination of catchment management technologies. It would inform resource allocation by policy makers in management of catchments and serve as a reference for investment in environmental protection. Well managed catchments contribute to improved livelihoods of the community through increased productivity enhanced by provision of adequate water for agriculture and domestic use. Eucalyptus tree planted in riparian areas would be replaced gradually with suitable agroforestry trees while intensive agricultural production in upper sub catchments would be done sustainably. Data generated may also be used by scholars.

1.4 Purpose of the Study

The study determined farmers' response to catchment management technologies in Kibuon and Tende catchments which were expected to improve land productivity and water quantity.

1.5 Objectives of the Study

Objectives of the study were to evaluate:

i. the level of degradation in Kibuon and Tende catchments before and after the project
ii. the knowledge, skills, and attitude of farmers on selected catchment management technologies promoted in the catchments.
iii. the level of uptake of selected catchment management technologies in Kibuon and Tende catchments.
iv. the level of implementation of integrated project extension approach in disseminating selected catchment management technologies to reduce catchment degradation.

1.6 Hypotheses of the Study

H_{01} There is no statistically significant difference in the level of degradation in Kibuon and Tende catchments before and after the project

H_{02} There is no statistically significant difference in knowledge, skills, and attitude of farmers on selected catchment management technologies promoted in the catchments

H_{03} There is no statistically significant difference in the level of uptake of selected catchment management technologies in Kibuon and Tende catchments

H_{04} There is no statistically significant difference in the level of implementation of Integrated project extension approach in disseminating selected catchment management technologies to reduce catchment degradation

1.7 Assumptions of the Study

The study assumed that respondents implemented the catchment management technologies which were used during the ILWMKTP project in the Kibuon and Tende catchments.

1.8 Scope of the Study

The study focused on farmers' response to catchment management technologies used in Kibuon and Tende catchments located in Homa Bay, Kisii and Nyamira Counties. It sought to develop a strategy to enhance uptake of catchment management technologies in the catchments by determining: the level of degradation in the catchment before and after project and determine the level of knowledge, skills and attitude of farmers on catchments management technologies promoted in the catchments. The levels of uptake of selected catchment management technologies in the catchments and implementation of Integrated Project Extension Approach in disseminating selected catchment management technologies in reducing degradation in Kibuon and Tende catchments were determined through the study.

1.9 Limitation of the Study

The research was limited to recall information on implementation of catchment management technologies during project implementation from respondents and key informants. Data collected was analyzed and triangulated to avoid errors. The study was also limited to physical and biological technologies that were used in catchment management in the study area. The study ensured that only data on biological and physical technologies was collected.

1.10 Definition of Terms

Introduction

For the purposes of this study the following definition of terms applied:

Basin:

A basin is depression on the earth's surface in which all water that flows through it drains out in one outlet (Wani, 2010). In the context of this study the area surrounding Kibuon and Tende rivers and drains its surface water to these two rivers were considered as a basin. Therefore the study covered the basins of the two rivers.

Catchment:

It is the area that supplies water by surface or sub surface flow to a given drainage system or body of water, be it a stream, river, lake or ocean (Darghouth, et al., 2008; Benham, Yagow, Chaubey & Douglas-Mankin, 2011). In the context of this study, Kibuon and Tende catchments were areas surrounding the two rivers. The catchments run through Nyamira, Kisii, and Homa Bay Counties and had 1,884,000 at the time of the study.

Complex Technology:

This is a soil and water conservation technology which most farmers lack awareness on its technical skills needed for its implementation (Asnake & Elias, 2017). In the context of this survey, these are technologies which required more time, knowledge, skills and resources to establish for example retention ditches and cut off drains.

Land Degradation:

It is the reduction in capacity of the land to produce benefits from a particular land use under specific form of management (Desalegna, Erkosa & Prabha, 2012). In the context of this study degraded land was a farm that had any of the following conditions; most of the top soil eroded, presence of rills, gullies and poor or sparse vegetation cover and low productivity.

Water turbidity:

It is water with pollutants arising from soil erosion, over-grazing, deforestation and intensive agricultural activities in catchments (Koundouri, 2003). In the context of this study, water turbidity referred to water in Kibuon and Tende rivers loaded with silt.

Catchment Degradation:

It is reduction in potential of land and water in a catchment to produce goods and services which may be temporary or permanent (Newby & Cramb, 2007). In the context of this research, catchment degradation was viewed in terms of low yields in maize, milk and forage, low quantity and quality of water in the two rivers, presence of soil erosion, inadequate terraces, less vegetation cover and inadequate agroforestry practiced by farmers.

Catchment Rehabilitation:

It is an integration of technologies within the boundaries of drainage areas for the optimum development of land, water, and plant resources to meet the basic needs of people sustainably (Wani, 2010; Benham, Yagow, Chaubey & Mankin, 2011). In the context of this study, it is an integration of soil conservation technologies implemented to reduce catchment degradation. Therefore study looked at the ways in which farmers managed catchment degradation through use of soil and water conservation technologies.

Catchment Management Technologies:

These are techniques used in soil and water conservation and sustainable land use forms (Atnafe et al., 2015). In the context of this research, the following technologies were considered; terraces check dams, grass strips established, cover crops, vegetation cover and agroforestry trees planted.

Integrated Project Extension Approach:

This is an approach in which resources from outside a catchment are concentrated in a location for a specific period (Ponniah, Ranjitha, Workneh, & Hoekstra, 2008). In the context of this study it considered soil and water conservation technologies that were disseminated to farmers through integrated project extension approach which embraces demonstrations on farms as a method of dissemination.

Participatory Extension Approach

This approach focuses on farmers group needs with a purpose of increasing food production at household level and improved quality of rural life for community members (Ochola, Maobe, & Basweti, 2017)**.** This study adopted the definition.

Farming System Extension Approach

The approach uses holistic approach at the local level by being close to research stations and developing technologies that address local constraints. Its success is measured by the extent to which people in the location adopt the technologies developed (Kromah, 2016)**.** This research adopted the definition.

Conventional Extension Approach:

According to Bunyatta, Onyango and Kibett, (2016) it is a service provision in which technologies are generated in research (KALRO) and transferred through Ministry of Agriculture extension services to farmers and utilizes top down trainer of trainees model. In the context of this study, it is a Ministry of Agriculture operated extension service which existed before introduction of integrated project based extension in the study locations of Kibuon and Tende catchments.

Diffusion:

According to Rogers and Shoemaker (1971), diffusion is a process of spreading of a new idea from source to its ultimate users or adopters. In the context of this research diffusion meant the spread of soil and water conservation technologies which were disseminated in Kibuon and Tende catchments through integrated project extension approach and spread amongst the farmers within the research area and beyond while dissemination means passing of agricultural technologies to users.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

This study explored literature on the uptake of selected catchment management technologies aimed at controlling catchment degradation globally, in the tropics and in Kenya. The technologies included terraces, grass strips, retention ditches, check dams, cover crops, contour ploughing and agroforestry practices. The researcher reviewed literature on level of degradation within Kibuon and Tende catchments before and after project implementation, Knowledge, skills, and attitude of farmers on catchment management technologies promoted in the catchments and the level of uptake of selected catchment management technologies in the study area. Additionally literature was sought on level of implementation of integrated project extension approach in dissemination of different catchment technologies. Both primary and secondary data was used in the study in Kibuon and Tende catchments.

2.2 Global Degradation of Catchments

Water is a critical resource in development and prosperity of any nation. Its scarcity and deterioration in quality hampers expansion of economic activities especially in least developed countries. Globally, fresh water resources are affected by increasing pressure due to competition from population growth, increased economic activities and improved living standards through economic empowerment (Gunya, 2009). There was over use of catchment resources to meet the needs of the high population in the upper parts of Kibuon and Tende catchments. The agricultural activities were extended into the hills which were not suitable for farming. In recent decades catchments in many parts of the world have emerged the most adversely affected natural degraded resource with negative environmental and socio-economic effects especially in developing countries (Darghouth et al., 2008). Many developing countries in the world are increasing their attention on catchment management due to being susceptible to food insecurity. India spends US$ 500 million on catchment management projects every year and water resources are already scarce in Tunisia, Kenya, Rwanda, Burundi, Algeria, Somalia and by 2025 they will be joined by Morocco, Egypt, Comoros and Ethiopia (Swallow, Onyango & Meinzen-dick, 2008). Owing to negative effects of degradation to the environment, Florida developed a Catchment Restoration Framework to address the holistic, eco-system based approach and incorporate its long standing water protection programmes through Florida Catchment Restoration Act (Graham, Jain, & Mathews, 2010).

Catchment degradation affected land productivity contributing to food insecurity in Kibuon and Tende catchments. Wide spread degradation and scarcity of land resources have affected negatively many food production systems around the globe causing a big challenge to feeding a world population expected to reach 9 billion people by 2050 (Manuelli, Hofer, & Vita, 2014). Degradation in Kibuon and Tende catchments contributed less vegetation cover in the lower parts of the catchments which resulted in lower productivity. Lake Cocibolca catchment in Nicaragua is a home to biodiversity and important to global and local environment including 750,000 people living in its boundaries. The catchment has lost most of its forests due to increased agriculture exposing its delicate soils to erosion contributing to high sedimentation loads in the lake thereby reducing water volume and quality (Klytchnikova, Cestti, Escurra & Pagiola, 2013).

Soil erosion was a major source of catchment degradation in Kibuon and Tende which reduced water quantities and quality in both catchments. Soil erosion is a wide spread form of soil degradation contributing to catchments degradation and poses threats to food production (Blinkov, Kostadinov & Marinov, 2013). Soil conservation technologies were implemented in Kibuon and Tende to reduce degradation. New Jersey Department of Agriculture developed standards for controlling soil erosion and sediment load to alleviate catchments degradation (Fisher, 2014).

2.3 Degradation of Catchments in the Tropics

Catchment degradation affects land productivity and hinders utilization of soil and water resources in catchments. It is an economic constraint in Ethiopia and its management has been applied to facilitate effective use of natural and social capitals (Tiki, Kewessa & Wudneh, 2016). Many countries are implementing projects to reduce catchment degradation. The projects are normally preceded by a survey to establish the level of degradation. In Kibuon and Tende catchments, Integrated Water Resources Management (IWRM) study was conducted to inform the level of degradation in the catchments. Senegal introduced the use of geographic information system and remote sensing approach to analyze socio-economic activities in the Senegal river catchments and control over exploitation (Merem & Twumasi, 2012).

Soil erosion and planting of eucalyptus trees in riparian areas caused degradation in Kibuon and Tende catchments. The upper parts of the catchments receive a lot of rain which causes soil erosion due to in adequate use of soil conservation technologies while in the lower parts towards Lake Victoria degradation was caused by flush floods. A study carried out in Ethiopia indicated that many environmentalists agree that soil erosion by water is key in catchment degradation process (Desalegna et al. , 2012). Kenya has been supported by SIDA to control catchment degradation through soil conservation programme. According to Mondal, Singh, Singh, Sinha and Kumar, (2013), conservation and sustainable management of natural resources get high priority in many countries and Indian catchment projects address conservation of natural resources to improve productivity.

Agricultural activities in the hilly parts of Kibuon and Tende catchments contributed to soil erosion which reflected in degradation. Jamaica is mountainous and has erosive soils that easily experience soil erosion and earth quakes polluting beaches and harbours. In view of this, the Government developed a policy to promote conservation and development of land and water resources in the catchments (Tiwari, Bajracharya, & Siatula, 2008). Agriculture is the main contributor to gross domestic product (GDP) in Kenya and if catchment degradation is not controlled the economy will be affected. In Ghana agriculture contributes 34.7 percent to gross domestic product yet it is faced with decreasing agricultural productivity due to catchment degradation (Nkegbe, Shankar & Ceddia, 2011). Profitability is crucial in conservation of catchments since farmers may not benefit from some of the interventions immediately. According to Mesfin, (2010) the decision to implement starts with perception of erosion problem since some of the structures take between 5-15 years before farmers start benefiting from them and their uptake is also affected by demographic, economic and social factors (Ibido, 2015 & Adjaye, 2008).

2.4 Degradation of Catchments in Kenya

Soil erosion, flush floods, high population, deforestation, brick making and planting of eucalyptus trees in riparian areas contribute to catchment degradation in any country. Major causes of catchment degradation include population increase, over-exploitation of natural resources, climate change and discharge of pollutants in the environment (GoK, 2014; Kieti, Kauti & Kisangau, 2016; Gunya, 2009). Degradation led to exposed sub soils in Kibuon and Tende catchments reducing land productivity. Catchment degradation reduces forest cover whose products are used by 80 percent of households in Kenya (Swallow & Meinzen-dick, 2008 & Lake Victoria South Catchment Area, 2012). Food security levels are threatened by low productivity in degraded catchments. The lower parts of the catchments in Kibuon and Tende which are drier were faced with inadequate food for their population. Kenya is faced with inter-related constraints linked to food instability, environmental degradation and competition for natural resources (Heiner, K. , Shames, S. & Spiegel, 2016).

Catchment degradation is a problem affecting the globe, Kenya included. It affects proper functioning of catchments which provide goods and services to the National and local communities (Kieti et al., 2016). Climate variations in Kenya have contributed to over utilization of natural resources. The country is moving into " ecological overshoot" whereby natural resources are depleted faster than they are restored for example around Lake Naivasha there is water scarcity due to over abstraction by horticulture production and industries in the area (World Bank, 2016).

About 70% of land in Kenya is arid, semi-arid and swampy which are not suitable for agricultural activities. The lower parts of Kibuon and Tende catchments were severely degraded before project implementation partly being close to Lake Victoria. The country has limited arable land (30%) of the total land mass which is exposed to economic activities that facilitate soil erosion reflected in degradation of catchments (deGraffenried & Sheperd, 2009).

Indigenous trees in the study area were cut down for charcoal burning and provision of fuel wood without replacement. More land was exposed to erosion agents such as rain which contributed to catchment degradation. Thiririki catchment on the Eastern slope of Aberdares Mountain has the upper part covered with dense forest where logging for charcoal burning and agricultural activities are done. The middle part of the catchment is intensively used for agricultural practices resulting in soil erosion and landslides while the lower part is densely populated with over extraction of water for cash crops and cut flowers. These activities have contributed to soil erosion and sedimentation of Thiririka River affecting the health of the catchments (Benham et al., 2011). This confirmed that catchment degradation contributes to low productivity of an ecosystem through human activities (Mainuri & Owino, 2016).

Eucalyptus trees planted along rivers Kibuon and Tende had high water abstraction which reduced water quantities in the two rivers. Intensive farming in hilly areas caused more degradation reducing productivity thereby contributing to low yields. Sio River originates from Kaujai in Bungoma and drains Berkeley Bay in Lake Victoria basin. A study carried out indicated that there is river bank encroachment, reclamation, conversion of wetlands for agricultural purposes and moving from perennial to annual crops. These changes have contributed to low water flow and quality hence the catchment not able to perform its functions (Obando, Makalle, & Bamutaze, 2007). Reduced water quantities, quality and eroded soils in Kibuon and Tende reduced food production in the catchments. There is need for a strong linkage between catchment degradation, food insecurity and vulnerability to climate change because as productivity reduces farmers over exploit natural resources leading to catchment degradation (Ndavi, Kioko, & Patrick, 2016).

Mount Elgon is a crucial catchment in Kenya as a source of major water sources in the region yet it is exposed to flooding, droughts, water scarcity and more soil erosion. There is land change from forest to agricultural activities that have reduced water flow subjecting the catchments to water stress. Through Mount Elgon Integrated Catchment Management Project, farmers have been trained on use of sustainable agricultural land use management practices, protection of river banks, springs, agroforestry and tree nursery establishment which have improved the water availability and its quality in the catchments (Skogen, 2010).

2.5 Extension Approaches

Agricultural extension service delivery is a process of passing agricultural knowledge and skills to farmers to improve their agricultural productivity. There are different approaches used in extension delivery; the conventional agricultural extension approach assumes that knowledge and skills are available but not used while commodity specialized approach targets a specific commodity. Training and visit approach provides feed-back from farmers to extension agents and to research while farming system development approach considers different farming systems practiced in different areas.

Participatory agricultural extension approach encourages farmers' participation while the integrated project extension approach concentrates resources in a particular location for a specific period (Ponniah et al., 2008).

2.5.1 Integrated Project Extension Approach in Management of Catchment Degradation

The research used the integrated project extension approach because the integrated land and water management project applied the project approach by using different technologies and concentrated resources in the two catchments. Project approach offered alternative technologies for farmers to choose from.

2.6 The Level of Degradation in Kibuon and Tende Catchments before and after Project

2.6.1 Level of Degradation in Kibuon and Tende Catchments before Integrated Land and Watershed Management Project in Kibuon and Tende (ILWMKTP)

Kibuon and Tende rivers are a source of water for the farmers in the catchments and a reconnaissance survey before project implementation showed that activities upstream of the two rivers if not checked would affect the irrigation scheme downstream. Degradation in the catchments before project implementation contributed to nutrient and sediment load in the two rivers reducing the base flow and water quality (Mwangi et al., 2015). Additionally, the two rivers released a lot of sediments into Lake Victoria before project implementation indicating that there was degradation in the catchments besides unsustainable land use practices.

According to African Water Facility (2009) established that the catchments were characterized by serious soil and water degradation which had resulted in less water in the two rivers indicated by significant decrease in the water flow. Further observation indicated that the upper part of the catchments had eucalyptus trees planted along the two rivers replacing indigenous ones. This contributed to high total solid and nitrogen in Kibuon and Tende rivers compared with Sondu Miriu in the neighbouring county (Kisumu County) that had less total suspended solids (Table 1).

Table 1: *Solid Transportation*

Solid Transport in Kibuon and Tende Rivers			Sondu Miriu
	Kibuon	Tende	Sondu Miriu
TSS (ppm)	1,409	916	90
Annual sediment yield(tons/km^2)	99	96	
Catchment size Km^2)	760	780	3,500

Source: (African Water Facility, 2008)

Growing of eucalyptus trees along Kibuon and Tende rivers contributed to reduced water levels in the two rivers. There was low agricultural productivity due to catchment degradation, encroachment of river banks that contributed to catchment degradation, there was high level of food insecurity before project implementation hence the subsistence farming (Mwangi et al., 2015). The study established that before project implementation, Kibuon and Tende catchments were degraded due to more soil erosion experienced in the catchment. According to Owade Water Resource Users Association (WRUA) (2012) the catchments were exposed to encroachment of the riparian land, river bank degradation, water scarcity and water pollution. Additionally, burning of charcoal, overstocking, poor farming methods were prevalent in the catchments before project implementation and farmers participated in brick making as well as deforestation. Soil erosion in the catchments contributed water turbidity in Kibuon and Tende rivers. The catchments had many unprotected springs which got silted during rainy seasons resulting in turbid water (Tende Water Users Association, 2012).

Economic activities by farmers resulted in catchment degradation. Farmers engaged in quarrying and sand harvesting as economic activities that impacted negatively to the environment. The research established that besides soil erosion, the catchments were affected by gulley erosion. Kabondo Water Users Association (2012) in their Sub-catchment management plan showed that there was high river bank and gulley erosion in the catchments contributing to low productivity. This contributed to low base flow and turbid water in the Kibuon and Tende rivers affecting the catchments negatively. Kibuon Water Resource Users Association (2012) cited the presence of various threats of catchment degradation such as high population, exploitation of natural resources by farmers and soil erosion caused by water being present in the catchments. Farmers in Kibuon and Tende catchments depleted natural resources in the catchments without replacement for example cutting of trees for charcoal burning without replacement.

African Water Facility, (2008) in its appraisal report for Integrated Land and Water Management Project in the Kibuon and Tende catchments showed that there was severe soil erosion and water degradation which contributed to reduced base flows, increased flash floods and high sediment loads in the two rivers. This called for development of appropriate technologies for conservation of natural resources by institutions like Kenya Agriculture and Livestock Research Organization (KALRO) Kisii, Kenya Forestry Research Institute (KEFRI) and Kenya Marine and Fisheries Research Institute (KMFRI).

Catchment degradation before project implementation in Kibuon and Tende was shown through the expected outcomes of the ILWMKTP project which included improve land management and water resources, reduce runoff, loss of nutrients and reduce sediment from the catchments. Low levels of base flow and reduced aquatic weeds indicate degradation in the catchments. Orodi (2011) in his study on status of Integrated Water Resource Management Programme Implementation and Climate Change explained that there was intensive horticultural production in the upper part of the catchments, growing of eucalyptus in the riverine, brick making, quarry activities, and absence of rain water harvesting from the hills. In the middle there was over abstraction of water due to human activities while in the lower catchment there was increased clearing of shrubs for agriculture which contribute to catchments degradation.

African Development Bank (2008) in their annual report indicated that ILWMKTP project in Kibuon and Tende catchments aimed at improving water quality and quantity through sustainable agriculture and land use activities in the catchments. The project also aimed at reducing nutrient and sediment transportation into the two rivers which confirmed that the catchments experienced soil erosion through improper land use practices. According to (Okung & Peterlis, 2015) in their study on pollution loading into Lake Victoria from Kenya catchment, pointed out that water from rivers in Lake

Victoria basin analysis indicated that Tende and Kibuon had high levels of Total Nitrogen (TN) and Total Suspended Solids (TSS) a reflection of serious degradation in the catchments. This informed the need for ILWMKTP project in the two catchments.

2.6.2 Level of Degradation in Kibuon and Tende Catchments after ILWMKTP Project

Integrated Land and Water Management Project in Kibuon and Tende ran from 2009 to 2014. Through its implementation, farmers were expected to implement soil and water conservation technologies disseminated through Integrated Project Extension Approach to reduce degradation that existed in the catchments before project implementation. According to Ndeda, (2014), a lot of achievements by ILWMKTP contributed to improvement in conservation of the catchments.

The achievements included; 14 Community Based Organizations (CBOs) had 595 langstroth hives colonized with bees, 19 CBOs had 70 fully stocked fish ponds, 60 acres of napier and Rhodes grass were planted, 47.5 km of soil conservation structures (terraces) were dug, 28,950 fruit trees were planted, 425 energy saving jikos and 60 rocket jikos were installed, 46 tree nursery established, 80 m of river bank protection on river Mogusii and Rianeti was done, 4 dams were rehabilitated and Nyakal spring was protected. Nineteen springs were protected; 10 in upper, 6 in the middle and 3 in the lower catchment. Aballa and Kideswa gullies were rehabilitated and 10 sets of gabions constructed across Rongo gulley in Kibuon catchment. This is an indication of conservation work having been achieved in the catchments hence reduced degradation.

During the study, it was established that farmers established soil conservation structures and economic activities to enhance reduction in catchment degradation. A progress report by (Mwangi, 2013) indicated that the community based organizations (CBO) that implemented the programme achieved the following: 1600 tissue culture bananas were planted, Some eucalyptus trees were removed and replaced with suitable agroforestry trees, tree nurseries were established, 26 bee hives set up, 3,943 tree seedlings sold and 2 springs protected among others.

2.7 Farmers' Knowledge, Skills, and Attitude on Catchment Management Technologies promoted

2.7.1 Farmers' Knowledge and Skills

Catchment management is crucial for people living there and there is need to dedicate their efforts towards improving and conserving their natural resources. In Kibuon and Tende catchments farmers had different levels of knowledge and kills which dictated technology uptake. Farmers' knowledge and skills are important in implementation of catchment management projects and their participation is strengthened through capacity building by stakeholders and extension service providers (Mercado, Catacutan, Stark, & Laotoco, 2014). There was need for knowledge and skills for farmers to establish soil conservation technologies. Knowledge and skills are critical in implementation of catchment management technologies and farmers' with more knowledge and skills increase uptake and diffusion (Perez & Tschinkel, 2003). Farmers need information on all aspects that enhance technology uptake to enhance implementation. To improve their knowledge they need basic information about the technology, independent research organizations to develop and test technologies, and independent advisory organizations to provide information and guide farmers (Organization for Economic Cooperation Development (OECD), 2001). Farmers need more sensitization on benefits of catchment management because most of them are not able to measure economic returns from investing in soil conservation structures. Knowledge on how to use catchment management technologies increases technology uptake rate (Wisdom & Chor, 2013).

Adoption of soil and water conservation technologies depends on the farmers' knowledge in relation to the technologies and their complexity (Rezvanfar, Samiee, & Faham, 2009). Knowledge and improved skills are significant in uptake of soil and water conservation technologies (Chomba, 2004) which agrees with a study by (Junge, Deji, Abaidoo, Chikoye & Stahr, 2009) which indicated the need for comprehensive information on uptake of soil and water conservation practices. Most farmers rarely take up technologies which have less information on how they should be implemented.

There was need to expose farmers to many trainings and demonstrations to increase their knowledge and skills. According to Violet, Gachene, Ngugi, Thuranira and Baaru (2002), it was established that building farmers' capacity on appropriate soil and water conservation practices enhanced their knowledge and skills on how to use the technologies which reflects in higher uptake rates. Their knowledge and perception on soil degradation is crucial for implementation of land management practices (Miheretu & Yimer, 2017). Farmers in Kibuon and Tende catchments were trained on establishment of the technologies on their farms which made implementation easy. Through exposure to more knowledge and skill farmers take up the technologies especially those with comprehensive information (Junge et al. , 2009). This study found out those farmers who had more knowledge and skills took up many technologies in Kibuon and Tende catchments. According to Mercado et al., (2014), knowledge and skills are necessary for implementation and uptake of catchments management technologies in any catchments.

2.7.2 Farmers' Attitude

Farmers' attitude plays a major role in uptake of catchment management practices and through it, they may choose to take up a technology or not. Positive attitude towards implementation of the technologies is important for high take up of the technologies (Hosseini, Daryaei, & Rahnama, 2014). Farmers who had positive attitude towards soil conservation technologies in Kibuon and Tende catchments took up many technologies. Farmers' attitude in terms of water resource management, norms and their change in behavior contributes to positive response towards catchment conservation and may encourage investment in the technologies (Pino, Toma, Rizzo, Miglietta & Peluso, 2017).

Positive attitude towards soil conservation technologies enhance implement most of the technologies on farms. Positive environmental attitude encourages farmers to take up catchment management technologies as they anticipate change (Prokopy, Towery & Babin, 2013). Farmers who were aware of benefits from soil conservation technologies in Kibuon and Tende catchments implemented many of them on their farms. The positive attitude among farmers towards effects of land degradation, benefits of soil conservation technologies and improvement in quality of land makes them adopt the technologies (Kipngeno, 2007). Farms with soil conservation technologies in Kibuon and Tende catchments experienced less erosion. Positive attitude towards alleviation of soil erosion on their farms take up soil and water conservation technologies to alleviate soil erosion and improve productivity (Kerse, 2018). Further, attitude shapes the farmers' opinion in terms of adoption of catchment management technologies. They need more time and extension services on conservation technologies because they have conservative attitude towards conservation technologies in catchments.

Attitude is significant in technology uptake and maintenance of degraded catchments. There is high uptake rate amongst farmers with positive attitude towards catchment management technologies (Wolka & Negash, 2014). Most technologies in Kibuon and Tende were implemented by farmers who had positive attitude. A study in Iran showed that farmers' positive attitude on uptake of catchment technologies and acceptance of soil erosion as a major constraint had a great contribution to uptake of the technologies (Hosseini et al., 2014). Support from the Government and private organizations motivated development of a positive attitude among farmers to take up soil and water conservation technologies (Zerssa, Bezabih & Dinkecha, 2017).

Cost of soil and water conservation technologies in Kibuon and Tende catchments affected uptake of technologies. High uptake rate of soil and water conservation technologies is enhanced by ease of use, low cost and their effectiveness among farmers that have a positive attitude (Junge et al., 2009). Most farmers who take up of soil and water conservation technologies show interest in taking up technologies with a short term impact. Farmers can adopt many technologies as long as benefits are higher than their cost of implementation. Farmers' positive attitude on the technologies and benefits increases the rate of uptake (Mithun, 2013).

2.8 Catchment Management Technologies

Catchment degradation is a threat to food security in the World through low land productivity especially in developing countries. Land is a major resource available hence the need to conserve it (Baumhardt, Stewart and Sainju, 2015). There was reduced land productivity in Kibuon and Tende catchments before project implementation. A decline in soil fertility, diminishing land holdings and erratic rainfall contribute to catchment degradation (Rehman, 2011; Fisher, 2014). The study in Kibuon and Tende catchments focused on both physical and biological technologies since the Integrated Project Extension Approach used both categories during implementation of ILWMKTP project interventions in the study area. According to Senkoro, (2010) catchment management technologies are grouped into physical/mechanical and biological measures. The physical ones include cut off drains, terraces, water ways and retention ditches while biological technologies include cover crops, agro-forestry, contour farming and grass strips establishment among others.

2.9 Level of Uptake of Catchment Management Technologies in Kibuon and Tende Catchments.

Catchments are important for their ecological, aesthetic and socio-economic values and provide services and products for the farmers who live there. Kibuon and Tende catchments provided few services and products before project implementation due to their degradation. Catchments are a home to many people whose livelihoods are dependent on utilization of natural resources in the catchments (Thapa, 2009). Implementation of soil conservation technologies in Kibuon and Tende catchments involved farmers and those who established required technologies improved their land productivity. Catchment management technologies which target natural resources and involve the community enhance crop and animal productivity, farmers' socio economic conditions, the ability of an environment to function well and sustainable land use (Palanisami & Kumar, 2009). Catchment interventions in Kibuon and Tende catchments assisted rural on-farm and off-farm households in improving their income. Newby and Cramb (2007), in their report on economic impacts of land care showed that high population contributed significantly to on-site and off-site impacts.

Dissemination of different soil conservation technologies in Kibuon and Tende catchments contributed to positive economic changes in the community. High agricultural yields reflected in improved income for some farms. According to McDonald, Weber, Padowski, Boucher and Shemie (2016), natural land cover reduces loading of flowing water reflecting in improved land productivity. Use of cover crops enhanced soil fertility in Kibuon and Tende catchments for the farmers who planted them. Cover crops enhance soil fertility in catchments by improving soil organic matter content and water infiltration thereby increasing land productivity (Nkegbe et al. 2011).

Trainings and demonstrations enhance uptake of technologies in Kibuon and Tende catchments. Farmers in Kibuon and Tende catchments planted fruit trees such as avocado and pawpaws which provided fruits besides protecting the catchment. Planting of fruit trees enticed farmers in Kaiti catchment in Makueni County to take up soil and water conservation measures while most farmers and institutions grew *Grevillea robusta* that reduced degradation and improved income (Kieti , Kauti & Kisangau, 2016). Farmers who grew cover crops in Kibuon and Tende catchments improved land productivity in the catchment. (Palanisami and Kumar, 2009) reported that catchment management technologies targeting vegetation cover, afforestation and water percolation resulted in great changes in the environment such as improved water levels in wells, changes in areas under irrigation and longer periods of water availability.

Land being an important resource, many countries have invested in it to have sustainable productivity and maintenance of catchments. India has invested a lot of resources through projects to restore land and water use, by training farmers on proper land and water use to reduce degradation. Through the projects, it was found that sediment load in rivers declined, silt load from smaller catchments reduced, some farms were rehabilitated using cashew nut trees and sisal which increased economic status of the farmers (Bhan, 2013).

Farmers in Kibuon and Tende catchment established terraces on their farms to reduce runoff speed thereby reducing rill erosion on their farms. A study conducted in Tigray in Ethiopia indicated that farms that established terraces reduced rill formation by 60 percent and yield improved by 25 percent and where natural forests were allowed to grow green cover increased by 50 percent (Mekonen & Tesfahunegn, 2011). Soil conservation structures reduced soil erosion in Kibuon and Tende catchments for the farmers who implemented them and increased agricultural productivity. Check dams were used by some farmers in Kibuon and Tende to reduce water speed in developing gullies to stop further development. Controlled gullies through check dams and gabions accumulated soil between 0.4-1.5m depth and reduced gulley development. Tiki et al. (2016) observed that farmers who took up check dams improved fertility of their farms while other farmers felt soil bunds were more effective in improving soil fertility because of minimal erosion. Soil and water conservation technologies, if taken up, are meant to improve livelihoods of the rural people, enhance availability of drinking water, wood fuel, fodder and improved agricultural productivity. According to Mondal et al., (2013), India invested in catchment interventions to improve livelihoods and sustainability in drought prone areas. A study carried out showed that implemented catchment technologies increased crop intensity, productivity and enhanced production of high value crops. Continuous establishment of the structures contributed to controlled soil loss, retained moisture, reduced runoff velocity (Atnafe et al., 2015).

Kibuon and Tende catchments experienced a lot of erosion before project implementation which contributed to silting of some water points. Sukhomajri village in India was characterized by floods, poor water quality, and sedimentation of Lake Sukhna which increased poverty, land and water degradation. This became a threat to the Lake and through Central Soil and Water Conservation Research and Training Institution, a soil and water conservation project was initiated to control erosion and resulted in increased productivity for example wheat yield increased from 40.6 tons to 63.6 tons while maize production grew from 40.9 to 54.3 tons (Lenton & Muller, 2009).

There were many agricultural activities undertaken in Kibuon and Tende catchments in the hilly upper parts of the catchments contributing to water turbidity in the catchment. Catchment degradation is a critical environmental constraint in the sloppy uplands of Philippine because agriculture and other economic activities affect other resource users in the catchments (Newby & Cramb, 2007). To control it, Philippine designed a Land

Care programme which developed conservation farming practices that reduced degradation and improved livelihoods in the catchments.

2.10 Level of Implementation of Integrated Project Extension Approach in Disseminating Catchment Management Technologies

Catchment degradation is a problem affecting the world and many technologies have been developed to alleviate it. Physical structures used in controlling soil erosion in catchments are divided in two categories: measures that reduce runoff for example terraces, diversion ditches, grassed waterways and those that stabilize slopes and reduce soil erosion for example retaining ditches and earth dams (Chakravarty, Ghosh & Suresh, 2011).

2.10.1 Use of Terraces

Catchment degradation has existed due to high human and livestock population and economic activities. Sloppy land in Ethiopia subjected the country to a lot of soil erosion contributing to catchment degradation. Terraces were applied in the Northern highlands which improved soil quality in the catchment including phosphorous, soil organic matter and carbon level in the farms (Sabhatu et al. , 2017). Soil erosion and inadequate use of soil conservation technologies contributed to catchment degradation in Kibuon and Tende catchments. Catchment degradation in Ethiopia was majorly caused by soil erosion and farmers used traditional methods to conserve soil and water until the Government introduced modern soil and water conservation technologies. A survey carried out showed that 85.7% of farmers in Gidan Wereda took up terrace construction successfully which improved water absorption and productivity reflected in improved yields (Miheretu, 2014).

Farmers in Kibuon and Tende catchments constructed terraces during project implementation to reduce degradation. In controlling soil erosion Ethiopia constructed terraces to trap sediments, reduce run off speed and on-site soil erosion through reduction of slope length and gradient (Sabhatu et al., 2017). Terraces in Kibuon and Tende catchments reduced soil erosion and contributed to improved productivity in the catchments. By controlling water flow, reducing soil erosion and creating fairly flat land for agriculture, terraces contributed to catchment healing (Chakravarty et al. , 2011).

2.10.2 Use of Fruit and Fodder Trees

Farmers grew fruit trees to conserve the catchments and serve as an income generating activity in Kibuon and Tende catchments. Suitable agroforestry trees were planted for provision of fodder for livestock complementing Napier and natural pasture. The fodder trees grew very fast, provided fodder and fuel wood in the catchments. According to Subudhi (2013), plantation of fruit trees, fodder trees increase biomass production, land productivity and reduced runoff in farms. Agroforestry trees reduced degradation in hilly parts of Kibuon and Tende catchments. Yangtse is an important river in China that experiences floods due to reclamation of flood plains for agricultural activities and siltation from soil erosion in the catchments. The Chinese Government through National Development and Reform Commission developed an integrated policy that focused on improving the degradation in the catchment through increasing forest cover and afforestation of sloppy farms which have decreased flood incidences, improved biodiversity and productivity (Pitock & Xu, 2010).

Demonstrations of fodder and fruit trees on farms contributed to reduced runoff, fruit production and improved productivity in Kibuon and Tende catchments. According to

Fernandez (2016), catchments in mountains in the tropics provide goods and services from crop, livestock, forestry and leisure activities that generate income for the inhabitants. Soil and water conservation was enhanced in Kibuon and Tende through use of catchment management technologies. According to (Chakravarty et al., 2011), there are benefits such as good hydrological cycle, soil conservation, prevention of climate change and preservation of biodiversity in healthy catchments. There is fear that agricultural activities being the main cause of deforestation in tropics might replace forests which will be reflected in degraded catchments. About 38 percent of China’s land mass is eroded because of deforestation and urbanization which escalate catchment degradation. Due to the impact on catchments, the country came up with a Natural Resource Conservation Policy that was taken up to restore affected areas like the basins of Yangtse and Yellow rivers through tree planting to conserve soil and water (Sun, Shao & Liu, 2014). Agroforestry reduces soil erosion, sediment transportation and enhance carbon sequestration thereby healing catchments and contributes to biodiversity. According to (Tennyson, 2005), forests in catchments provide biodiversity conservation, catchment protection and economic value of forests.

Demand for agricultural land and over-grazing have contributed to catchment degradation and through afforestation catchment degradation has reduced. In India, various schemes have been established to reduce catchment degradation through soil and water conservation measures, reclamation of degraded land and proper land use (Bhan, 2013).

Agroforestry trees planted in Kibuon and Tende catchments provided fruits, timber and conserved environment. According to Joshi (2008), introduction of multi-purpose trees has many benefits to the farmer for example one type of tree can provide fuel wood, fruits and fodder. Introduction of fruit trees in the lower parts of Kibuon and Tende catchments provided fruits and protected the environment. Loess Plateau in China was once under forest cover but following agricultural activities and economic development, area under forest reduced. Through efforts by the Chinese Government forested areas increased from 6.1percent to 9.5 percent (Bin, 2009). Fruit tree planting improves aesthetic value of a catchment and increase its biodiversity. According to Palanisami and Kumar, (2009), planting of trees on private land and common lands was undertaken in Nadu as part of catchment management. This increased green cover, improved the environment, catchments and eco-index varied from 1.8 percent to 43 percent.

2.10.3 Use of Vetivar Grass as a Vegetation Cover

Vegetative cover intercepted rainfall, covered soil with litter and maintained soil structure reflected in improved productivity in Kibuon and Tende catchments. Any vegetation that is adapted to the environmental conditions of a catchment can be used to reduce soil erosion (Adugna & Belayneh, 2012). However dual purpose ones are more suitable for example provision of forage, fruits and wood fuel (Joshi, 2008). Vetivar grass strips were used on some farms in Kibuon and Tende catchments for their effectiveness in controlling soil erosion. A study carried out in Kandhamal district found out that vegetative cover for example Vetivar grass increased rice yield, reduced soil losses and decreased runoff (Subudhi, 2013). It was cheaper to establish vetiver grass strips compared to terrace construction in Kibuon and Tende catchments. A study in

South Nigeria indicated that the use of vegetation barrier was efficient in controlling soil erosion and cost effective in terms of its establishment (Eni, 2012).

Sediments produced through soil erosion were moved to new areas developing uneven ground and when they reached Kibuon and Tende rivers, they caused water turbidity. The University of Guam in Pacific Island established the importance of vetivar grass in reducing siltation by trapping the sediments and thereby restoring quality of water downstream and shores contributing to healthy marine life (Guerrero & Desamito, 2016). Catchment degradation being a global issue, many studies have been carried out on its impact on the environment. The researches in China, Kenya, Madagascar, Peru, Senegal & Thailand have been done on construction of soil conservation structures and use of vegetation cover.

Vetiver grass was used in control of soil erosion, increase water infiltration and degradation in Kibuon and Tende watershed. The Royal Development Projects Board of Thailand initiated development of Vetiver grass, propagation, management and use which resulted in high uptake of the grass nationally as a control measure for catchment degradation. Effects of soil erosion were adverse on environmental protection in Kibuon and Tende catchments due to clogging of Kibuon and Tende rivers. The University of Guam and US- forest Division in the Pacific, conducted a study on effectiveness of vetiver grass in controlling sedimentation that contribute to low quality and quantity of water in a catchment and results showed that areas planted with vetiver had less sediments transported to water bodies (Golabi, Iyekar, & Denney, 2009). They trapped eroded soil particles and reduced runoff speed in Kibuon and Tende catchments. Pakistan is a predominantly agricultural country whose population has overused land resources contributing to catchment degradation. Over-grazing is prevalent and has greatly contributed to the degradation. A study by Joshi (2008), indicated that besides planned agricultural practices and keeping livestock away for a season encouraged establishment of lush grasses to develop and heal the degraded catchments. This was followed by planting of shrubs and vetivar grass in hilly areas which bound the soil together resulting in controlled erosion hence healing of the catchments.

Vetiver grass has extensive root system which held soil together and reduced soil erosion in Kibuon and Tende catchments. According to Joshi (2008), vetivar grass was used in Nepal to control soil erosion and the species grew in a wide range of ecological zones. Its extensive-fibrous root system bound topsoil and nutrients from erosion. The roots also improved soil organic matter when they dried up. It is used in water ways in Hindu Kush Himalayan region to reduce; run off speed, transport of sediments from natural drains, dispose-off water from roads or discharge the runoff through culverts preventing gulley formation (Chakravarty et al., 2011).

2.10.4 Use of Check Dams to Control Gullies

Farmers in Kibuon and Tende catchments used check dams to control soil erosion by reducing water speed in the gullies to prevent further development. According to Subudhi (2013), plugging of gullies resulted in reduced runoff speed increasing infiltration and healing of gullies. Checked dams if used effectively contribute to gulley healing and restore land productivity with time. Through healing the gulley head, the run off flow reduces and when the affected area is subjected to relevant soil conservation measures, productivity is enhance (Joshi, 2008).

Check dams increased water infiltration in Kibuon and Tende catchments contributing to less soil erosion. In the Nile catchment an initiative was developed to reduce sedimentation in the river, stabilize gulley sides through use of vegetation cover, check dams on gully bed to improve infiltration and reduce amount of water flowing through the gulley to river Nile (Adugna & Belayneh, 2012). Check dams increased water infiltration in Kibuon and Tende catchments making available water for crop production. Stabilization of gulley beds increased water availability increasing crop productivity from 6.65 percent to 16.59 percent in Tamil Nadu catchments (Mondal et al., 2013). Many farmers in Kibuon and Tende catchments used check dams to control gulley development on their farms to reduce catchment degradation. An impact assessment was conducted in North Ethiopia on soil and water conservation technologies used. The findings showed that 90 percent of the farmers constructed check dams to stabilize gullies which resulted in reduced soil erosion and grew tomatoes, potatoes, carrots and onions successfully. Following implementation of the technologies more biomass was produced reflecting in environmental rehabilitation (Mekonen & Tesfahunegn, 2011).

Check dams reduced water speed flowing in the gullies in Kibuon and Tende catchment, allowed for harvesting of more water and contributed to gulley healing. A study conducted in Ethiopia on effectiveness of catchments management technologies established that besides other soil and water conservation technologies, gulley control through use of check dams was effective in reducing water flow in the gulley hence reduced soil erosion (Tiki et al., 2016).

2.10.5 Replacement of Eucalyptus Trees with Suitable Agroforestry Trees

Farmers with farms in riparian areas of Kibuon and Tende rivers grew eucalyptus trees for commercial purposes. According to a study by Orodi (2011), eucalyptus production was concentrated in the upper part of the catchments which reflected in low base water flow. Through integrated project extension approach, farmers were introduced to suitable agroforestry trees and sensitized on replacement of the eucalyptus with the agroforestry ones. They cut down some of the eucalyptus and planted the suitable agroforestry trees in the riparian to restore water quantity. Although the replacement went on during the project period, eucalyptus trees are still growing in some parts of the riparian areas of the catchments. Streams that had eucalyptus near had reduced volume of water since the trees used a lot of water during their growth. Eucalyptus trees use a lot of water during their growth period whereby a tree that is 3 years old consumes twenty litres of water per day competing with animals and human beings. Continued production of eucalyptus in catchments increase water shortages experienced (Vinci, 2015). There was none or very little vegetation growth near or under eucalyptus trees that were planted in the catchment. Allelopathic effect of eucalyptus stops growth of any other vegetation under them destroying biodiversity. According to Zhang et al., (2012) eucalyptus are seen as heavy consumers of water with a high potential of depleting water resources hence not suitable for riparian areas.

Areas in Kibuon and Tende catchments in which eucalyptus had been replaced by suitable agroforestry trees had adequate water soil nutrients were replenished. In Ethiopia eucalyptus is associated with water and soil nutrients depletion, and suppression of flora growth caused by its allelopathic condition (Jaleta, Mbilinyi, Mahoo & Lemenih, 2016).

Additionally, eucalyptus trees have led to degradation and reduced water quantity in rivers, drying up of streams in the highlands because of their high transpiration rate ranging from 0.5 to 6.0 mm per day besides high water abstraction from shallow wells. They should not be grown near any water sources; wetlands, along rivers, swamps and lakes because they consume a lot of water interfering with hydrological cycle (Menge, 2013). Eucalyptus trees caused biomass depletion, excessive water use and reduced catchment productivity in Kibuon and Tende catchments. Research findings in South Africa by Amaury (2016), found out that eucalyptus contribute to decreased stream-flow because of their faster growth in early stages and negatively affect water balance. Some of the fish ponds that were excavated near eucalyptus trees in Kibuon and Tende catchments dried up. A study in Koga catchments in Ethiopia found out that eucalyptus trees lower water table, reduce water availability for agricultural production reducing productivity due to nutrient depletion (Chanie, 2009). He further established that eucalyptus easily show signs of water stress in their early stages when there is water shortage which is an indication of high water demand and competition for the same with other plants in the same area

2.11 Identification of Gaps to be Filled by this Study

Reasons to why catchment management technology uptake is low in Kibuon and Tende catchments despite unified trainings, demonstrations and grants that were provided for continued used of the technologies.

2.12 Theoretical Framework

The study was informed by diffusion theory (Rogers, 1995).The theory has various concepts; complexity which refers to the degree of difficulty in understanding and using the technology, compatibility which relates to degree to which the technology is compatible with current objectives and philosophies of the programme participant while triability is the potential to experiment the technology on a smaller and less intensive scale. Relative advantage is the possibility of increased income, reduced cost or other factors that may make adopting a technology advantageous over alternatives. Observability is concerned with opportunity to see the technology implemented. The theory assumes that each individual passes through the five stages of adoption process which include knowledge, persuasion, decision making, implementation and confirmation when adopting an innovation. Diffusion of an innovation takes place when there is an innovation, communication, time for adoption, channels and social system which frames the innovation- decision process. Despite this, the diffusion theory over looked the fact that a technology can be rejected even if it is well understood Waterman (2000). The theory had little consideration of technology characteristics and how they change with time affecting adoption Wolfe (1994). According to Kole (2000), diffusion theory by Rogers has pro-innovation bias by assuming that all members of a social system should adopt the technology quickly.

Catchment management technologies through integrated project extension approach reached farmers through the same process. Farmers got knowledge on the technologies from the organizations that participated in implementation of Integrated Land and Water Management Project in Kibuon and Tende catchments. They went through persuasion stage, made a decision to implement the technologies and confirmation was done by the actualization of technology uptake in the study area. Technology uptake was enhanced by the fact that most technologies were not complex to adopt, they were compatible with farmers' activities and had relative advantage of increasing productivity. There was observability of catchment management technologies by the farmers who implemented them in other previous catchments.

2.13 Conceptual Framework

It was expected that implementation of ILWMKTP project in the study area would reduce degradation in Kibuon and Tende catchments. Farmers were supposed to construct soil and water conservation structures, plant agroforestry trees and establish grass strips by using vetivar and Napier grass. This would reduce catchment degradation reflected in improved productivity, income, hence food security. Catchment management technologies considered were; terraces, cover crops, grass strips and agroforestry. The study looked at farmers' knowledge, skills, and attitude towards catchment management technologies. Dependent variable was level of catchment rehabilitation in terms of knowledge, skills and attitude. Moderator variables were age, gender, land size and education level of the respondent (Figure 1).

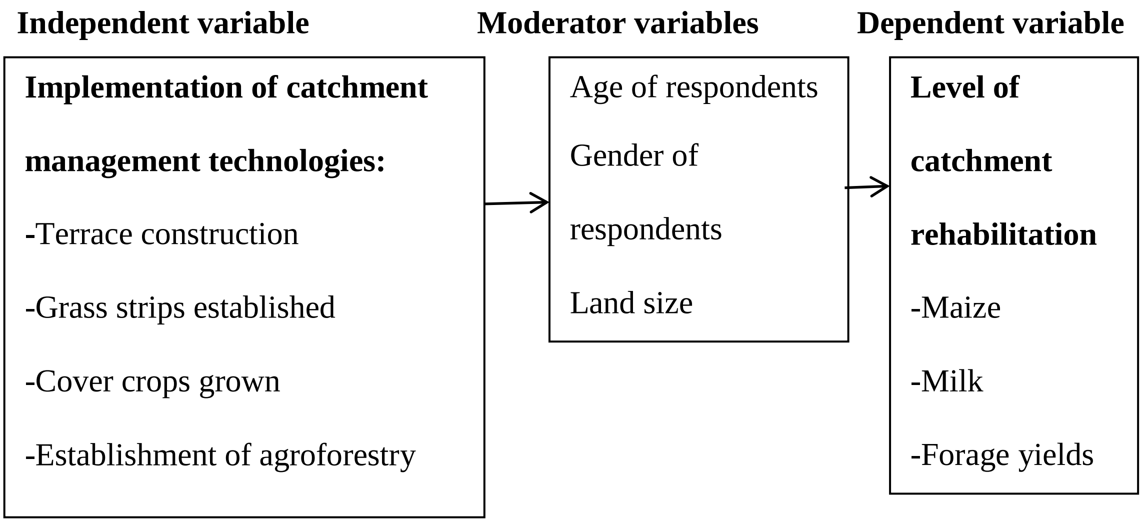

***Figure 1**:* Conceptual Framework in Kibuon and Tende Catchments

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Introduction

Chapter three covered geographical description of the study area, research design, population of the study, sample size and sampling techniques, instrumentation, validity and reliability, data collected, data collection procedures, and data analysis.

3.2 Research Design

The design was an *ex post facto* research design with cross sectional survey approach combining qualitative and quantitative data collection. *Ex post facto* is a systematic empirical enquiry without direct manipulation of independent variables since they have already taken place (Manjunath, 2014). *Ex post facto* was a suitable design since the study was conducted after implementation of Integrated Water Management Project in survey area and would provide the required data for the study. The study utilized primary and secondary data. Primary data was collected from respondents and key informants through interview schedule and a questionnaire respectively. The study also used observation and image interpretations for additional information. Secondary data was collected from reports, policy documents and books from Government institutions. The design was suitable because respondents had equal chances to participate in the survey since they implemented the project and conditions during the interview were not altered.

3.3 Geographical Description of the Study Area

Kibuon and Tende catchments were selected for the study and cover Homa Bay, Kisii and Nyamira Counties in South West Kenya. According to the census for 1999 in

African Water Facility, (2008) total beneficiaries were 1,884,000 farmers but the Integrated Land and Catchments Management Project in the catchments covered 9,475 farmers. The area was purposively selected for the study because it implemented a project on catchments management. The study area has bimodal rainfall pattern; Homa Bay County lies between LM_1 to LM_4 agro ecological zones and receives 450-1000 mm of rain per year. The county practices mixed farming through production of maize, sorghum, sugar cane, beans, rice and rears mostly the zebu cattle (Mwangi et al., 2015). Kisii County has LH_1, LH_2 and LH_3 agro ecological zones and receives between 1500mm to 2000mm per year. The county produces vegetables, bananas, sugar cane, tea and rears Zebu cattle and dairy cows (Mwangi et al., 2015). Nyamira lies between LH_1 to UM_2 agro ecological zones and receives between 1500 mm to 2000mm of rain per year. The county produces maize, vegetables, bananas, beans and rears dairy animals. The Kibuon and Tende catchments run from the upper parts of Nyamira and Kisii Counties through Homa Bay County to Lake Victoria (Mwangi et al., 2015).

Kibuon catchment was divided in 3 sub catchments; Kibuon (K1) is located in Nyamira South Sub County. The sub catchment has high population and intensive mixed farming is practiced. Crops include maize, beans and farmers reared poultry, Zebu cattle and dairy cows and poultry. Kabondo sub catchment (K2) has its highest point (21000 m above sea level) in Nyaramba market in Nyamira County. It covers Nyamira North and parts of Nyamira South and Oyugis area in Rachuonyo Sub County. There was planting of eucalyptus trees in the sub catchment, cultivation was done on steep slopes and farmers had small land sizes except in Rachuonyo Sub County. The main crops grown include maize, beans, vegetable, bananas and sweet potatoes. Farmers also rear dairy animals and Zebu cattle. Kasipul sub catchment (K3) is on the upper and hilly parts of Kibuon-Tende catchment in Rachuonyo South and it is not highly populated. They practice mixed farming is system in which maize, sorghum, beans are grown and zebu cattle reared. Quarrying which was present in the sub catchment before project implementation was stopped. Kibuon, Kabondo, Kasipul sub catchments are in Kibuon river catchment. Tende Sub catchment (T1) is located in Kitutu Chache Sub County in Kisii County. It receives more rainfall and common crops in the sub catchment are maize beans dairy cows. The sub catchment has high population hence the practice of intensive farming to feed the high population. Isanta sub catchment (T2) starts in Kiomoncha market in Marani sub county which had unprotected river banks, they grow maize, beans, horticulture and dairy production and has fairly high population.

Mogusii sub catchment (T3) runs from Manga in Marani Sub County and covers parts of Kisii County near Nyakoe market and parts of Rachuonyo North and Rangwe Sub Counties. Mixed farming with hill top cultivation was evident. The sub catchment is in UM_1 with a high population of 987 people per km_2 and the lower parts are in $LM_{4.}$ There were poor soils, cultivation on slopes, growing of maize, beans, vegetables and fruit trees. There was dairy production involving cross breeds. Tende, Isanta and Mogusii sub catchments were located in Tende river catchment. Each catchment had three sub catchments hence the numbers 1-3 in each catchment. Tende (T1) and Kibuon (K1) are located in the upper part of the two catchments. Kibuon (K2) and Tende (T2) are found in middle catchments while Kibuon (K3) and Tende (T3) are located in the lower parts of both catchments towards Lake Victoria (Figure 2).

A Map for the Project Area in Nyanza Province

Figure 2: Project Area in Nyanza Province

Source:(African Water Facility, 2008)

A Map of Kibuon and Tende Catchments

Kibuon was 52km long and drained 760km^2 while Tende river was 49 km long and drained 780 km^2. The catchments had 1,884,000 farmers (African Water Facility, 2008)

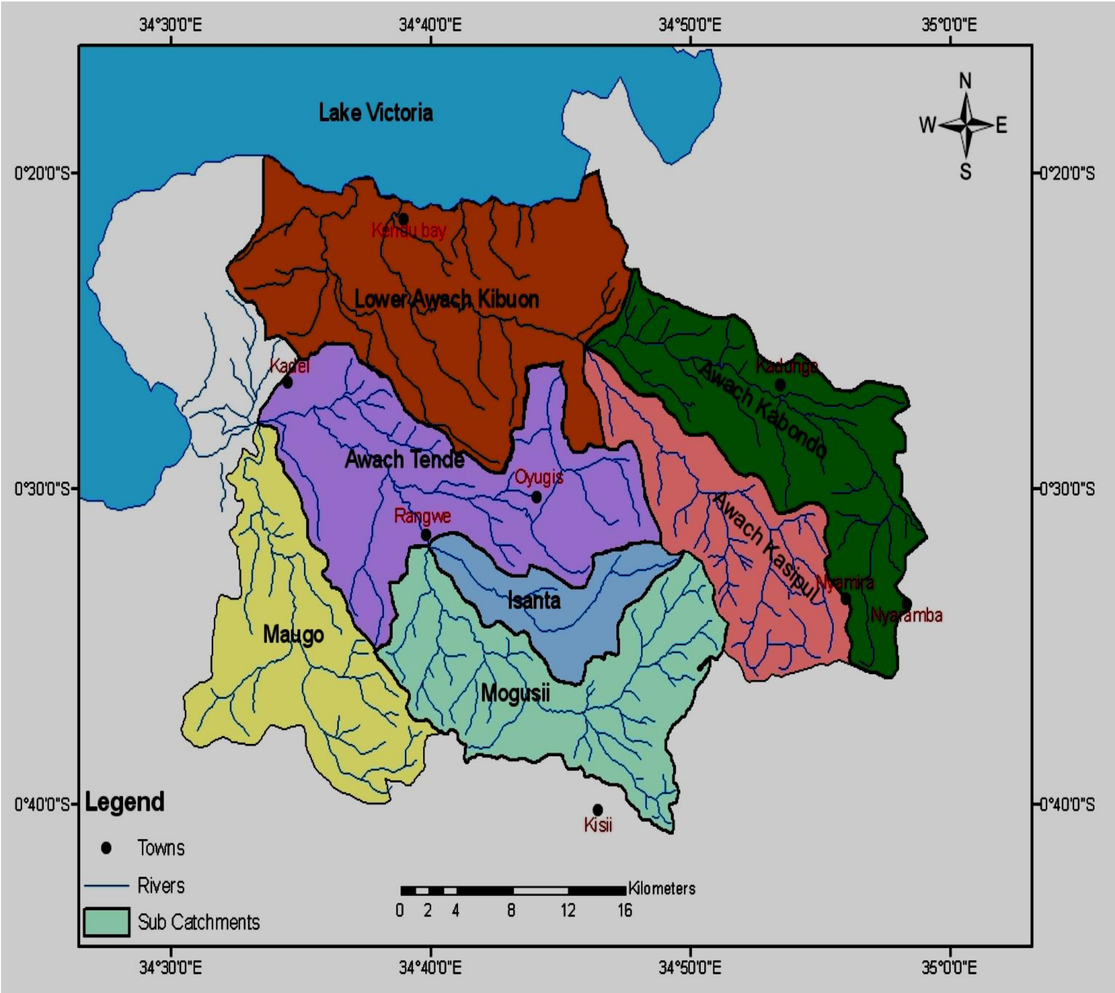

Figure 3: Kibuon and Tende Catchments

Source: Adopted from Reconnaissance Survey of the Kibuon and Tende River Catchments of South West Kenya (Mwangi et al. , 2015)

A Map for Demarcated Sub- catchments for Kibuon and Tende Catchments

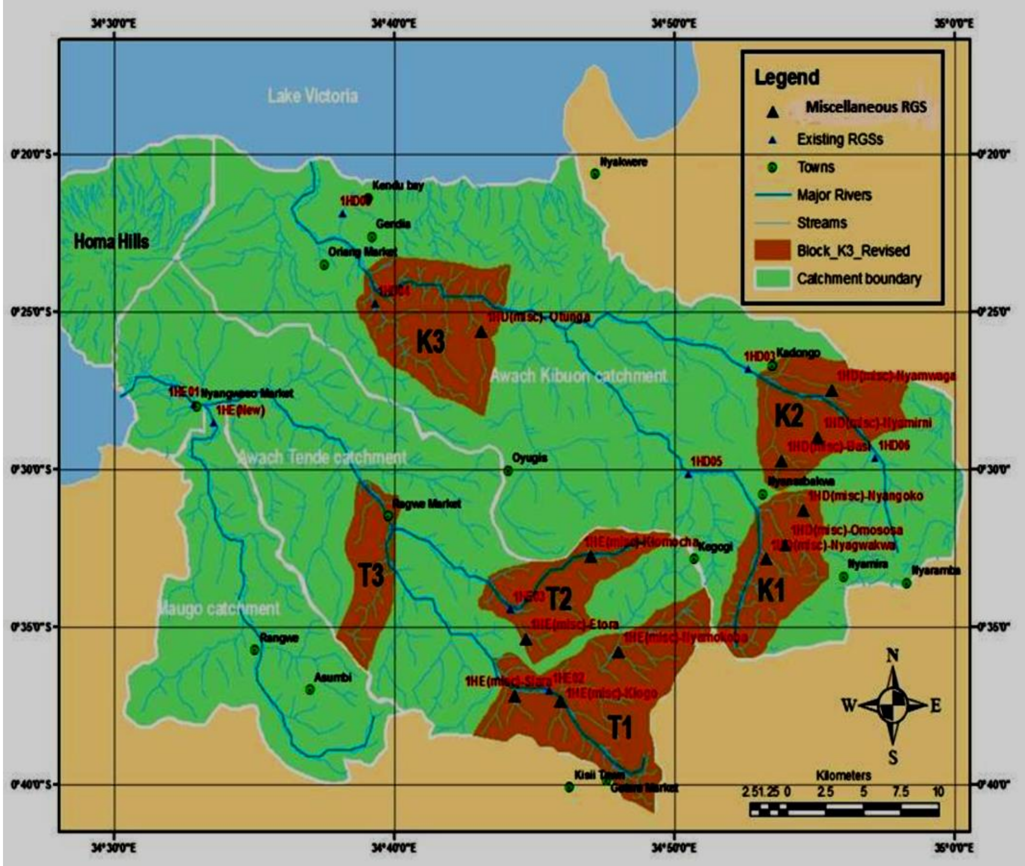

***Figure 4*: Demarcated Sub Catchments**

Source: Adopted from Reconnaissance Survey of the Kibuon and Tende River Catchment of South West Kenya (Mwangi et al. , 2015)

3.4 Target Population

The target population was 68 CBOs that participated in implementation of ILWMKTP project with a membership of 9,475 farmers in the project area (Ndeda, 2014). The sample chosen for the study was 370 members of 34 CBOs.

3.5 Sample Size and the Sampling Procedures

The study area was selected purposively for having implemented a catchment management project and therefore had the data that was required for the study. Multiple-stage cluster sampling method was used proportionately. The study area was divided into sub catchments based on the area where the project was implemented and each sub catchment was represented by a number of CBO members. Through proportionate simple random sampling, 50 per cent of the CBOs were selected for the study. Simple random sampling was used to get respondents proportionately in each CBO. From 68 CBOs, 34 CBOs were systematically selected each member was selected through simple random sampling procedures. A sample size table by Krejcie and Morgan (1970) in a research paper by Hashim, (2010) recommends a sample size of at least 370 people. The study covered 9 staff who participated in implementation of the project and 370 respondents from the sub catchment proportionately (Table 2).

Table 2 : *A Summary for Sampling Procedure for ILWMKTP Farmers*

River	Sub catchment	Number of CBO	Target population	Sample of CBOs	Sample of Farmers
Kibuon	Kibuon (K1)	4	375	2	15
	Kabondo (K2)	14	1,805	7	70
	Kasipul (K3)	14	1,300	7	51
Tende	Tende (T1)	18	3,789	9	148
	Isanta (T2)	8	1,210	4	47
	Mogusii (T3)	10	996	5	39
Total		68	9,475	34	370

3.6 Instrumentation

The study applied interview schedule and questionnaire to respondents and key informants respectively to gather data. A research test was developed to test respondents' attitude towards catchment management technologies. The tools were suitable because the researcher asked for additional information and clarification from respondents who were not able to write. This ensured that data collected met the objectives of the study. Data collected was analyzed and results obtained and generalized to a wider area although care and more research needed to be conducted since there may be variations in factors contributing to uptake of catchments management technologies in different areas.

3.7 Validity and Reliability

3.7.1 Validity

It is the extent to which an instrument meets the objectives and contents of a study effectively. Through thorough examination of the instruments by supervisors, it was ensured that questions in the tool addressed objectives of the study. Faculty staff were able to look at the questionnaire during proposal defense to correct the questions ensuring content validity. The researcher improved on the tool through discussions with colleagues to ensure that questions were well captured to address objectives of the study and enhance content and internal validity.

3.7.2 Reliability

The researcher developed a questionnaire for 9 extension service providers and an interview schedule for 20 respondents. The interview schedule was pre-tested on 20 respondents in Shikusi catchment in Shinyalu Sub County of Kakamega County while the questionnaire was pre-tested on 9 extension staff who participated in soil and water conservation project in Kakamega County. Captured responses in pre-testing were analyzed using Cronbach's Alpha which recommends a coefficient value of 0.7 or above (Mugenda & Mugenda, 2003). Reliability of this study indicated that respondents gave result of 0.83 coefficient value while key informants had a reliability of 0.87. Cronbach's Alpha was suitable since it takes less time to compute and gives conservative estimates hence no room for erroneous conclusions (Mugenda & Mugenda, 2003).

3.7.3: Statement of Ethical Considerations

The researcher ensured that respondents were not subjected to any harm, respect for their dignity was ensured, consent was obtained from the respondents prior to the study and privacy for research participants was ensured. Any communication in terms of the research was done with honesty and bias was avoided in presentation of primary data.

3.8 Data Collection Procedure

A research permit was sought from National Commission of Science, Technology and Innovation (NACOSTI) through Kisii University. Department of agriculture in the study area was informed. Data was collected from 370 respondents through face to face interviews. The study utilized primary and secondary data, and literature was collected from books, journals, reports, policy documents and research papers. Secondary data collected was complemented by data from face to face interview that was conducted in the catchments. There was triangulation of data from the farmers and extension staff.

3.9 Data Analysis

Quantitative data was analyzed using statistical package for social sciences version 25. Data coding was done before being entered into SPSS software and cleaned to remove any errors that may have been made during data entry. Qualitative data was dummy coded and analyzed using SPSS. The analysis was done in terms of variables for each objective in the study. Data was analyzed using descriptive and inferential statistics. Descriptive statistics was used to determine means and standard deviations among sub catchments in terms of catchments management technologies.

For inferential statistics, ANOVA was used to compare means in sub catchments on catchments management technologies. Tukey post hoc determined significant differences on catchments management technologies while Chi square was used to determine if there was any significant relationship between sub catchments and catchments management technologies. Pearson correlation established strength and direction of the association between independent and dependent variables.

Paired samples t-test determined significant differences in degradation level before and after project implementation while correlation showed strength and direction of association between technologies and increase in maize, milk and forage. The results were rated on a 5 point likert scale where 1 represented strongly disagree, 2 was disagree, 3 was neutral, 4 was agree and 5 represented strongly agree. Level of significance for inferential statistics was set at 0.05% (Table 3).

Table 3: *A Summary of Data Analyses for Each Hypothesis*

Hypothesis	Independent variables	Dependent variable	Statistical method
H_{01}. There is no statistically significant difference in the level of degradation in Kibuon and Tende catchments before and after the project	Implementation of catchment management technologies: -terraces constructed -grass strips established -cover crops established	Level of catchment rehabilitation -knowledge -skills -attitude	Mean, standard deviations, ANOVA, Tukey post hoc, Chi square, Pearson correlation and paired samples t-test were used to analyze data
H_{02} There is no statistically significant difference in knowledge, skills, and attitude of farmers on catchments management technologies promoted in the catchments.	-Knowledge -Skills -Attitude	-Terracing -Cover cropping -Grass strip establishment Agro forestry	ANOVA, Tukey post hoc test were used in data analysis. Frequencies were also used
$H_{03.}$ There is no statistically significant difference in level of uptake of selected catchments	-Number of terraces -Cover crops	Uptake of technologies	ANOVA and Tukey post hoc test and Pearson

management technologies in Kibuon and Tende basins	-Grass strips -Acreage under agro-forestry		correlations were used to analyze data
H_{04} There is no statistically significant difference in the level of implementation of Integrated Project Extension Approach in disseminating different catchments management technologies to reduce catchments degradation	Those using; -terraces -vegetation cover -Check dams	Technology uptake	ANOVA, Tukey post hoc and Pearson correlation were used to analyze data

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

4.1 Introduction

Chapter four presents results and discussions of the study based on objectives and hypotheses which were formulated. The chapter also discusses socio economic data collected from the respondents during the survey.

4.2 General Respondents' Characteristics

Socio economic data was discussed with respect to their influence on farmers' response to catchment management technologies in Tende and Kibuon catchments in South West Kenya. They included gender, age, marital status, level of education, family size and size of land for respondents.

4.2.1 Gender of the Respondents

The study interviewed 370 respondents who comprised of 63.2 percent men and 36.8 percent women. Majority of project implementers (234) out of 370 were men while 136 were women. Most women in Kibuon and Tende catchments participated in alternative economic enterprises that did not require a lot of energy to manage for example poultry and goat production. The number for men was higher than the one for women because they owned land in Kibuon and Tende and made decisions on how it should be utilized. The men also provided labour for tedious work in terms of terraces construction in the catchments. It was expected that men in the project would influence women positively towards catchment management technologies and engage them in some field activities through provision of labour. These findings agreed with a research report by Wagayehu and Lars (2015) in their study on adoption of soil and water conservation measures

(SWCM) by subsistence farmers Ethiopia which established that although men were heads of households and responsible for decision making on farm activities, women constituted primary labour. Increase in labour requirements in soil and water conservation activities was achieved through involvement of women in farm activities to control soil erosion by implementing decisions made by men. According to Tennyson (2005) in his study on review and assessment of catchment management strategies and approaches, FAO promoted participation of men and women in activities in their catchment programmes and their direct involvement has been successful through provision of labour and skills in technology establishment in catchments thereby increasing uptake rate (Table 4).

Table 4: *Gender of the Respondents*

Gender	Frequency	Percentage
0 (Male)	234	63.2
1 (Female)	136	36.8
Total	370	100

4.2.2 Age of Respondents

Data on age of respondents was analyzed and majority of the respondents (74.3 percent) were above 40 years of age and most of them were between 50-60 years old while 5.7 percent were below 40 years old. Respondents below 30 years represented the lowest percentage (1.4) of the total sample size (Table 5).

Table 5 *Age Ranges for Respondents*

Age ranges	Frequency	Percentage
20-30 years	5	1.4
30-40 years	16	4.3
40-50 years	58	15.7
50-60 years	221	59.7
Above 60 years	70	18.9
Total	370	100

Data analysis indicated that participation in catchment management technologies was influenced by age. Older people valued land more than young people therefore made the decision to participate in soil and water conservation activities to conserve the catchments which improved soil fertility and translated in increased productivity. The young men although learned, they did not own land. This is in line with findings by Bayard, Jolly and Shannon (2006) in their study on adoption and management of soil conservation practices in Haiti which indicated that age influenced participation in soil and water conservation whereby uptake increased with progression in age which was also reported by (Sheikh, Redzuan, Samah, & Ahmad, 2014) in their study on factors influencing farmers' participation in water management.

4.2.3 Marital Status of Respondents

Majority of the respondents interviewed were married (99.5 percent). Married men had more labour for technology uptake provided by wives and children unlike those who were not married. The project worked with men, women and youth who were either married or single (Table 6).

Table 6: *Marital Status*

Marital status	Frequency	Percentage
Married	368	99.5
Not married	2	.5
Total	370	100

Men made decisions on which soil and water conservation technology to be taken up on their farms while women and youth implemented decisions made by men through provision of family labour. They participated in catchment management to restore their farms and improve on productivity in maize, milk and forage for improved household income.

Rehema (2014) noted similar observations in her study on factors influencing adoption of soil conservation measures, sustainability and socio economic impacts among smallholder farmers in Mbeya rural District in Tanzania which established that married women participated in soil conservation to increase family income although decisions on technologies were made by men. German, Mansoor, Alemu, Getachew, Mazengia, and Stroud, (2006) confirmed in their study on participatory integrated catchment management that successful watershed management needed to address constraints affecting both women and youth in relation to decision made by men in the catchment for active participation by family members. There was need to consider female domains like reduced areas under agroforestry reflected in less wood fuel and how land use practices affected livelihoods of the people living in catchments.

4.2.4 Farmer's Level of Education

Most of the respondents attained primary level of education followed by secondary level and the least percentage (1.4 percent) of respondents attained tertiary level (Table 7).

Table 7: Farmers' Level of Education

Age ranges	Frequency	Percentage
Not gone to school	33	8.9
Primary level	193	52.2
Secondary level	130	35.1
Middle level college	9	2.4
Tertiary	5	1.4
Total	370	100

This analysis showed that farmers participated and were able to implement soil conservation technologies as long as they had basic education and were taken through the trainings which was similarly reported by Lesch and Wachenheim (2014) in their study on factors influencing conservation practice adoption in agriculture which established that education was found to be inconsistent in participation of respondents in soil and water conservation technologies.

Participation in catchment management technologies increases with proper trainings regardless of academic background. This did not agree with findings by Sheikh et al. (2014) in their study on factors influencing farmers' participation in water management .

4.2.5 Family Size for Respondents

The respondents had varied family sizes whereby majority had more than 5 family members (70 percent), followed by 5 members (23.8 percent), then the rest had between 2- 4 family members (Table 8).

Table 8: *Family Size for Respondents*

Number of family members	Frequency	Percentage
2	2	.5
3	5	1.4
4	16	4.3
5	88	23.8
Above 5	259	70
Total	370	100

A high number of households provided labour that was required in participation of catchment management technologies in the catchments which did not agree with a study by Tadesse and Belay (2004) on factors influencing adoption of soil conservation measures in southern Ethiopia which established that family size affected participation in watershed management technologies negatively. Big family sizes capitalized on short term benefits and would not consider participating in soil conservation whose benefits are long term. Similar findings were reported by Mutuyimana (2015) in her findings on effects of integrated soil and water management on livelihoods of smallholders in Burega sector which reported family size being important for active participation by farmers in soil and water conservation.

4.2.6 Size of Land for respondents

Land sizes varied widely ranging from ½ an acre to more than one acre. Half of the respondents (49.7 percent) owned more than one acre, 39.9% owned one acre and 10.8% had less than one acre of land (Table 9).

Table 9: *Size of Land*

Acreages	Frequency	Percentage
½ acre	10	2.7
¾	30	8.1
1 acre	146	39.5
More than one acre	184	49.7
Total	370	100

Most of the respondents who implemented Integrated Land and Catchments Project had more than 1 acre of land because some of the technologies required more space for their construction while those with smaller pieces of land put one retention ditch on the upper part of their farms and invested in cover crops and agroforestry along the fence. These findings were also reported by Tadesse and Belay (2004) on factors influencing adoption of soil conservation measures in Southern Ethiopia who reported size of land being positive and significantly influenced uptake of soil conservation technologies which agreed with findings by Mutuyimana (2015) in a research on effects of integrated soil and water management on livelihoods of smallholders in Burega sector which established that size of land affected uptake of soil and water conservation technologies.

4.3 Level of Catchment Degradation in Kibuon and Tende Catchments Before and After Integrated Land and Water Management Project

Catchment degradation before and after Integrated Land and Water Management in Kibuon and Tende project (ILWMKTP) was determined through interview schedules and questionnaires. Data was analyzed using ANOVA, Tukey post hoc test, Chi square, Descriptive statistics, Pearson correlation and paired samples T-test statistical methods of analysis. Multiple comparisons were used to show pairs of sub catchments which were different in terms of technology uptake. Catchment management technologies considered were; rill erosion, gullies in the basins, Napier grass established, denuded land, deforestation, Vetivar grass strips, retention ditches constructed, check dams used, cover crops planted, road side erosion control, water turbidity, agroforestry, and area of land conserved for the period before and after project implementation.

4.3.1 Level of Degradation in the Catchments before and after Project Implementation

i. Rill Erosion in the Catchments Before and After Project Implementation

Kibuon K1 sub catchment reported the highest amount of rill erosion at a mean of 4.80 with standard deviation of 0.775 followed by Kibuon K2 sub catchment at a mean of 4.76 with a standard deviation of 0.690. Mogusii T3 sub catchment had a mean of 4.46 with standard deviation of 0.790 while Kasipul K3 sub catchment had a mean of 4.45 with standard deviation of 0.808. Isanta T2 sub catchment had a mean of 4.30 with a standard deviation of 0.462. Tende T1 sub catchment had a mean of 4.06 with a standard deviation of .455.

During the period after project implementation, Kibuon K1 attained a mean of 3.87 with a standard deviation of 0.834 which indicated minimal rill erosion in the sub catchment. It was followed by Mogusii T3 with a mean of 3.85 and standard deviation of 1.113. Third in reporting was Isanta T2 with a mean of 3.55 and standard deviation of 1.138. This was followed by Tende T1 with a mean of 3.51 with standard deviation of 0.986 then Kibuon K2 followed with a mean of 3.50 with standard deviation of 1.370. The sub catchment that reported the least on rill erosion control was Kasipul K3 with a mean of 3.12 and standard deviation of 1.306. Kibuon K1 had the highest mean score on less rill erosion and the least was from Kasipul K3. There was reduced rill erosion after project implementation (Table 10).

Table 10: *Sub Catchment Means on Rill Erosion Before and After Project Implementation*

Sub catchment	N	Mean	Standard deviation	Mean	Standard deviation
	Before			After	
Kibuon K1	15	4.80	.775	3.87	.834
Kibuon K2	70	4.76	.690	3.50	1.370
Kasipul K3	51	4.45	.808	3.12	.1.370
Tende T1	148	4.06	.455	3.51	.986
Isanta T2	47	4.30	.462	3.55	1.138
Mogusii T3	39	4.46	.790	3.85	1.113
Total	370	4.35	.671	3.51	1.151

The degree of confidence interval was set at 95% and ANOVA results indicated that there was a statistically significant difference at F= 14.745 and p= 0.000 on the level at which rill erosion contributed to catchment degradation in different the sub catchments before project implementation (Table 11).

Table 11: *ANOVA Results on Rill Erosion Before Project Implementation*

Variations	Sum of squares	df	Mean of square	F	Sig.
Between groups	26.614	5	5.323	14.745	.000
Within groups	131.397	364	.361		
Total	158.011	369			

The analysis of variance indicated significant differences at F =2.852, p = 0.055 on the level at which rill erosion contributed to catchment degradation in different sub catchments (Table 12).

Table 12: *ANOVA Results on Rill Erosion After Project Implementation*

Variations	Sum of squares	df	Mean square	F	Significant
Between groups	14.262	5	2.852	2.190	.055
Within groups	474.194	364	1.303		
Total	488.457	369			

Multiple comparison before project implementation showed significant mean differences between Kibuon K1 and Tende T1 (.712 mean and significant at 0.001), followed by Kibuon K2 and Tende T2 (.669 mean and significant at 0.001), Isanta T2 had a mean of 0.459 with a significant value of p = .001. The results showed different levels of rill erosion in the catchments before project implementation while after project implementation Mogusii T3 and Kasipul K3 had a higher mean difference of 0.729 with a significant level of 0.034 indicating the pair was significantly different in their responses on rill erosion.

Tukey post hoc analysis indicated three homogeneous sub sets before project implementation; Tende T1 had a significantly lower level of rill erosion compared to Mogusii T3, Kibuon K2 and Kibuon K1. It was similar to Isanta T2 and Kasipul K3 while Kibuon K1 and Kibuon K2 comparably and significantly higher levels of rill erosion Kasipul K3 and Kibuon K1 had a significantly higher (4.8) level of rill erosion compared to Isanta T2 and Tende T1. Isanta T2 was significantly lower than K2 and Kibuon K1 while Mogusii T3 was only comparatively higher than TendeT1. Kasipul K3 and Isanta T2 were not significantly different to any sub catchment. During the period after project implementation, Tukey post hoc analysis indicated that Kasipul K3 was significantly different from Kibuon K1 by experiencing less rill erosion than Kibuon K1 which had a high mean (3.87). Kasipul K3 was comparable to Kibuon K2, Tende T1, Isanta T2, Mogusii T3 and Kibuon K1. Kibuon K2, Tende T1, Isanta T2 and Mogusii T3 were significantly not different from other sub catchments. Kibuon K1 and Kibuon K2 had comparable and significant levels of rill erosion. This implied that the two sub catchments did not have adequate measures in place to control rill erosion (Table13).

Table 13: *Tukey Post Hoc Results on Rill Erosion Before and After Project Implementation*

Sub catchment	N	1	2	3	1	2
		Before			After	
Tende (T1)	148	4.09			3.51	3.51
Isanta (T2)	47	4.30	4.30		3.55	3.55
Kasipul (K3)	51	4.46	4.46	4.46	3.12	
Mogusii (T3)	39		4.51	4.51	3.85	3.85
Kibuon (K2)	70			4.76	3.50	3.50
Kibuon (K1)	15			4.80		3.87
Significant		.069	.628	.131	.057	.717

Kibuon K1 experienced more rill erosion than Tende T1 which indicated that although both of them were in high rainfall areas, Tende T1 farmers took the initiative to protect their soils more than farmers in Kibuon K1. The two sub catchments were in the upper part of the catchments which are highly populated and faced with intensive agricultural practices to feed the high population thereby contributing to more erosion. Through Pearson correlation, there were weak negative correlations between level of rill erosion and maize yields (r -0.058) for milk (r-0.117) and forage (r -0.122) which implied that an increase in rill erosion contributed to a decrease in maize, milk and forage yields. This showed that Kibuon (K1) and Tende (T1) sub catchments had reduced maize, milk and forage yields. About 100 percent of key informants confirmed existence of rill erosion before project implementation (Table 14).

Table 14: *Chi Square Results on Rill Erosion and Increase in Maize, Milk and Forage Yields Before Project Implementation*

Sub catchment	Independent variable	Chi square	df	P value (0.05)
Kibuon K1	rill erosion	.714	2	.700
Kibuon K2	rill erosion	19.302	16	.253
Kasipul K3	rill erosion	12.632	9	180
Tende T1	rill erosion	45.818	16	.000
Isanta T1	rill erosion	6.133	4	.189
Mogusii T3	rill erosion	21.067	12	.049
Total		17.954	16	.327

During the period after project implementation, Kibuon K1 reported controlled rill erosion in the sub catchments which was attributed to ILWMKTP project that disseminated catchment management technologies and suitable climatic conditions that supported biological and physical technologies. This indicated a slightly high uptake of technologies in the sub catchment. Chi Square indicated a significant relationship in Tende T1 (Chi Square = 45.818, df = 16, p value 0.000) and Kibuon K2 (Chi Square = 27.676, df = 16, p value .035).

This was an indication that there was a significant relationship between the sub catchments and rill erosion thereby influencing maize, milk and forage yields. Rill erosion and an increase in maize yield had r 0.141 while milk yield had r .111and more forage had r 0.094 correlations (Table 15).

Table 15: *Chi Square Results on Rill Erosion and Increase in Maize, Milk and Forage Yields After Project Implementation*

Sub catchment	Independent variable	Chi square	df	P value (0.05)
Kibuon K1	rill erosion	10.222	8	.250
Kibuon K2	rill erosion	27.676	16	.035
Kasipul K3	rill erosion	9.709	12	.641
Tende T1	rill erosion	45.818	16	.000
Isanta T1	rill erosion	10.226	12	.596
Mogusii T3	rill erosion	14.319	16	.575
Total		33.411	16	.007

There was high rill erosion in the sub catchments before project implementation. Higher levels of rill erosion before project implementation were also reported by Mwangi et al., (2015) in their study on reconnaissance survey of Kibuon and Tende Catchments before project implementation. African Water Facility (2008) in their study on Integrated Land and Water Management in Kibuon and Tende River reported more pressure on land and faster population growth as factors that contributed to poor agricultural and land management techniques which resulted in a lot of soil erosion in the sub catchments before project implementation.

Findings after project implementation showed that less rill erosion contributed to increase in yields for; maize, milk and forage which was also reported by 66.6 percent of the key informants who reported reduced rill erosion contributing to improvement in maize, milk and forage yields. Kangogo (2016) in his study on impact of soil erosion on maize production confirmed that reduced rill erosion contributed to an increase in maize and forage yields which contributed to increased milk yield. Zomer, Bossio, Trabucco, and Yuanjie (2007) in their study on trees and water which established that protected soil enhanced water infiltration reduced soil erosion caused by surface runoff, sustained plant growth thereby increasing crop productivity.

ii. Gullies in the Catchments Before and After Project Implementation

Through descriptive statistics, Kasipul K3 reported higher levels of uncontrolled gullies with a mean of 4.63 and a standard deviation of .698 compared to Tende T1 with a mean of 3.98 with a standard deviation of 0.644. Kibuon K2 had a mean of 4.59 with a standard deviation of 0.698. Kibuon K1 had a mean of 4.47 with a standard deviation of .834 while Isanta had a mean of 4.13 with a standard deviation of 0.797. Mogusii T3 had a mean of 4.08 with a standard deviation of 1.036. Kibuon K1 reported high level of gulley controlled after project implementation at a mean of 3.93 with a standard deviation of 0.961. It was followed by Mogusii T3 with a mean of 3.74 with a standard deviation of 1.069. Kibuon K2 was third with a mean of 3.33 and standard deviation of 1.370. Isanta T2 was fourth with a mean of 3.26 and standard deviation of 1.170 followed by Tende T1 with a mean of 3.11 and a standard deviation of 0.973. The last was Kasipul K3 at a mean of 3.04 with a standard deviation of 1.232 reporting the least controlled gullies after project implementation (Table 16).

Table 16: *Sub Catchment Means on Gullies in the Catchments*

Sub catchment	N	Mean	Standard deviation	Mean	Standard deviation
		Before		After	
Kibuon K1	N	4.47	.834	3.93	.961
Kibuon K2	70	4.59	.698	3.10	1.416
Kasipul K3	51	4.63	.663	2.90	1.136
Tende T1	148	3.98	.644	3.01	1.010
Isanta T2	47	4.13	.797	3.11	1.088
Mogusii T3	39	4.08	1.036	2.92	1.201
Total	370	4.24	.780	3.05	1.151

Degree of confidence interval was set at 95% and ANOVA results indicated statistically significant difference (F= 10.870, p = .000) on the level at which uncontrolled gullies in the six sub catchments contributed to degradation before project implementation. This indicated that although there were gullies in all catchments, their levels varied within sub catchments hence the significant differences between them. Tende sub catchment had the least gullies due to small farm holdings most farmers conserved their farms reducing number of gullies (Table 17).

Table 17: *ANOVA Results on Gullies in the Catchments Before Project Implementation*

Variations	Sum of squares	df	Mean square	F	Sig.
Between groups	29.172	5	5.834	10.870	.000
Within groups	195.372	364	.53		
Total	224.543	369			

The analysis of variance after project implementation showed that there were significant differences at F = 3.431, p= .000 on the level at which controlled gullies contributed to reduction in catchment degradation in different sub catchments. This showed that results on many gullies controlled had influence on increase in maize, milk and forage yields in the catchments (Table 18).

Table 18: *NOVA Results on Controlled Gullies in the Catchment After Project Implementation*

Variations	Sum of squares	df	Mean square	F	Significant
Between groups	21.853	5	4.371	3.431	.000
Within groups	463.717	364	1.274		
Total	485.570	369			

On multiple comparisons, Mogusii T3 and Kasipul K3 had a higher mean difference of .704 with significance at .041 followed by Mogusii T3 and Tende T1 which had a mean difference of 0.629 with a significance value of 0.026. This indicated that their scores on controlled gullies were different. The Post hoc analysis indicated that Tende T1 had significantly lower levels of uncontrolled gullies compared to Mogusii T3, Isanta T2, Kibuon K1, Kibuon K2 and Kasipul K3 while it was similar to Mogusii T3 and Isanta T2. Kasipul K3 had higher level of uncontrolled gullies compared to Kibuon K2, Kibuon K1, Isanta T2, Mogusii T3 and Tende T1 sub catchments. Isanta T2 was not significantly different to any sub catchment. This showed that runoff in Tende T1 was controlled from the upper part of the sub catchment to the lower parts reducing gulley formation.

Further Tukey post hoc results after project implementation reported that Kasipul K3 was significantly different from Kibuon K1 by reporting lower number of gullies controlled than Kibuon K1 which reported a higher number of gullies controlled. Kasipul K3 reported few gullies controlled compared with Tende, Isanta T2, Kibuon K2 and Mogusii T3. Isanta T2, Kibuon K2 and Mogusii T3 were not significantly different from any sub catchment (Table 19).

Table 19 : *Tukey Post Hoc Results on Gullies in the Catchments Before and After Project Implementation*

Sub catchment	N	1	2	3	4	1	2
		Before				After	
Tende T1	148	3.98				3.11	
Mogusii T3	39	4.08	4.08			3.74	3.74
Isanta T2	47	4.13	4.13	4.13		3.26	3.26
Kibuon K1	15		4.47	4.47	4.47		3.93
Kibuon K2	70			4.59	4.59	3.33	3.33
Kasipul K3	51				4.63	3.04	
Significant		.949	.179	.064	.926	.068	.088

Kasipul had many uncontrolled gullies because it had more open land with a lot of zebu animals under free range system which contributed to gulley development compared to Tende T1 which had dairy animals under zero grazing system. Kibuon K2 had a slightly higher number of uncontrolled gullies because the lower part lies in South Karachuonyo which practices free range type of livestock rearing compared to Kibuon K1. Chi Square was used to analyze data on uncontrolled gullies and increased maize, milk and forage yields. Results showed significant relationship between uncontrolled gullies and increased maize (Chi square = 23.324, p = 0.025) in Mogusii T3 sub catchment while milk and forage increase were not significant (Table 20).

Table 20: *Chi Square Results on Gullies and Increase in Maize, Milk, and Forage Yields*

Sub catchment	Independent variable	Chi square	df	P value (.05)	Chi square	df	P value
Kibuon K1	gullies in the basins	9.583	12	.652	8.437	12	.750
Kibuon K2	gullies in the basins	17.201	16	.373	24.320	16	.083
Kasipul K3	gullies in the basins	7.660	12	.811	13.737	16	.618
Tende T1	gullies in the basins	7.624	12	.814	16.081	16	.447
Isanta T2	gullies in the basins	9.454	9	.396	8.634	12	
Mogusii T3	gullies in the basins	23.234	12	.025	29.931	12	.003
Total					19.023	16	.267

There was evidence that uncontrolled gullies affected maize, milk and forage yields which was confirmed by 88.9 percent of the key informants. Through Pearson correlation, there was a weak negative correlation between level of uncontrolled gullies and increase in maize (r -0.030), milk (r -0.013) and forage yields (r -0.075). This meant that an increase in number of uncontrolled gullies contributed to a decrease in maize and milk yields. The findings indicated that sub catchments in Kibuon catchment had many uncontrolled gullies than those in Tende catchment. This was similar to the findings by Mwangi et al., (2015) in their study on Reconnaissance Survey of the Kibuon and Tende catchments before project implementation which established that there were few gulley controlled in the catchments.

Kibuon K1 had a higher mean (3.93) among sub catchments on many controlled gullies after project implementation. There were many controlled gullies in Kibuon K1 compared to Kasipul K3 because Kibuon K1 is located in the Kisii highlands which receives a lot of rain compared to Kasipul K3. A report from key informants (77.7 percent) indicated the presence of many controlled gullies in the catchments after project implementation.

Chi Square test showed that relationship between many controlled gullies and increased maize, milk and forage yields in Mogusii T3 catchments was statistically significant (Chi Square = 29.931, df = 12, p value = 0.003). However, the other sub catchments did not have a significant relationship.

Many gullies controlled had a weak correlation with increased maize (r 0.192) and milk yields (r 0.157) while more forage was r .194. These findings indicated that an increase in number of gullies controlled contributed to an increase in maize, milk and forage yields (Table 21).

Table 21: *Chi Square Analysis Results on Controlled Gullies and Increase in Maize, Milk and Forage Yields after Project Implementation*

Sub catchment	Independent variable	Chi square	df	P value (.05)
Kibuon K1	Gullies controlled after project	8.437	12	.750
Kibuon K2	Gullies controlled after project	24.320	16	.083
Kasipul K3	Gullies controlled after project	13.737	16	.618
Tende T1	Gullies controlled after project	16.081	16	.447
Isanta T2	Gullies controlled after project	8.634	12	.734
Mogusii T3	Gullies controlled after project	29.931	12	.003
Total		51.699	16	.000

Respondents who controlled gullies after project implementation contributed to increase in maize, milk and forage in the catchments. Those who failed to control them reduced land productivity as agreed by Desta (2015) in their findings on gulley assessment, prevention and control which established that inadequate gulley controls leads to low land productivity. According to Adugna & Desta (2012) in their guide on gulley prevention and control, catchment degradation decreased land productivity established that gulley control improves land productivity.

iii Napier Grass Established Before and After Project Implementation

Various means were achieved before project implementation in the sub catchments through descriptive statistics. Kibuon K2 reported the lowest level of Napier grass established with a mean of 4.41 and a standard deviation of 1.014. It was followed by Isanta T2 with a mean of 4.26 with a standard deviation of 0.570. Kasipul K3 was third with a mean of 3.98 and a standard deviation of 1.273 which was followed by Mogusii T3 with a mean of 3.95 and a standard deviation of 1.123. Tende T1 reported a lowest mean (3.84) on establishing less Napier with a standard deviation of 1.273 while Kibuon K1 had the lowest mean of 3.67 and standard deviation of 1.633.

Descriptive statistics after project implementation reported Kibuon K1 with the highest amount of Napier grass established with the mean of 4.20 and a standard deviation of 1.265. It was followed by Kasipul K3 which had a mean of 3.24 and standard deviation of 1,210. Third in reporting was Tende T1 with the mean of 3.20 and standard deviation of 1.088, Kibuon K2 was fourth with a mean of 3.16 and standard deviations of 1.369. Isanta followed with a mean of 3.02 and standard deviation of 1.073. The sub catchment that reported less Napier grass established was Mogusii T3 at 2.97 and a standard deviation of 1.287 (Table 22).

Table 22: *Sub Catchment Means on Napier Grass Established Before and After Project Implementation*

Sub catchment	N	Mean	Standard deviation	Mean	Standard deviation
		Before		After	
Kibuon K1	15	3.67	1.633	4.20	1.265
Kibuon K2	70	4.41	1.014	3.16	1.369
Kasipul K3	51	3.98	1.273	3.24	1.210
Tende T1	148	3.84	.726	3.20	1.073
Isanta T2	47	4.26.	.570	3.02	1.073
Mogusii T3	39	3.95	1.123	2.97	1.287
Total	370	4.03	.974	3.19	1.202

Degree of confidence interval was set at 95% and analysis of variance indicated significant differences at F= 4.456, p = .000 on the level at which different amount of napier grass established affected catchment degradation in different sub catchments before project implementation (Table 23).

Table 23: *ANOVA Results on Napier Grass Established Before Project Implementation*

Variations	Sum of square	df	Mean of square	F	Sig.
Between groups	20.171	5	4.034	4.456	.000
Within groups	329.559	364	.905		
Total	349.730	369			

According to multiple comparisons, Kibuon K2 and Tende T1 had a high mean difference of 0.570 significant at 0.001 which implied that the two sub catchments were significantly different from each other in terms of quantities of Napier grass established.

Further, ANOVA test results after project implementation showed statistically significant differences at F- 2.639, p = .023 on the level at which napier grass established contributed to reduced catchment degradation in different sub catchments (Table 24).

Table 24: *ANOVA Results on Napier Grass Established After Project Implementation*

Variations	Sum of squares	df	Means squares	F	Significant
Between groups	18.656	5	3.731	2.639	.023
Within groups	514.720	364	1.414		
Total	533.376	369			

In multiple comparisons, Kibuon K1 and Mogusii T3 had a high mean difference of 1.226 significant at .010, Kibuon K1 and Isanta T2 had 1.179 mean significant at .012, Kibuon K1 and Tende T1 had a mean difference of 0.997 significant at 0.026 .

Two homogeneous sub sets were displayed before project implementation; Kibuon K1 had significantly more Napier grass established compared to Kibuon K2 while Tende T1, Mogusii T3, Kasipul K3 and Isanta T2 were not significantly different from any sub catchment. Kibuon K2 had significantly lower level of established Napier grass compared with Tende T1 and Isanta T2. Forty percent of the key informants reported less Napier grass established before implementation of ILWMKTP project as a fodder for their livestock without knowing it also reduced soil erosion. In multiple comparisons before project implementation, Kibuon K1 and Mogusii T3 had a high mean difference of 1.226 significant at .010, Kibuon K1 and Isanta T2 had 1.179 mean significant at .012, Kibuon K1 and Tende T1 had a mean difference of 0.997 significant at 0.026.

A test run for homogeneous subsets after project implementation sub catchments appeared in two subsets before project implementation. Kibuon K1 was different from the rest of the sub catchments because it reported more Napier grass established compared to the other sub catchments after project implementation. Kasipul K3 had less napier grass grown compared to Kibuon K2, Mogusii T3, Isanta T2 and Tende T1 but it was similar to Kibuon K2, Mogusii T3, Isanta T2, and Tende T1 (Table 25).

Table 25: *Tukey Post Hoc Results on Napier Grass Planted*

Sub catchment	N	1	2	1	2
		Before		After	
Kibuon K1	15	3.67			4.20
Tende T1	148	3.84	3.84	148	
Mogusii T3	39	3.95	3.95	3.16	
Kasipul K3	51	3.98	3.98	2.97	
Isanta T2	47	4.26	4.26	3.20	
Kibuon K2	70		4.41	3.02	
Significant		.072	.090	.082	

Kibuon K2 reported less Napier before programme implementation because the lower part of the catchment in Kadongo borders dry areas towards the lake which is not suitable for Napier grass due to harsh climate while Kibuon K1 is in Kisii highlands which receives a lot of rain which supports Napier production.

The findings indicated that sub catchments in the upper part of the catchments produced more Napier because of more rainfall received in the area. Sub catchments in the middle part of the catchment produced more Napier than those in the lower parts of the two catchments because it forms a transition between Kibuon K1 and Kasipul K3.

Chi Square results before project implementation on more Napier grass established and increased maize, milk and forage yields showed no significant relationship which meant that amount of Napier grass produced was not enough to influence maize, milk and forage productivity. It was established that after project implementation less Napier established had a significant relationship with increased maize and milk yields, and more forage in Mogusii T3 sub catchment (Chi Square = 21.969, df = 12, p value = .038). However there was no significant relationship in the other sub catchments which implied that there was no clear evidence to show that less Napier grass established affected increase in maize, milk and forage yields directly from the sub catchments (Table 26).

Table 26: *Chi Square Results on Napier Established and Increase in Maize, Milk, and Forage Yields*

Sub catchment	Independent variable	Chi square	df	P value (0.05)
Kibuon K1	Napier grass established	9.323	16	.900
Kibuon K2	Napier grass established	18.414	16	.300
Kasipul K3	Napier grass established	18.369	16	.303
Tende T1	Napier grass established	17.613	12	.128
Isanta T2	Napier grass established	5.618	6	.467
Mogusii T3	Napier grass established	21.969	12	.038
Total		31.176	16	.013

About 77.7 percent of the key informants indicated that less Napier grass was established in the catchments before project implementation compared with after project implementation. Through Pearson correlation there was a weak correlation value of r -.004 between less Napier established and maize increase in yield, r -0.055 with increase in milk and more forage had r 0.020.

The findings before project implementation showed that a reduction in Napier grass grown contributed to a decrease in maize and milk yields but increase in forage yields which implied that a decrease in Napier grass established contributed to production of other fodder varieties hence the positive correlation with forage which was confirmed by Mwangi et al.(2015) in their study on reconnaissance Survey of the Kibuon and Tende Catchments before project implementations which reported that less Napier grass affected increase in maize and milk yields. The study recommended planting of Napier grass to reduce soil erosion and improve on dairy production in the watersheds. This was shared by Govers, Merckx, Wesemael and Oost (2017) in their findings on why we need smart agricultural intensification who established that vegetation measures such as grass including napier grass control runoff speed thereby reducing soil erosion but areas with less grass runoff speed enhanced soil erosion .

About 56 percent of the key informants reported an increase in Napier grass established after project implementation which contributed to soil conservation reflected in reduced soil erosion. Napier grass had weak correlations; increase in maize yields had r .265, increase in milk had r .103 while more forage had a weak correlation of r .200. The findings showed that an increase in Napier grass established contributed to increase in maize, milk and forage yields.

This report was confirmed by Orodho (2012) in his research findings on the role and importance of Napier grass in smallholder dairy industry in Kenya who established that Napier grass influenced milk yield when harvested at the right stage. Napier grass has no influence on milk yields if harvested very early or late in age. This information was also shared with Mutegi, Mugendi, Verchot and Kung'u (2008) in their research on combining Napier grass with leguminous shrubs which established that napier grass influenced yield in milk production positively while Napier grass without leguminous fodder did not affect increase in maize yield. Chi Square results on more Napier grass established and increased maize, milk and forage yields showed no significant relationship which meant amount of Napier grass produced was not enough to influence maize, milk and forage productivity (Table 27).

Table 27: *Chi Square Analysis Results on Napier Grass Established and Increase in Maize, Milk and Forage Yields After Project Implementation*

Sub catchment	Independent variable	Chi square	df	P value (.05)
Kibuon K1	Napier established after project	11.958	12	.449
Kibuon K2	Napier established after project	25.057	16	.069
Kasipul K3	Napier established after project	17.580	16	.349
Tende T1	Napier established after project	24.841	16	.073
Isanta T2	Napier established after project	12.434	12	.411
Mogusii T3	Napier established after project	12.434	12	.411
Total		59.383	16	.000

iv Denuded Land Before and After Project Implementation

Descriptive statistics determined means of the six sub catchments before project implementation; Kibuon K2 out of six sub catchments reported more denuded land before project implementation with a mean of 4.49 and a standard deviation of 0.928. Isanta T2 had a mean of 4.15 with a standard deviation of 0.751 while Mogusii T3 had a mean of 4.00 with a standard deviation of 1.051. Kasipul K3 had a mean of 3.92 and a standard deviation of 1.051 and Tende T1 reported the lowest amount of denuded land with a mean of 3.85 and a standard deviation of .794.

Descriptive statistics used after project implementation reported Kibuon K1 with the highest level of less denuded land (Mean = 4.47, standard deviation = 0.640) followed by Kibuon K2 that had a mean of 3.91 and a standard deviation of 1.032. Kasipul K3 had a mean of 3.82 with a standard deviation of 1.072 while Tende T1 had a mean of 3.35 and standard deviation of 1.142. Isanta T2 had a mean of 3.28 and standard deviation 1.210 followed by Mogusii T3 with a mean of 3.21 and a standard deviation of 1.321 (Table 28).

Table 28: *Sub Catchment Means on Denuded Land Before and After Project Implementation*

Sub catchment	N	Mean	Standard deviation	Mean	Standard deviation
		Before		After	
Kibuon K1	15	3.40	1.404	4.47	.640
Kibuon K2	70	4.49	.928	3.91	1.032
Kasipul K3	51	3.92	1.309	3.82	1.072
Tende T1	148	3.85	.794	3.35	1.142
Isanta T2	47	4.15	.751	3.28	1.210
Mogusii T3	39	4.00	1.051	3.21	1.321
Total	370	4.02	.988	3.54	1.166

The ANOVA analysis results indicated significant differences at F = 5.773, p = 0.000 on the level at which denuded land contributed to catchment degradation in sub catchments before project implementation (Table 29).

Table 29: *ANOVA Results on Denuded Land Before Project Implementation*

Variations	Sum of squares	df	Mean squares	F	Sig.
Between groups	26.444	5	5.289	5.773	.000
Within groups	333,459	364	.916		
Total	359.903	369			

Multiple comparisons showed that Kibuon K2 and Kibuon K1 had a mean difference of 1.086 and significant at .001, Kibuon K2 and Tende T1 had a mean difference of .634 significant at p = 0.000, Kibuon K2 and Kasipul K3 had a mean difference of 0.564 and standard deviation of 1.76 significant at 0.18. This indicated that number of denuded farms was different in the sub catchments hence significantly different among sub catchments. Analysis of variance showed that there were significant differences at F = 6.252, p = 0.000 on the level at which denuded land contributed to catchment degradation in different sub catchments (Table 30).

Table 30: *ANOVA Results on Denuded Land Before Project Implementation*

Variations	Sum of squares	df	Mean squares	F	Sig.
Between groups	26.444	5	5.289	5.773	.000
Within groups	333,459	364	.916		
Total	359.903	369			

Tukey post hoc analysis results on denuded land before project implementation indicated three levels of homogeneous sub sets. Kibuon K1 was significantly less denuded compared to T2 and Kibuon K2. Kibuon K2 was significantly more denuded compared to K1, K3 and T1. More denuded land was reported in Kibuon K2 than Kibuon K1. This was attributed to the hot effects of Lake Victoria in the lower parts of Kibuon K2 that borders Kasipul K3 which experiences harsh weather due to the influence from Lake Victoria. Kibuon K2 forms a transition between Kibuon K1 and Lower Kibuon K3 which is comparatively dry. Kibuon K1 had less denuded land because the sub catchment receives more rain and has more trees that provide land cover.

Further Tukey post hoc analysis indicated that sub catchments appeared in two sub sets after project implementation. Mogusii T3 was significantly different from Kibuon K1 by many respondents reporting more denuded land, but similar to Isanta T2, Tende T1, Kasipul K3, and Kibuon K2. Kibuon K1 reported less denuded land compared to Mogusii T3 while Kasipul K3 and Kibuon K2 were not significantly different to any other sub catchments (Table 31).

Table 31: *Tukey Post Hoc Results on Denuded Land*

Sub catchment	N	1	2	3	1	2
		Before			After	
Kibuon K1	15	3.40			4.47	
Tende T1	148	3.85	3.85	3.35		
Kasipul K3	51	3.92	3.92	3.82	3.82	
Mogusii T3	39	4.00	4.00	4.00	3.21	
Isanta T2	47		4.15	4.15	3.28	
Kibuon K2	70			4.49	3.91	
Significant		.066	.744		.064	.122

Kibuon K2 reported more denuded land before project implementation which was attributed to harsh weather in parts of the sub catchment accompanied with more livestock which are not confined. The lower part of the sub catchment is dry and receives heavy erratic rainfall which causes soil erosion subjecting the sub catchment to denudation. Isanta T2 and Mogusii T3 had comparably high level of denuded land. The results also showed that sub catchments in the middle (2) and lower parts (3) of the two catchments reported more denuded land due to reduced amount of rain fall as the catchments approaches Lake Victoria. Chi Square was used to determine a relationship between level of denuded land and increased maize and milk yields, and more forage. Mogusii T3 had a significant relationship indicating that there was evidence to show that more denuded land influenced increase in maize, milk, and fodder yields negatively (Table 32).

Table 32: *Chi Square on Denuded Land and Increase in Maize, Milk, and Forage Yields*

Sub catchment	Independent variable	Chi square	df	P value (.05)
Kibuon K1	denuded land	16.250	16	.436
Kibuon K2	denuded land	12.752	16	.691
Kasipul K3	denuded land	20.757	16	.188
Tende T1	denuded land	19.748	16	.232
Isanta T2	denuded land	5.540	9	.985
Mogusii T3	denuded land	18.819	12	.093
Total		31.082	16	.013

Pearson correlation between more denuded land and increase in maize yields had a weak correlation of r - 0.078, milk had r -0.002 while forage had r -0.053. These findings indicated that an increase in denuded land resulted in a decrease in maize, milk and forage yields. About 55.5 percent key informants reported reduced land productivity in denuded farms in the catchments which was shared by Desalegna, Erkosa and Prabha (2012) in their study on characterization and cost estimation of erosion in Abay basin which reported loss of land productivity up to 1.8 percent through land denudation. This information agreed with findings by Orodi (2011) on status of Integrated Water Resources Management Project implementation and climate change adaptation measures which established that Kibuon K2 sub catchment had more livestock under free range system of production and fewer sources of water which contributed to more land denudation thereby reducing land productivity.

Kibuon K1 reported less land denudation while Mogusii T3 reported more after project implementation. The location for Kibuon K1 is in the Kisii highlands with more rain supporting vegetation growth and reducing land denudation compared to Mogusii T3 which partly receives less rainfall in areas towards Lake Victoria. Data collected was subjected to Chi Square and there was a significant relationship in Tende T1 sub catchment (Chi Square = 38.989, df = 16, p value = 0.001) between less denuded land and increase in maize, milk and forage yields. This implied that less denuded land contributed to more soil protection and fertility improvement which reflected in the improved yields in maize, milk and forage yields. Reduction in denuded farms was reported by 56 percent of the key informants (Table 33).

Table 33: *Chi Square Results on Denuded Land and Increase in Maize, Milk and Forage Yields After Project Implementation*

Sub catchment	Independent variable	Chi square	df	P value (.05)
Kibuon K1	denuded land	5.000	6	.544
Kibuon K2	denuded land	16.241	16	.436
Kasipul K3	denuded land	11.315	12	.502
Tende T1	denude land	38.989	16	.001
Isanta T2	denuded land	10.314	16	.850
Mogusii T3	denuded land	22.590	16	.125
Total		40.446	16	.001

Pearson correlation indicated a weak correlation (r 0.073) between less denuded land and increase in maize. Milk had a correlation value of r 0.072 while forage yield had correlation of 0.167. The correlations between denuded land and increase in maize, milk and forage yields implied that an increase in less denuded land contributed to an increase in maize, milk and forage. This finding agreed with a study by Kieti et al. (2016) on biophysical conditions and land use methods which reported that denuded land reduces land productivity in catchments. According to Koundouri (2003) in his study on catchments economics, it was determined that exposure of soil to rain and runoff due to land denudation enhances soil erosion, loss of soil fertility but if controlled agricultural productivity in watersheds improves.

v Deforestation in the Sub Catchments Before and After Project Implementation

Descriptive statistics presented the following results realized; Kibuon K2 out of the six sub catchments reported a higher level of deforestation at mean of 4.57 with a standard deviation of .753, Isanta T2 had a mean of 4.19 and standard deviation of .680, Kasipul K3 followed with a mean of 4.12 with a standard deviation of 1.143, Mogusii T3 had a mean of 4.08 and standard deviation of .929, Kibuon K1 had a mean of 4.00 with a standard deviation of 1.195 and Tende T1 had the least levels of deforestation before project implementation at a mean of 3.84 with a standard deviation of .789.

The period after project implementation had the following means; Kibuon K1 had a mean of 4.40 with a standard deviation of 1.056, Kibuon K2 had a mean of 3.61 and 1.289 standard deviation, Mogusii T3 had a mean of 3.54 and a standard deviation of 1.047, Kasipul K3 had a mean of 3.53 and standard deviation of 1.222, Tende T1 had a mean of 3.16 and 1.048 standard deviation, Isanta T2 had a mean of 3.15 and standard deviation of 1.215 (Table 34).

Table 34: *Sub Catchment Means on Deforestation Before and After Project Implementation*

Sub catchment	N	Mean	Standard deviation	Mean	Standard deviation
		Before		After	
Kibuon K1	15	4.00	1.195	4.40	1.056
Kibuon K2	70	4.57	.753	3.61	1.289
Kasipul K3	51	4.12	1.143	3.61	1.289
Tende T1	148	3.84	.789	3.16	1.048
Isanta T2	47	4.19	.680	3.15	1.215
Mogusii T3	39	4.08	.929	3.54	1.047
Total	370	4.09	.895	3.38	1,173

At 95% degree of confidence interval, ANOVA results indicated that there were statistically significant differences at F= 6.954 p= .000 on the level at which deforestation contributed to catchment degradation in different sub catchments before project implementation (Table 35).

Table 35: *ANOVA Test Results on Deforestation Before Project Implementation*

Variations	Sum of squares	df	Mean squares	F	Significant
Between groups	25.781	5	5.156	6.954	.000
Within groups	269.908	364	.742		
Total	295.689	369			

Multiple comparisons showed that Kibuon K2 and Tende T1 had a significant mean difference of .727, p = .025, Kibuon K2 and Mogusii T3 had a significant mean of .495 with a p- value of .049. The results indicated the two pairs being significantly different by having different levels of deforestation.

The analysis of variance showed that there were significant differences at F= 4.823, p= .0.000 on the level at which deforestation contributed to catchment degradation in different catchments although their mean values were low. Multiple comparisons before project implementation showed that Kibuon K1 and Tende T1 had a high mean difference of 1.251 significant at 0.001, Kibuon K1 and Isanta had 1.251 mean significant at 0.004 (Table 36).

Table 36: *ANOVA Results on Deforestation After Project Implementation*

Variations	Sum of squares	df	Mean square	F	Significant
Between groups	31.536	5	6.307	4.823	.000
Within groups	475.967	364	1.308		
Total	507.503	369			

Tukey post hoc analysis indicated sub catchments grouped into two sub sets in relation to the level of deforestation .Tende T1 was significantly less deforested compared to Kibuon K2 while Kibuon K2 was significantly more deforested compared to K1 and T1. Sub catchment Mogusii T3, Kasipul K3 and Isanta T2 were not significantly different from any sub catchment. Tende T1 sub catchment covers part of Kisii highlands which contribute to more rain and trees in the sub catchment. This type of environment resulted in more vegetation cover hence less deforestation in Tende T1 while part of Kibuon K2 sub catchment was faced with free range livestock rearing system, absence of soil conservation structures and land cultivation done against contours loosing productive land hence reduced productivity.

Homogeneous sub sets after project implementation displayed 2 levels of sub sets. Kibuon K1 was significantly different from Mogusii T3 and had reduced deforestation compared to Mogusii T3 that had a lower mean. Mogusii was similar to Isanta T2, Kibuon K2, Tende T1, and Kasipul sub catchments (Table 37).

Table 37: *Tukey Post Hoc Results on Deforestation Before and After Project Implementation*

Sub catchment	N	1	2	1	2
		Before		After	
Tende T1	148	3.84		3.13	3.13
Kibuon K1	15	4.00			3.73
Mogusii T3	39	4.08	4.08	2.92	
Kasipul K3	51	4.12	4.12	3.37	3.37
Isanta T2	47	4.19	4.19	3.06	3.06
Kibuon K2	70		4.57	3.10	3.10
Significant		.482	.117	.535	.119

There was more cutting down of trees to provide fire wood and charcoal in Kibuon K2 before project implementation compared to Tende T1 contributing to high levels of deforestation. Sub catchments in the middle parts (2) of the two catchments were faced with more deforestation. Kibuon K1 reported high levels of reduced deforestation in the sub catchment compared to Mogusii T3 after project implementation.

This could be attributed to ILWMKTP project that disseminated agroforestry practices and afforestation using indigenous trees that provided fire wood and had less water abstraction. Mogusii T3 reported low levels of reduced deforestation possibly few respondents took up agroforestry technologies during ILWMKTP project, climatic conditions in part of the sub catchment is not conducive for growing of trees and charcoal burning has not been abandoned although reduced.

Chi Square was used to analyze data on more deforestation and increased maize, milk and forage yields before project implementation. The following outputs were realized for the period before project implementation; Kasipul K3 (Chi Square = 30.133, df = 16, p value =0 .017) and Mogusii T3 (Chi Square = 19.331, df = 9, p value = 0.023). The rest of the sub catchments did not have a significant relationship; Kibuon K1 (Chi Square = 23, df = 16, p value = 1.00), Kibuon K2 (Chi Square = 11.000, df = 16, p value = 0.809) Tende T1 (Chi Square= 10.888, df = 12, p value .539 and Isanta T2 (Chi Square = 3.259, df = 9, p value = 0.953). All sub catchments except Mogusii T3 and Kasipul K3 did not have evidence that more deforestation affected increase in maize, milk yields and more forage (Table 38).

Table 38: *Chi Square Results on Deforestation and Increase in Maize, Milk, and Forage Yields Before Project Implementation*

Sub catchment	Independent variable	Chi square	df	P value (.05)
Kibuon K1	deforestation	23.542	16	.100
Kibuon K2	deforestation	11.000	16	.809
Kasipul K3	deforestation	30.133	16	.017
Tende T1	deforestation	10.888	12	.539
Isanta T2	deforestation	3.259	9	.953
Mogusii T3	deforestation	19.331	9	.023
Total		32.066	16	.010

Key informants (77 percent) reported more deforestation in the catchments before project implementation which contributed to reduced yields in maize, milk and forage. Through Pearson correlation, more deforestation and increase maize and milk yields had a weak correlation of r -0.041 and r -0.077 while more forage had r 0.069. This indicated that deforestation affected maize and milk increase negatively. An increase in deforestation resulted in a slight increase in forage possibly the deforested areas provided natural pastures to the livestock hence the positive correlation value for more forage. This indicated that sub catchments that had high levels of deforestation experienced yield reduction in maize and milk.

These findings were shared by (Mwangi et al., 2015) in their study on reconnaissance survey of the Kibuon and Tende River Catchments before project implementation which found out that deforestation contributed to low productivity and was confirmed by Wamalwa (2009) in his study on prospects and limitations of integrated catchment in Mara watershed which reported deforestation contributing to loss of productive land.

Chi Square analysis after project implementation reported Mogusii T3 having a significant relationship between reduced deforestation and increase in; maize, milk and forage yields; (Chi Square = 30.001, df = 12, p value = 0.003) which indicated that reduced deforestation contributed to an increase in maize, milk and forage yields. Reduced deforestation was reported by 77.8 percent of the key informants which reflected in reduced less soil erosion (Table 39).

Table 39: *Chi Square Analysis Results on Deforestation and Increased Maize, Milk and Forage Yields After Project Implementation*

Sub catchment	Independent variable	Chi square	df	P value (.05)
Kibuon K1	deforestation	9.375	12	.671
Kibuon K2	deforestation	24.755	16	.074
Kasipul K3	deforestation	13.769	16	.616
Tende T1	deforestation	22.919	16	.116
Isanta T2	deforestation	6.951	12	.861
Mogusii T3	deforestation	30.001	12	.003
Total		65.342	16	.000

Pearson correlation on reduced deforestation and increase was r 0.168 for maize, r. 151 for milk while forage yields had r 0.097. The findings showed that a reduction in deforestation resulted in increase in maize, milk and forage yields. These findings were confirmed by Gunya (2009) in his research on participatory catchment management to decrease land degradation and sediment transport in Kagera and Nyando catchments of Lake Victoria which established that controlled deforestation resulted in increased productivity improving food security in catchments. Zomer et al. , (2007) in their research on trees and water confirmed that reduced deforestation through tree planting increased land productivity and enhanced livelihoods and improved economic security.

vi Vetiver Grass Strips established Before and After Project Implementation

Through descriptive statistics many respondents in Kibuon K2 reported absence of Vetiver grass strips at a mean of 4.59 with a standard deviation of 0.909, Kasipul K3 had a mean of 4.51 with a standard deviation of 0.612. Kibuon K1 had a mean of 4.40 with a standard deviation of 1.121 while Mogusii T3 had mean of 4.36 with 0.628 with a standard deviation. Isanta had a mean of 4.28 with a standard deviation of 0.452 while Tende (T1) had the least mean of 4.14 with a standard deviation of 0.547. Kibuon K2 had the lowest number of vetiver grass strips while Tende T1 had more vetiver grass strips than Kibuon 2 before project implementation. Data analysis was run on presence of many vetiver grass strips after project implementation. Kibuon K2 had the highest mean of 3.81 with a standard deviation of 1.207. Kibuon K1 was second with a mean of 3.80 and a standard deviation of 1.082. Kasipul K3 had a mean of 3.53 and a standard deviation of 1.155, Mogusii T3 had a mean of 3.51 with a standard deviation of 1.144. Isanta T2 had a mean of 2.96 with a standard deviation of 0.999. Tende T1 had a mean of 3.25 with a standard deviation of 1.136 and Isanta T2 had a mean of 2.96 mean and a standard deviation of 0.999 (Table 40).

Table 40: *Sub Catchment Means on Vetiver Grass Strips Before and After Project implementation*

Sub catchment	N	Mean	Standard deviation	Mean	Standard deviation
		Before		After	
Kibuon K1	15	4.40	1.121	3.80	1.082
Kibuon K2	70	4.59	.909	3.81	1.207
Kasipul K3	51	4.51	.612	3.51	1.144
Tende T1	148	4.14	.547	3.25	1.161
Isanta T2	47	4.28	.452	2.96	.999
Mogusii T3	39	4.36	.628	3.51	1.144
Total	370	4.33	.686	3.41	1.161

Analysis of variance results showed that there were significant differences at F= 5.267, Sig. =.000 on the level at which few vetivar grass strips established affected catchment degradation in different sub catchments before project implementation (Table 41).

Table 41: ANOVA Results on Vetiver Grass Strips Before Project Implementation

Variations	Sum of squares	df	Mean square	F	Significant
Between groups	11.700	5	2.340	5.267	.000
Within groups	161.730	364	.444		
Total	173.430	369			

Post hoc tests reported the following pairs having significant differences in their scores; Kibuon K2 and Tende T1 had mean difference of 0.444 significant at 0.001 while Kasipul K3 and Tende T1 had a mean difference of 0.368 significant at 0.010. The pairs were statistically different from each other implying that the number of vetiver grass strips varied in the sub catchments.

Analysis of variance after project implementation indicated that there were significant differences at F= .4.388, p = 0.000 on the level at which vetivar grass strips established contributed to reduced catchment degradation in different sub catchments (Table 42).

Table 42: *ANOVA Results on Vetiver Grass Strips After Project Implementation*

Variations	Sum of squares	df	Mean squares	F	Significant
Between groups	28.276	5	5.655	4.388	.000
Within groups	469.100	364	1.289		
Total	497.376				

Multiple comparisons before project implementation showed Kibuon K2 and Isanta T2 had a higher mean difference of .857 significant at 0.001 and Kibuon K2 and Tende T1 had .564 mean difference and significant at 0.009. The three sub catchments were significantly different.

The sub catchment had two sub sets in relation to absence of vetiver grass strips before project implementation. Tende T1 had slightly more vetiver grass strips compared to Isanta T2, Mogusii T3, Kibuon K1, Kasipul K3 and Kibuon K2 which reported low number of vetiver grass strips compared to Tende T1 which had a lower mean. Isanta T2, Mogusii T3, Kibuon K1 and Kasipul K3 were not significantly different from any sub catchment. Kibuon K2 had few vetivar grass strips established compared to Tende T1 and Isanta T2.

There were two homogeneous sub sets after project implementation in which Isanta T2 was significantly different from Kibuon K2 and Kibuon K1 by reporting fewer vetiver grass strips. There were many vetiver grass strips after project implementation in Kibuon K2 compared to Isanta T2 which had a low mean. Isanta T2 was similar to Tende T1, Mogusii T3 and Kasipul K3. Tende T1, Mogusii T3 and Kasipul K3 were significantly not different from any sub catchment (Table 43).

Table 43: *Tukey Post Hoc Results on Vetiver Grass Strips Before and After Project Implementation*

Sub catchment	N	1	2	1	2
		Before		After	
Tende T1	148	4.14		3.25	3.25
Isanta T2	47	4.28	4.28	2.96	
Mogusii T3	39	4.36	4.36	3.51	3.51
Kibuon K1	15	4.40	4.40		3.80
Kasipul K3	51	4.51	4.51	3.53	3.53
Kibuon K2	70		4.59		3.81
Significant		.235	.319	.230	.244

Kibuon K2 had very few vetiver grass strips while Tende T1 had slightly more before project implementation. This was attributed to conducive climatic conditions in Tende T1 sub catchment compared with the lower part of Kibuon K2 sub catchment which is slightly drier due to the effect from Lake Victoria. Sub catchments in the middle and lower parts of the catchments reported less vetiver grass strips established. This was due to reduction of rainfall amount from the upper part of the catchments towards Lake Victoria. Less rainfall in the lower catchment is not able to sustain establishment of vetivar grass strips. Kibuon 2 had the highest number of vetiver grass strips compared to Isanta T2 sub catchment after ILWMKTP project implementation project. This was contributed by land sizes which could allow construction of many grass strips in Kibuon K2 than in Isanta T2.

Data on vetiver grass strips and an increase in maize, milk and forage yields was analyzed using Chi Square to determine any relationship between them. The results failed to show significant relationships indicating that there was no clear evidence to show that absence of vetiver grass strips did not influenced maize, milk and forage yields (Table 44).

Table 44: *Chi Square Results on Vetiver Grass Strips and Increased Maize, Milk and Forage Yields Before Project Implementation*

Sub catchment	Independent variable	Chi square	df	P value
Kibuon K1	Vetiver grass strips	8.125	16	.945
Kibuon K2	vetiver grass strips	12.982	16	.674
Kasipul K3	Vetiver grass strips	14.670	12	.260
Tende T1	Vetiver grass strips	7.465	12	.825
Isanta T2	Vetiver grass strips	1.404	3	.705
Mogusii T3	Vetiver grass strips	10.347	6	.111
Total		17.503	16	.354

A correlation value of r -0.106 on absence of vetiver grass strips and increase in maize yield was achieved. Milk yields increase had r -0.101 and more forage had r 0.069. The negative correlations indicated that an increase in absence of vetiver grass strips contributed to a decrease in maize and milk yields while more forage had a positive correlation indicating that absence of vetiver grass strips provided more land for forage production.

Soil erosion causes devastating effects on land and livelihoods of any community which can be controlled by various soil and water conservation technologies including vetiver grass strips. In their absence soil erosion degrades land reducing agricultural productivity as reported by Gnansounou, Alves and Raman (2017) in their study on multiple applications of vetiver grass which established that Vetiver grass has a dense root system which holds and reinforces the soil together reducing catchment degradation. Low utilization of vetiver grass strips and absence of other soil conservation technologies subject productive land to degradation in catchments (Kafle and Balla, 2008)

Chi Square was used to determine a relationship between many vetiver grass strips after project implementation and an increase in maize, milk and forage yields. Results showed significant relationships in Kibuon K1 (Chi Square = 28.750, df = 16, p value = 0.026) and Mogusii T3 (Chi Square = 36.616, df = 12, p value = 0.001) indicating that vetiver grass strips in the two sub catchments contributed to reduced soil erosion that influenced an increase in maize, milk, and forage yields positively. Although Kibuon K2 led in number of vetiver grass strips, the increase did not contribute much to increase in maize, milk and forage yields (Table 45).

Table 45: *Chi Square Analysis Results on Vetiver Grass Strips and Increase in Maize, Milk and Forage Yields After Project Implementation*

Sub catchment	Independent variable	Chi Square	df	P value (.05)
Kibuon K1	Vetiver grass strips	28.750	16	.026
Kibuon K2	Vetiver grass strips	17.601	16	.348
Kasipul K3	Vetiver grass strips	25.721	16	.058
Tende T1	Vetiver grass strips	11.613	16	.770
Isanta T2	Vetiver grass strips	11.724	12	.468
Mogusii T3	Vetiver grass strips	36.616	12	.001
Total		59.003	16	.000

Pearson correlation showed that many vetiver grass strips had weak correlations with increase in; maize yield (r 0.108), milk (r 0.052) and forage yields r 0.149. This was an indication that vetiver grass strips contributed to increase in maize, milk but less on forage.

A study on vetiver Grass by (Grimshaw, 2009) indicated that they reduce runoff flow, increase infiltration thereby increasing crop and livestock productivity. Gnansounou, Alves and Raman (2017) in their study on multiplications of vetiver grass established that vetiver root network can grow up to a depth of 3 meters increasing infiltration, holding the soil together and reducing soil erosion which is normally reflected in land productivity.

vii Retention Ditches Constructed Before and After Project Implementation

Using descriptive statistics, Kibuon K2 reported lower number of retention ditches with a mean of 4.67 and a standard deviation of 1.136 followed by Kibuon K1 that had a mean of 4.53 and a standard deviation of 1.302, Kasipul K3 had a mean of 4.41 with a standard deviation of 1.221, Mogusii T3 had a mean of 4.18 with standard deviation of .854 while Tende T1 reported a high number of retention ditches construction with 3.75 mean and standard deviation of 0.959. Data collected was subjected to descriptive statistics after project implementation and the following means and standard deviations were achieved; Mogusii T3 had a mean of 3.82 with a standard deviation of 0.914. Kasipul K3 had a mean of 3.41 with a standard deviation of 0.963, Kibuon K1 had mean of 3.33 and a standard deviation of 1.113. Kibuon K2 had a mean of 3.31 and standard deviation of 1.280 while Tende T1 had a mean of 3.19 with a standard deviation of 1.084. Isanta T2 had the lowest mean of 3.09 and standard deviation of 1.060. Mogusii T3 had a higher number of retention ditches compared to Isanta T2 (Table 46).

Table 46: *Sub Catchment Means on Retention Ditches Constructed Before and After Project Implementation*

Sub catchment	N	Mean	Standard deviation	Mean	Standard deviation
		Before		After	
Kibuon K1	15	4.53	1.302	3.33	1.113
Kibuon K2	70	4.67	1.136	3.31	1.280
Kasipul K3	51	4.41	1.221	3.41	.963
Tende T1	148	3.75	.959	3.19	1.084
Isanta T2	47	4.09	.717	3.09	1.060
Mogusii T3	39	4.18	.854	3.82	.914
Total	370	4.14	.894	3.30	1.102

Degree of confidence was set at 95% and the analysis of variance showed statistically significant differences at F= 14.331, p = 0.000 on the level at which different numbers of retention ditches constructed affected catchment degradation in selected sub catchments before project implementation (Table 47).

Table 47: *ANOVA Results on Retention Ditches Constructed Before Project Implementation*

Variations	Square of sums	df	Mean square	F	Significant
Between groups	48.561	5	9.712	14.331	.000
Within groups	246.682	364	.678		
Total	295.243	369			

Multiple comparisons showed significant differences in number of retention ditches constructed between Kibuon K1 and Tende T1which had a mean difference of .783 mean and significant at 0.002, Kibuon K2 and Tende T1 had 0.921 significant at 0.001, Kibuon K2 and Isanta T2 had a mean difference of .586 significant at .003, Kibuon K2 and Mogusii T3 had a mean difference of .492 significant at .035 while Kasipul K3 and Tende T1 had a mean difference of 0.662 significant 0.001.The pairs were significantly different from each other. Kibuon K1 and Tende T1 had high differences in retention ditches constructed compared to Kasipul and Tende T1.

The analysis of variance after project implementation indicated that there were statistically significant differences at F= 2.560, p = 0.027 on the level at which retention ditches reduced catchment degradation in selected sub catchments (Table 48).

Table 48: *ANOVA Results on Retention Ditches Constructed After Project Implementation*

Variations	Sum of squares	df	Mean square	F	Significant
Between groups	15.219	5	3.044	2.560	.027
Within groups	432.878	364	1.189		
Total	448.097	369			

Post hoc multiple comparisons indicated that Mogusii T3 and Isanta T2 had the highest mean difference of 0.735 significant at 0.024. Mogusii T3 and Tende T1 had a significant mean difference of 0.631 significant at 0.018. The comparisons indicated that the sub catchments were significantly different. Sub catchments in the study area appeared in three sub sets before project implementation. Kibuon K2 reported a lower number of retention ditches compared to Kibuon K2 which reported lower numbers of retention ditches constructed but similar to Isanta T2 and Mogusii T3. Tende T1 reported a higher number of retention ditches constructed before project implementation compared to Isanta T2, Mogusii T3, Kasipul K3, Kibuon K1 and Kibuon K2. Mogusii T3 and Isanta T2 were not significantly different to any sub catchment. Kibuon K2 had a significantly lower number of retention ditches constructed compared to Isanta T2 and Tende T1. Isanta T2 had significantly higher number of retention ditches than Kibuon K1 and Kibuon K2 while Kasipul K3 and Kibuon K1 were comparatively lower than Tende T1.

Homogeneous sub sets after project implementation was in two levels. Isanta T1 had the lowest mean (3.09) on retentions ditches constructed compared to Mogusii T3 (3.82) that had more retention ditches constructed. Tende T1, Kibuon K2, Kibuon K1, Kasipul K3 and Mogusii T3 were not significantly different from any sub catchment. Isanta also had less retention ditches constructed compared to Tende T1, Kibuon K2, Kibuon K1, Kasipul K3 and Mogusii T3 (Table 49).

Table 49: *Tukey Post Hoc Results on Retention Ditches Constructed Before and After Project Implementation*

Sub catchment	N	1	2	3	1	2
		Before			After	
Tende T1	148	3.75			3.19	3.19
Isanta T2	47	4.09	4.09		3.09	
Mogusii T3	39	4.18	4.18	4.18	3.82	3.82
Kasipul K3	51		4.41	4.41	3.41	3.41
Kibuon K1	15		4.53	4.53	3.33	3.33
Kibuon K2	70			4.67	3.31	3.31
Significant.		.196	.158	.091	.773	.112

The findings show that Kibuon K2 sub catchment had very few retention ditches before project implementation which could be attributed to flash floods and livestock effects from free range system of production. Some respondents in Tende T1 had retention ditches probably constructed previously through the Ministry of Agriculture and the need to save land from degradation following an increase in population and high rainfall amounts. Retention ditches were fewer in middle and lower parts of the catchments which could be attributed to free range livestock system that hampered maintenance of retention ditches. There were many retention ditches in Tende T1 sub catchment because there was need to protect the soil due to high population. Owing to the small land sizes, some farmers constructed one retention ditch at the upper part of the farm and avoided other technologies that needed more space. Mogusii T3 sub catchment had a higher number of retention ditches compared with other sub catchments in Tende and Kibuon catchments. This was attributed to land sizes and flash floods that accompany erratic rainfall in the sub catchment.

Chi Square results before project implementation showed that there was no sub catchment with significant relationship. Kibuon K1 (Chi Square = 16.667, df = 16, p = value ,407), Kibuon K2 (Chi Square = 10.759, df = 16, p value = .427), Kasipul K3 (Chi Square = 21.611, df = 16, p value = .156), Tende T1 (Chi Square = 10.893, df = 16, p value = .816), Isanta T2 (Chi Square = 3.423, df = 12, .992) and Mogusii T3 (Chi Square = 7.929, df = 9, p value = .541). The findings showed that there was no evidence to show that lack of retention ditches influenced increase in maize, milk and forage yields (Table 50).

Table 50: *Chi Square Results on Retention Ditches and Increase in Maize, Milk, and Forage Yields Before Project Implementation*

Sub catchment	Independent variable	Chi square	df	P value (.05)
Kibuon K1	Retention ditches	16.667	16	.407
Kibuon K2	Retention ditches	10.759	16	.427
Kasipul K3	Retention ditches	21.611	16	.156
Tende T1	Retention ditches	10.893	16	.816
Isanta T2	Retention ditches used	3.423	12	.992
Mogusii T3	Retention ditches used	7.929	9	.541
Total		27.019	16	.041

About 78 percent of the key informants reported absence of retention ditches in the catchments. Pearson correlation analysis gave a weak correlation between retention ditches and increase in maize yield (r -0.098), milk yields had r -0.073 while forage yields had a correlation value of r-0.099.

The results indicated that absence of retention ditches contributed to reduced maize, milk and forage yields which agreed with a study by Sustainet East Africa (EA) (2010) on technical manual on soil and water conservation which established that retention ditches increased infiltration, reduced soil erosion and their absence exposed productive soil to erosion reducing land productivity. These findings were confirmed by Reinchert (2014) through his study on catchment development in Malawi which established that retention ditches reduced runoff and increased infiltration reflecting in high productivity.

Data on many retention ditches and increase in maize, milk and forage yields after project implementation was subjected to Chi Square to establish significant relationship between them. Mogusii T3 had a significant relationship; (Chi Square = 27.025, df = 12, p value = 0.008) while the other sub catchments failed to show a significant relationship; Mogusii T3 reported presence of many retention ditches that reduced soil erosion translating in increased maize, milk and forage yields (Table 51).

Table 51: *Chi Square Results on Retention Ditches and Increase in Maize, Milk and Forage Yields After Project Implementation*

Sub catchment	Independent variable	Chi square	D	P value (.05)
Kibuon K1	retention ditches after project	14.875	12	.248
Kibuon K2	retention ditches after project	14.678	16	.548
Kasipul K3	retention ditches after project	23.863	16	.093
Tende T1	retention ditches after project	18.410	16	.300
Isanta T2	retention ditches after project	12.104	9	.208
Mogusii T3	retention ditches after project	27.025	12	.008
Total		54.617	16	.000

Use of retention ditches was reported by 78 percent which reduced runoff on farms in the sub catchments in Kibuon and Tende catchments. Pearson correlation indicated a weak correlations between many retention ditches and increase in maize (r 0.152), milk, (r 0.166) and more forage had r 0.091 which showed that many retention ditches reduced soil erosion contributing to an increase in maize and milk yields in the basins.

These findings agreed with a study by Senkoro (2010) on impact of soil erosion control practices which showed that water harvesting through structures such as retention ditches rehabilitated watersheds and increased maize and milk yields. Similar findings were reported by Atnafe et al. (2015) in their study on determinants of adoption of soil and water conservation techniques in Goromti catchment in Ethiopia whereby farmers used retention ditches to reduce runoff in the catchment.

viii Check Dams Used in Gulley Control Before and After Project Implementation

Data analysis through descriptive statistics provided different means and standard deviations before project implementation. Kibuon K2 had a higher mean of 4.39 with a standard deviation of 1.054. Mogusii T3 followed with a mean of 4.38 and a standard deviation of 0.633. Kibuon K1 had a mean of 4.20 with a standard deviation of 1.082. Kasipul K3 had a mean of 4.20 with a standard deviation of 1.114. Isanta T2 had a mean of 4.17 with a standard deviation of 0.670. Isanta T2 had the least responses on no check dams used in gulley control.

Data analysis through descriptive statistics established means and standard deviations for the period after project implementation. Kibuon K2 had a mean of 3.57 with a standard deviation of 1.234 while Kasipul K3 had a mean of 3.27 with a standard deviation of 1.060. Kibuon K1 had a mean of 3.00 with a standard deviation of 1.000 and Tende T1 had a mean of 2.91 with a standard deviation of 1.115. Isanta T2 had a mean of 2.98 and a standard deviation of 1.115 while Tende T1 had a mean of 2.91 with a standard deviation of 1.115 (Table 52).

Table 52: *Sub Catchment Means for Check Dams used in Gulley Control Before Project Implementation*

Sub catchment	N	Mean	Standard deviation	Mean	Standard deviation
		Before		After	
Kibuon K1	15	4.20	1.082	3.00	1.00
Kibuon K2	70	4.39	.126	3.57	1.234
Kasipul K3	51	4.20	1.114	3.27	1.060
Tende T1	148	3.95	.831	2.91	1.115
Isanta T2	47	4.17	.670	2.98	1.053
Mogusii T3	39	4.38	.633	3.28	1.050
Total	370	4.15	.909	3.14	1.113

The analysis of variance results indicated statistically significant difference at F = 3.077, p= .010 on the level at which check dams used in gulley control affected catchment degradation in selected sub catchments before project implementation (Table 53).

Table 53: *ANOVA Results on Check Dams used in Gulley Control Before Project Implementation*

Variations	Sum of squares	df	Mean squares	F	Significant
Between groups	12.363	5	2.473	3.077	.010
Within groups	292.462	364	.803		
Total	304.824	369			

The analysis of variance indicated that there were significant differences at F= 3.939, p = 0.002 on the level at which check dams control catchment degradation in different sub catchments after project implementation (Table 54).

Table 54: *ANOVA Results on Check Dams Used in Control of Gullies After Project Implementation*

Variations	Sum of squares	DF	Mean square	F	Significant
Between groups	24.392	5	4.878	3.939	.002
Within groups	450.852	364	1.239		
Total	475	369			

Multiple comparisons table indicated that Kibuon K1 and Tende T1 had a significant mean difference of 0.666 significant at 0.001. Under homogeneous sub sets before project implementation, respondents in all sub catchments provided responses that were not significantly different therefore display in one sub set. The sub catchments had similar characteristics in relation to check dam use in gulley control. Kibuon K1 reported a lower number of check dams used in gulley control compared to Tende T1 and Kibuon K1 while Tende T1 was similar to all sub catchments.

Homogeneous sub sets sub catchment means were displayed in one sub set after project implementation. This indicated that their responses on use of many check dams were closely related therefore not significantly different although Kibuon K2 reported a higher number of check dams used compared to Tende T1 that had a lower mean 2.91. Tende T1 had few check dams used in gulley control compared with Isanta T2, Kibuon K1, Kasipul K3, Mogusii T3 and Kibuon K2 and all sub catchments were not significantly different from any sub catchment (Table 55).

Table 55: *Tukey Post Hoc Results on Check Dams used in Gulley Control Before and After Project Implementation*

Sub catchment	N	1	1
		Before	After
Tende T1	148	3.72	2.91
Kibuon K2	15	3.80	3.57
Kasipul K3	51	3.84	3.27
Mogusii T3	39	4.05	3.28
Isanta T2	47	4.11	2.98
Kibuon K1	70	4.34	3.00
Significant		.102	.091

Most respondents from the six sub catchments reported less use of check dams in gulley control before project implementation which could be attributed to personal initiatives since check dams could be constructed from both cheap and expensive materials Mogusii (T3), Isanta (T2) and Kibuon (K1) reported very few check dams in use. This could be attributed to their fairly conducive climatic conditions that allow vegetation growth providing ground cover therefore reducing the need for check dams.

Key informants (77.8 percent) reported absence of check dams in gulley control before project implementation. Kibuon K2 had many check dams compared to Tende T1. Some parts of Kibuon K2 share climatic conditions with Kisii County which receives a lot of rain contributing to a high number of Check dams to regulate runoff speed in the sub catchments. There was a significant relationship between check dams used in gulley control and an increase in maize, milk and forage yields in Kasipul K3 (Chi Square = 29.219, df = 16, p value = 0.023). It was evident that absence of check dam use in gulley control influenced maize, milk and forage yields. Lack of check dam use in gulley control and increase in maize milk and forage yields had a weak correlation (r -0.002 and r -0.007) respectively while more forage had r-0.099 (Table 56).

Table 56: *Chi Square on Check Dams Used in Gulley Control and Increase in Maize, Milk and Forage Yields Before Project Implementation*

Sub catchment	Independent variable	Chi square	df	P value (.05)
Kibuon K1	check dams used to control gullies	8.170	12	.772
Kibuon K2	check dams used to control gullies	20.187	16	.212
Kasipul K3	check dams used to control gullies	29.219	16	.023
Tende T1	check dams used to control gullies	14.799	16	.539
Isanta T2	check dams used to control gullies	3.994	9	.912
Mogusii T3	check dams used to control gullies	15.203	12	.231
Total		26.021	16	.054

This was an indication that absence of check dam use contributed to low maize, milk and forage yields. These findings were shared with Farm Africa (2017) in their study on integrated catchment management in which check dams were used to plug gullies in watersheds to reduce degradation. This was also reported by (Mondal et al., 2013) in their study on decomposition of productivity growth in catchments which reported check dams being used to reduce water flow in gullies.

Chi Square results on many check dams used in gulley control after project implementation showed that there were significant relationships with an increase in maize, milk and forage yields in Kibuon K2 (Chi Square = 27.942, df = 16, p value 00.032), Isanta T2 (Chi Square = 23.759, df = 12, p value = .022) and Mogusii T3 (Chi Square = 22.479, df = 12, p value = 0.032). Significant relationship in Kibuon K2, Isanta T2 and Mogusii T3 indicated presence of some check dams used in controlling gullies thereby reducing degradation through soil erosion. This contributed to soil fertility hence increased maize, milk and forage yields. The other three sub catchments reported fewer check dams thereby not contributing to increased maize, milk and forage yields (Table 57).

Table 57: *Chi Square Analysis Results on Check Dams Used in Gulley Control and Increase in Maize, Milk and Forage Yields After Project Implementation*

Sub catchment	Independent variable	Chi square	Df	P value (.05)
Kibuon K1	check dams used to control gullies	24.286	16	.083
Kibuon K2	check dams used to control gullies	27.942	16	.032
Kasipul K3	check dams used to control gullies	10.429	16	.843
Tende T1	check dams used to control gullies	16.309	16	.432
Isanta T2	check dams used to control gullies	23.759	12	.022
Mogusii T3	check dams used to control gullies	22.479	12	.032
Total		59.333	16	.000

About 67 percent of the key informants reported some use of check dams in controlling soil erosion. Pearson correlation between many check dams used in gulley control and increase in maize yield had a weak correlation of r 0.179, increase in milk had r 0.121 while forage had r 0.101. This was an indicated that use of many check dam in gulley control contribute to an increase in maize, milk and forage. The need to reduce runoff speed which is important in gulley control can be done through stabilization of gullies by use of structural measures including check dams to heal gullies improving soil fertility. This provides more agricultural areas that reflect in increased productivity confirmed by FAO (2017) in their study on catchments which established that check dam used improved land productivity in catchments. This was also reported by Adugna and Desta (2012) in their guide on soil conservation which reported check dams reducing watershed degradation.

ix Cover Crops Planted Before and After Project Implementation

Descriptive statistics was used in analysis on cover crops planted in the catchments before project implementation. Kibuon K2 out of six sub catchments had the highest mean of 4.33 with a standard deviation of 0.557. Kasipul K3 had a mean of 4.41 with a standard deviation of 0.753 followed by Kibuon K1 with a mean of 4.33 and standard deviation of 0.724. Isanta T2 had a mean of 4.00 with a standard deviation of 0.808, Mogusii T3 had a mean of 3.92 with a standard deviation of 1.156. Tende T1 reported less at a mean of 3.80 with a standard deviation of 0.070. Kibuon K2 had the least number of cover crops while Tende T1 had a higher number than Kibuon K2.

Descriptive statistics was used to analyze data for the period after project implementation. Mogusii T3 had a mean of 3.64 with standard deviation of 1.163 while Kasipul K3 had a mean of 3.24 with a standard deviation of 0.992. Kibuon K2 had a mean of 3.21 with a standard deviation of 1.250. Isanta T2 had a mean of 3.21 with standard deviation of 1.063 while Tende T1 had a mean of 3.01 with a standard deviation of 1.113 (Table 58).

Table 58: *Sub Catchment Means on Cover Crops Planted Before and After Project Implementation*

Sub catchment	N	Mean	Standard deviation	Mean	Standard deviation
		Before		After	
Kibuon K1	15	4.33	.724	2.73	1.163
Kibuon K2	70	4.34	1.128	3.21	1.250
Kasipul K3	51	4.41	.753	3.24	.992
Tende T1	148	3.80	.961	3.01	1.113
Isanta T2	47	4.11	.857	3.21	1.062
Mogusii T3	39	3.92	1.156	3.64	.986
Total	370	4.11	.886	3.16	1.119

The ANOVA analysis indicated significant differences at F = 12.989, p = 000 on the level at which cover crops planted controlled catchments degradation in different sub catchment before project implementation (Table 59).

Table 59: *ANOVA Results on Cover Crops Planted Before Project Implementation*

Variation	Sum of squares	df	Mean square	F	Significant
Between groups	43.858	5	8.772	12.989	.000
Within groups	245.817	364	.675		
Total	289.676	369			

The ANOVA test results after project implementation showed that there were significant differences at F = 2.535, p= .028 on the level at which cover crops contributed to reduced catchment degradation after project implementation (Table 60).

Table 60: *ANOVA Results on Cover Crops Planted After Project Implementation*

Variations	Sum of squares	df	Mean square	F	Significant
Between groups	15.555	5	3.111	2.535	.028
Within groups	446.715	364	1.227		
Total	462.270	369			

On multiple comparisons, Mogusii T3 and Tende T1 had a significant mean difference .628 significant at .022 which meant they were significantly different. During the period before project implementation, sub catchments were displayed in three sub set levels where by Tende T1 had slightly more cover crops planted compared to Mogusii T3, Isanta T2, Kibuon K1, Kibuon K2 and Kasipul K3 but similar to Mogusii T3 and Isanta T2. Isanta T2 and Kibuon K2 were not significantly different to any sub catchment. Kasipul K3 has less cover crops planted compared to Tende T1 and Mogusii T3.

Homogeneous sub sets for the period after project implementation were displayed in two sub sets in which Kibuon K1 planted few cover crops compared to Mogusii T3. Tende T1, Isanta T2, Kibuon K2 and Kasipul K3 were significantly not different from any other sub catchment. Kibuon K1 had fewer cover crops compared to Tende T1, Isanta T2, Kibuon K2 Kasipul K3 and Mogusii T3 (Table 61).

Table 61: *Tukey Post Hoc Analysis Results on Few Cover Crops Planted Before and After Project Implementation*

Sub catchment	N	1	2	3	1	2
		Before			After	
Tende T1	148	3.80			3.01	3.01
Mogusii T3	39	3.92				3.64
Isanta T2	47	4.00	4.00		3.21	3.21
Kibuon K1	15		4.33	4.33	2.73	
Kibuon K2	70	4.34	4.34		3.21	3.21
Kasipul K3	51		4.41	4.41	3.24	3.24
Significant		.886	.094	.458	.345	.127

Kasipul K3 reported few cover crops planted while Tende T1 reported more which was attributed to their different climatic conditions. Kasipul K3 has a hot type of climate while Tende T1 has cool climate. The variations could be attributed to erratic rainfall in Kasipul sub catchment which affects growing of cover crops. Free range system of farming interferes with growing of cover crops by livestock since most of them are fodder crops. Isanta (T2), Kibuon (K1) and Kibuon (K2) reported less cover crops planted since the sub catchments are fairly populated with small land holdings therefore there is competition between cover crops and food crops. About 77.7 percent key informants agreed that there were few cover crops planted before project implementation in the sub catchment.

Before project implementation Mogusii 3 sub catchment was faced with flash floods, erratic rainfall, seasonal streams with dry environmental conditions due to its location in Lower Midlands four (LM_4). There was need for establishment of cover crops like ground nuts, beans, *Mucuna pruriens* (Mucuna), *Desmodium uncinatum* (Silver leaf Desmodium) and lucerne through ILWMKTP project implementation which increased ground cover reducing effects of flash floods. The cover crops reduced catchment degradation in Mogusii T3 than Kibuon K1, Tende T1, Isanta T2, Kibuon K2 and Kasipul K3 sub catchments contributing to improved yields in maize, milk and forage.

Chi square results before project implementation were not significant which indicated lack of evidence on few cover crops influencing an increase in maize and milk yields, and more forage since yield is determined by many factors besides cover crops (Table 62).

Table 62: *Chi Square Results on Cover Crops and Increase in Maize, Milk and Forage Yields Before Project Implementation*

Sub catchment	Independent variable	Chi square	df	P value (.05)
Kibuon K1	cover crops	24.583	16	.078
Kibuon K2	cover crops	18.095	16	.318
Kasipul K3	cover crops	6.220	12	.905
Tende T1	cover crops	17.722	16	.340
Isanta T2	cover crops	7.245	12	.841
Mogusii T3	cover crops	14.656	16	.550
Total		14.656	16	.550

Pearson correlation indicated a weak negative correlation with increase in maize and milk yields (r -0.035, r -0.082) respectively while forage yields had a positive correlation of .116. The findings showed that reduction in cover crops contributed to lower maize and milk yields while fewer cover crops contributed to more space for forage production hence the positive correlation. This was supported by Ketterings, Swink, Sjoerd, Czymmek, Beegle, and Cox, (2008) in their study on Nitrogen benefits of winter cover crops which established that cover crops reduced splash erosion, root network held the soil firmly reducing soil erosion thereby improving crop and livestock productivity which was confirmed by Wallace, Alwyn, Liebert, Ackroyd, Vann, Curran, Keene, VanGessel, Ryan and Mirsky (2017) in their research on corn and soy bean production which established that poor cover crop reduced biomass production and soil organic matter which reduced productivity in watersheds.

Chi Square results on many cover crops planted and increase in maize, milk and more forage yields for the period after project implementation showed significant relationship in Kibuon K1 (Chi Square = 22.250, df = 12, p value = 0.035 and Mogusii T3 (Chi Square = 21.240, df = 12, p value = 0.042. Respondents who planted many cover crops restored their soils and contributed to increase in yields in maize, milk and forage while sub catchments without significant relationship indicated they planted but not enough to create a significant difference in maize, milk and forage yields (Table 63).

Table 63: *Chi Square Results on Cover Crops and Increase in Maize, Milk and Forage Yields After Project Implementation*

Sub catchment	Independent variable	Chi square	df	P value (.05)
Kibuon K1	cover crops planted	22.250	12	.035
Kibuon K2	cover crops planted	22.240	16	.136
Kasipul K3	cover crops planted	17.975	16	.325
Tende T1	cover crops planted	19.107	16	.263
Isanta T2	cover crops planted	7.431	9	.592
Mogusii T3	cover crops planted	21.643	12	.042
Total		77.296	16	.000

An improvement in use of cover crops was reported by 77.7 percent key informants. Pearson correlation (increase in maize had r 0.229, increase in milk had r 0.195 while forage had r 0.026). The results indicated an improvement in cover crops planted which contributed to conserved soils hence increased maize milk and forage. These findings showed that many cover crops contributed to increase in maize, milk and forage yields. Tuan (2015) in his study on soil conservation methods found out that cover crops reduced splash erosion, root network held the soil firmly reducing soil erosion thereby improving crop and livestock productivity which was also reported by Okeyo (2013) in her study on effects of soil and water conservation technologies which reported that cover crops protected soil from destruction by rain drops and restored lost nutrients increasing land productivity.

x Kibuon and Tende Water being Turbid Before and After Project Implementation

Descriptive statistics was applied on data collected before project implementation and Isanta T2 reported water being turbid at a mean of 4.83 with standard deviation of .433.

Mogusii T3 had a mean of 4.82 with a standard deviation of .389, Kibuon K2 had a mean of 4.80 with a standard deviation of 0.499.Tende T1 had a mean of 4.66 with a standard deviation of 0.822 while Kibuon K1 had mean of 4.53 with a standard deviation of 1.125. Kasipul K3 had mean of 4.43 and standard deviation of 0.985 indicating the lowest responses on water being turbid.

Descriptive statistics was used to analyze data on Kibuon and Tende water turbidity for the period after project implementation. Mogusii T3 had the highest mean of 4.62 with a standard deviation of .633, Kibuon K2 had a mean of 2.81 with a standard deviation of 1.688. Kibuon K1 had a mean of 2.80 with a standard deviation of 1.656, Isanta T2 had a mean of 2.26 with a standard deviation of 1.635. Kasipul K3 had a mean of 2.25 with a standard deviation of 1.495 while Tende T1 had a mean of 2.15 and a standard deviation of 1.635 Table 64).

Table 64: *Sub Catchment Means on Water Turbidity Before and After Project Implementation*

Sub catchment	N	Mean	Standard deviation	Mean	Standard deviation
		Before		After	
Kibuon K1	15	4.53	1.187	2.80	1.656
Kibuon K2	70	4.80	.966	2.81	1.656
Kasipul K3	51	4.43	1.041	2.25	1.495
Tende T1	148	4.66	.832	2.15	1.635
Isanta T2	47	4.83	.433	2.26	1.635
Mogusii T3	39	4.82	.614	4.62	.633
Total	370	4.69	.743	2.59	1.712

ANOVA analysis results showed that there were statistically significant differences at F= 2.355, p = .040 on level at which catchment degradation contributed to Kibuon and Tende water turbidity in selected sub catchments before project implementation (Table 65).

Table 65: *ANOVA Results on Kibuon and Tende Water being Turbid Before Project Implementation*

Variation	Sum of squares	df	Mean squares	F	Significant
Between groups	6.382	5	1.276	2.355	.040
Within groups	197.251	364	.542		
Total	203.632	369			

The analysis of variance results showed that there were significant differences at F= 16.922, p= .000 on the water turbidity level in selected sub catchments after project implementation (Table 66).

Table 66: *ANOVA Results on Clear Water in the Catchments After Project Implementation*

Variation	Sum of squares	df	Mean square	F	Significant
Between groups	203.988	5	40.798	16.922	.000
Within groups	877.569	364	2.411		
Total	1081.557	369			

According to multiple comparisons, Kibuon K2 and Tende T1 had .666 mean difference significant at .039, Mogusii T3 and Isanta T2 had 2.360 mean difference significant at .000, Mogusii T3 and Tende T1 had 2.467 mean significant at .000, Mogusii T3 and Tende T1 had 2.467 mean of difference significant at .000, Mogusii T3 and Kasipul K3 had 2.367 mean significant at .000, Mogusii T3 and Isanta T1 had 2.360 mean significant at .000, Mogusii T3 and Kibuon K1 had 1.815 significant at .002 and Mogusii T3 and Kibuon K2 had 1.801 significant at .002.

All sub catchments before project implementation were displayed in one sub set meaning their scores on water turbidity were not significantly different hence one sub set. Kasipul K3 had the least mean indicating that water in Kibuon and Tende rivers was less turbid in that sub catchment while Isanta reported high levels of water turbidity which implied that the water was more turbid in Isanta sub catchment compared to Kasipul catchment. Kasipul K3 was similar to Kibuon K1, Kibuon K2, Tende T1, Mogusii T3 and Isanta T2. Differences in means were not big enough to have a significant difference on water turbidity.

There were 2 levels of homogeneous subsets after project implementation. Mogusii had the highest report on Kibuon and Tende water being turbid after project implementation. The least report on water turbidity was from Tende T1 which got the lowest mean (2.15). Tende T1 was similar to Kasipul K3, Isanta T2, Kibuon K1 and Kibuon K2. The results indicated that water was slightly clear in Mogusii T3 than Tende T1 (Table 67)

Table 67: *Tukey Post Hoc Results on Water Turbidity Before and After Project Implementation*

Sub catchment	N	1	1	2
		Before	After	
Kasipul K3	51	4.43	2.25	
Kibuon K1	15	4.53	2.80	
Kibuon K2	70	4.66	2.81	
Tende T1	148	4.80	2.15	
Mogusii T3	39	4.82		4.62
Isanta T2	47	4.83	2.26	
Significant		.164	.460	

Respondents from the six sub catchments reported water in Kibuon and Tende being turbid although there were slight differences. Results implied that many respondents in Tende (T1), Isanta (T2), Mogusii (T3) reported Kibuon and Tende water being turbid while in Kibuon (K1), Kibuon (K2) and Kasipul (K3) reported the water in the two rivers being less turbid. Generally the results indicated that water was turbid before project implementation because of high mean values above 4.00 due to river encroachment, intensive farming in the highlands and deforestation in the catchments. Five sub catchments (Kibuon 2, Kibuon 1, Isanta 2, Kasipul 3 and Tende 1) scored low on water in Tende and Kibuon rivers being clear. This is an indication that although soil and water conservation technologies were implemented in the catchments, there was still soil erosion being experienced. Mogusii T3 scored highest on Tende and Kibuon water being clear which could be attributed to more cover crops in use. Through use of Chi Square, results indicated that water turbidity and increase in maize, milk and forage yields had a significant relationship which implied that it influenced increase in maize, milk and forage negatively. Farmers moved long distances looking for clean water for domestic and livestock leaving very little time for the farm work and livestock hence reduced productivity in Tende T1 (Chi Square = 36.477, df = 6, p value 0.002). All key informants (100 percent) reported that water in Kibuon and Tende rivers was turbid before project implementation and farmers travelled long distances in search for clean water (Table 68).

Table 68: *Chi Square Results on Water Turbidity and Increase in Maize, Milk and Forage Yields Before Project Implementation*

Sub catchment	Independent variable	Chi Square	df	P value (.05)
Kibuon K1	Kibuon and Tende water being turbid	4.688	8	.790
Kibuon K2	Kibuon and Tende water being turbid	19.471	16	.245
Kasipul K3	Kibuon and Tende water being turbid	15.820	12	.200
Tende T1	Kibuon and Tende water being turbid	36.477	16	.002
Isanta T2	Kibuon and Tende water being turbid	6.664	6	.353
Mogusii T3	Kibuon and Tende water being turbid	5.272	6	.509
Total		34.261	16	.005

Water turbidity in the basins had a weak negative correlation with increase in maize yields (r -0.028) and milk (r -0.086) and yields (r -0.070). This indicated that there was some level of soil erosion in all the six sub catchments which contributed to high water turbidity in Kibuon and Tende rivers reflected in reduced maize, milk and forage yields. This was also confirmed by high mean differences among sub catchments which was reported by African Water Facility, (2008) in their feasibility study in the catchments before project implementation . Transport of pollutants arising from soil erosion, over-grazing, deforestation and intensive agricultural activities contribute to turbid water in catchments which reduces agricultural productivity confirmed by Koundouri (2003) in their study on catchment Economics which found out that soil erosion enhanced catchment degradation. Chi Square results after project implementation reported Tende T1 to have a significant relationship between Kibuon and Tende water being clear and increase in; maize, milk. and forage yields; (Chi Square = 36.477, df = 16, p value = 0.002). These results showed that clear water influenced increase in maize, milk and forage (Table 69).

Table 69: *Chi Square Results on Clear Water and Increase in Maize, Milk and Forage Yields After Project Implementation*

Sub catchment	Independent variable	Chi square	df	P value (.05)
Kibuon K1	clear water	16.042	12	.189
Kibuon K2	clear water	23.509	16	.101
Kasipul K3	clear water	21.356	16	.165
Tende T1	clear water	36.477	16	.002
Isanta T2	clear water	19.455	12	.078
Mogusii T3	clear water	11.592	12	.479
Total		26.668	16	.045

Livestock improved their health and productivity, manure was used on maize and forage farms to increase their yields. Women and children saved time spent looking for clean water and spend it on the farms and taking care of the animals for increased productivity, Pearson correlation had weak correlation on Kibuon and Tende water being turbid and increase in maize (r 0.026) milk (r 0.042) and forage yields got r 0.073. Reduced water turbidity was reported by 66.6 percent of the key informants. This indicated that clear water contributed to increase in maize, milk and forage yields which agreed with Dessie and Bredemeier (2013) in their study on effects of deforestation on water quality which reported that clear water increased land productivity in catchments. The research findings were also reported by Gnansounou et al., (2017) in their study on multiple application of vetiver grass which trapped soil sediments reducing their transportation. Misigo and Suzuki, (2018) in their study on spatial-temporal sediment hydrodynamics reported nutrient loads in Nyanza Gulf still high in Kibuon and Tende rivers (Table 70).

Table 70: *Water Quality and Sediment Loads After Project Implementation*

River	Area Ha	TSS mg/L	TN mg/L	TP mg/L	Sed load ton/Ha/yr
Awach-Kibuon	54,914.9	577.59	1.5431	0.3089	1.08/Ha/yr
Awach- Tende	68,642.6	526.50	1.6700	0.0823	0.96
Nyando	359,780.8	384.43	1.1687	0.3699	4.07
Sondu Miriu	344,584.2	198.14	1.1101	1.1674	1.5

Source (Misigo & Suzuki, 2018)

xi Area put Under Agroforestry Before and After Project Implementation

Data gathered was analyzed using descriptive statistics to establish means for each sub catchment before project implementation. Kibuon K2 out of six sub catchments had the highest scores on less area put under agro forestry at a mean of 4.44 mean with a standard deviation of 0.828. Kasipul K3 had a mean of 4.18 with a standard deviation of 0.713, Tende T1 had a mean of 3.93 with a standard deviation of 0.555 while Isanta T2 had a mean of 3.89 and a standard deviation of 0.598. Kibuon K1 had a mean of 3.87

with a standard deviation of 1.598. Least responses were realized in Kibuon K1 showing that the sub catchment had more area under agroforestry than Kibuon K2 which ranked high on less area under agroforestry.

Data was subjected to descriptive statistics for the period after project implementation. Kibuon K1 had a mean of 4.73 and standard deviation of 0.458, Kibuon K2 had a mean of 4.13 and standard deviation of 1.048. Kasipul K3 had a mean of 3.88 and standard deviation of 0.973, Mogusii had a mean 3.82 and standard deviation of 0.970. Tende T1 had 3.64 mean and standard deviation of 0.970 while Isanta had 3.55 mean and 0.928 (Table 71).

Table 71: *Sub Catchment Means on Area put Under Agroforestry Before and After Project Implementation*

Sub catchment	N	Mean	Standard deviation	Mean	Standard deviation
		Before		After	
Kibuon K1	15	3.87	1.598	4.73	.458
Kibuon K2	70	4.44	.828	4.13	1.048
Kasipul K3	51	4.18	.713	3.88	.973
Tende T1	148	3.93	.555	3.88	.973
Isanta T2	47	3.89	.598	3.55	.928
Mogusii T3	39	3.72	.826	3.82	.970
Total	370	4.03	.764	3.82	.979

ANOVA analysis results indicated that there were significant differences at F= 7.241, p = .000 on the level at which area put under agroforestry reduced catchment degradation in selected sub catchments before project implementation(Table 72).

Table 72: *ANOVA Results on Area put Under Agroforestry Before Project Implementation*

Variation	Sum of squares	df	Mean square	F	Significant
Between groups	19.504	5	3.901	7.241	.000
Within groups	196.106	364	.539		
Total	215.611	369			

Multiple comparison showed that Kibuon K2 and Mogusii T3 had a high mean difference of .725 significant at 0.001, Kibuon K2 and Tende T1 had significant mean difference at .510 mean at p = 0.001, Kibuon K2 and Isanta T2 with a mean difference of .549 at p = .001, Kibuon K2 and Kasipul K3 with Mogusii T3 had .459 at p = .041. Kasipul K3 had low scores for less area put under agroforestry. ANOVA test results for the period after project implementation indicated significant differences at F= 6.208, p = .000 on the level at which area put under agroforestry contributed to reduced catchments degradation in different sub catchments (Table 73).

Table 73: *ANOVA Results on Area put Under Agroforestry After Project Implementation*

Variations	Sum of squares	df	Mean Square	F	Significant
Between groups	27.774	5	5.555	6.208	.000
Within groups	325.728	364	.895		
Total	353.503	369			

Multiple comparisons showed that Kibuon K1 and Isanta T2 had a mean difference of 1.180 significant at .000, Kibuon K1 and Tende T1 had 1.098 mean difference significant at .000, Kibuon K1 and Mogusii T3 had a mean difference of .913 significant at .020, Kibuon K1 and Kasipul K3 had a mean difference of 0.851 significant at 0.028. Kibuon K2 and Isanta T2 had a mean difference of 0.575 significant at 0.017, and Kibuon K2 and Tende T1 had 0.493 mean significant at 0.005.

In Homogeneous subsets, sub catchments appeared in two levels before project implementation. Mogusii T3 was significantly different from Kibuon K2 by reporting more area put under agroforestry while Kibuon K2 reported less area. Mogusii T3 was similar to Kibuon K1, Isanta T2, Tende T1 and Kasipul K3 was not significantly different from any sub catchment.

Under homogeneous sub set for the period before project implementation Kibuon K1 was significantly different from Isanta T2 by reporting more area put under agroforestry. Isanta T2 had less area under agroforestry than Tende T1, Mogusii T3, Kibuon K2, Kasipul K3, Kibuon K2 and Kibuon K1 and was similar to Tende T1, Mogusii T3, Kibuon K2, Kasipul K3 and Kibuon K1. Kibuon K2 was not significantly different from any sub catchment (Table 74).

Table 74: *Tukey Post Hoc Analysis Results on Area put Under Agroforestry Before and After Project Implementation*

Sub catchment	N	1	2	1	2
		Before		After	
Mogusii T3	39	3.72		3.82	
Kibuon K1	15	3.87			4.73
Isanta T2	47	3.89		3.55	
Tende T1	148	3.93		3.64	
Kasipul K3	51	4.18	4.18	3.88	
Kibuon K2	70		4.44	4.13	4.13
Significant		.067	.599	.081	.057

Kibuon K2 had the highest report on less area put under agroforestry compared with Mogusii T3 before project implementation. The upper parts of Mogusii T3 sub catchment got more rain which facilitated growing of some agroforestry trees while climate in the lower parts of Kibuon K2 cannot support agroforestry practices hence the highest average on less area put under agroforestry. Some parts of Kasipul (K3) are in LM_4 which experiences harsh climatic conditions to support agroforestry.

About 77.7 percent key informants reported less area put under agroforestry in the catchments before project implementation. Differences in responses between respondents in Mogusii T3 and key informants could be attributed to respondents not being accurate in estimating areas under agroforestry.

Kibuon K1 sub catchment runs from Nyamira County at 2100 metres above sea level in lower highlands one (LH_1) ecological zone which is characterized with a lot of rainfall. The sub catchment planted agroforestry trees to provide fuel, fodder and protect soils. There was need to increase areas under agroforestry due to high quantities of rainfall received in the sub catchment. Isanta T2 had the least area put under agroforestry because of small farm holdings due to population and dependency on wood fuel for energy.

Chi square method of analysis was applied to data gathered to establish any relationship between less area put under agroforestry and increased maize, milk and forage yields before project implementation and there was no significant relationship between them.

This indicated absence of clear evidence to show that less area put under agroforestry influenced increase in maize, milk and forage yields. Chi square for less area put under agroforestry; Mogusii T3 (Chi Square 22.163, df = 16 p value = .138, Tende T1 (Chi Square = 21.589, df = 16, p = 0.157) and Isanta (Chi Square = 9.381, df = 12, p value = .670), Kibuon K2 (Chi = 10.512, df = 12, p = .571). Kasipul K3 (Chi = 8.246, df = 9, p = 0.510) and Kibuon K1 (Chi = 6.111, df = 6, p = .411) as indicated in (Table 75).

Table 75: *Chi Square Result for Area put Under Agroforestry and Increase in Maize, Milk and Forage Yields Before Project Implementation*

Sub catchment	Independent variable	Chi square	df	P value (.05)
Kibuon K1	area put under agro-forestry	6.111	6	.411
Kibuon K2	area put under agro-forestry	10.512	12	.571
Kasipul K3	area put under agro-forestry	8.246	9	.510
Tende T1	area put under agro-forestry	21.589	16	.157
Isanta T2	area put under agro-forestry	9.381	12	.670
Mogusii T3	area put under agro-forestry	22.163	16	.138
Total		30.325	16	.010

Through Pearson correlation, area put under agroforestry and increase in maize yield had a positive correlation of r .038 for maize, increase in milk had r .023 while forage had r 0.090 correlation values. This was an indication that agroforestry contributed to high productivity hence the positive correlations as reported by Mugendi, Mucheru-muna, Waswa and Mugwe (2007) on agroforestry for land and water management in Kenya which established that agroforestry improves land productivity.

These findings were also confirmed by Anique, Simone, Michela and Oliver (2017) in their research on agroforestry for landscape restoration which found out agroforestry improved land productivity by meeting the needs for poor resource farmers through increased productivity, soil stabilization, and strip cropping to reduce soil erosion.

Chi Square was used to determine relationship between more areas put under agroforestry and increased maize, milk, and forage yields after project implementation. There was significant relationship in Kasipul K3 (Chi Square = 31.686, df = 16, p value = 0.011), Tende T1 (Chi Square = 84.499, df = 16, p value = 0.001) and Mogusii T3 (Chi Square 25.450, df = 12, p value = 0.013) (Table 76).

Table 76: *Chi Square Analysis Results on Area put Under Agroforestry and Increase in Maize, Milk and Forage Yields After Project Implementation*

Sub catchment	Independent variable	Chi square	df	P value (.05)
Kibuon K1	area put under agroforestry	13.437	12	.338
Kibuon K2	area put under agroforestry	11.769	16	.760
Kasipul K3	area put under agroforestry	31.686	16	.011
Tende T1	area put under agroforestry	84.499	16	.001
Isanta T2	area put under agroforestry	9.581	12	.653
Mogusii T3	area put under agroforestry	25.450	12	.013
Total		90.013	16	.000

The significant relationship indicated that some respondents practiced agro forestry which contributed to conserved soils, replenished soil nutrients which resulted in increased maize, milk and forage yields. The agroforestry trees provided forage for livestock thereby increasing the amount of available forage and milk yield. However, lack of significant relationship in other sub catchments was an indication of less agro-forestry practiced in those sub catchments which was reflected in low maize, milk and forage yields. There was a weak correlation between areas put under agroforestry and maize yield increase (r .162), increase in milk (r 0.104) and forage yields had a medium correlation of r 0.458. These findings were shared with Dawson, Carsan, Franzel, Kindt, Breugel, Graudal, Lilleso, Orwa and Jamnadas, (2014) in their study on agro forestry, livestock, fodder production and climate change adaptation which established that agroforestry increase productivity in catchments which was also reported by FAO (2005) in their study on realizing the economic benefits of agroforestry which found out that agroforestry replenished lost nutrients thereby increasing productivity.

xii Conserved Land Before and After Project Implementation

Through descriptive statistics sub catchments had varied means before project implementation. Kibuon K2 reported less conserved land area with a mean of 4.13 mean and a standard deviation of 1.089, Kasipul had a mean of 3.98 with a standard deviation of 0.969 while Isanta T2 had a mean of 3.68 mean and standard deviation of 0.862. Mogusii T3 had a mean of 3.51 and standard deviation of 1.097, Kibuon K1 scored low on less area conserved compared to other sub catchments at mean of 3.47 and a standard deviation of 1.356.

Data on more land area conserved after project implementation was subjected to descriptive statistics to get means and standard deviations. Kibuon K1 was the highest on more land area conserved at a mean of 4.13 mean with a standard deviation of 0.743. Kasipul K3 had a mean of 3.61 and a standard deviation of 1.078, Kibuon K2 had a mean of 3.57 with a standard deviation of 1.030 while Isanta T2 had a mean of 3.26 with a standard deviation of .820. Tende T1 had a mean of 3.22 with a standard deviation of 0.939 while Mogusii T3 had the lowest mean of 3.08 with a standard deviation of 1.178 (Table 77).

Table 77: *Sub Catchment Means on Conserved Land Before and After Project Implementation*

Sub catchment	N	Mean	Standard deviation	Mean	Standard deviation
		Before		After	
Kibuon K1	15	3.47	1.356	4.13	.743
Kibuon K2	70	4.13	1.089	3.57	1.030
Kasipul K3	51	3.98	.969	3.61	1.078
Tende T1	148	3.61	.845	3.22	.939
Isanta T2	47	3.68	.862	3.26	.820
Mogusii T3	39	3.51	1.097	3.08	1.178
Total	370	3.75	.986	3.37	1.007

Analysis of variance results showed that there were significant differences at F= 4.086, p = .000 on the levels at which conserved land reduced catchments degradation in different sub catchments before project implementation (Table 78).

Table 78: *ANOVA Results on Conserved Land Before Project Implementation*

Variation	Sum of squares	df	Mean square	F	Significant
Between groups	19.059	5	3.812	4.086	.000
Within groups	339.560	364	.933		
Total	358.619	369			

The analysis of variance table indicated that there were significant at F= 4.469, p= .001 on the level at which land area conserved contributed to reduced catchment degradation in different sub catchments after project implementation (Table 79).

Table 79: *ANOVA Results on Land Area Conserved After Project Implementation*

Variation	Sum of squares	DF	Mean square	F	Significant
Between groups	21.630	5	4.326	4.469	.001
Within groups	352.380	364	.968		
Total	374.011	369			

Multiple comparisons before project implementation showed that Kibuon K2 and Tende T1 had a high mean difference of .514 significant at .004, Kibuon K2 and Mogusii T3 had a mean difference of .616 significant at .019 implying that the sub catchment were significantly different from each other. Homogeneous sub sets for land area conserved produced two columns. Kibuon K1 reported more area conserved compared to Kibuon K2 that had a high mean on less land area conserved. Kibuon K1 reported more area conserved compared with Mogusii T3, Tende T1, Isanta T2, Kasipul K3 and Kibuon K2 and was similar to Mogusii T3, Tende T1, Isanta T2 and Kasipul K3. Mogusii T3, Tende T1, Isanta T2 and Kasipul K3 were not significantly different to any sub catchment. Multiple comparisons after project implementation showed that Kibuon K1 and Mogusii T3 had 1.056 mean difference significant at 0.006, Kibuon K1 and Isanta T2 had .878 mean difference significant at 0.033 while Kibuon K1 and Tende T1 had 0.910 mean difference significant at 0.009 the sub catchments were significantly different from each other. Sub catchments were displayed in the first and second level of sub sets. Kibuon K1 was significantly different from Mogusii T3 and had more area conserved than Mogusii T3 which had the lowest mean. Mogusii T3 was similar to Tende T1, Isanta T2, Kibuon K2, Kasipul K3 and Kibuon K1and it had less area conserved compared to Tender T1, Isanta T2, Kibuon K2, Kasipul K3 and Kibuon K1 (Table 80).

Table 80: *Tukey Post Hoc Analysis Results on Conserved Land Before and After Project Implementation*

Sub catchment	N	1	2	1	2
		Before		After	
Kibuon K1	15	3.47			4.13
Mogusii T3	39	3.51	3.51	3.08	
Tende T1	148	3.61	3.61	3.22	
Isanta T2	47	3.68	3.68	3.26	
Kasipul K3	51	3.98	3.98	3.61	3.61
Kibuon K2	70		4.13	3.57	3.57
Significant		.179	.58	.166	.121

Kibuon K2 sub catchment reported less land area conserved while Kibuon K1 had more land area conserved before project implementation. The variations were attributed to climatical conditions whereby Kibuon K1 covers parts of Kisii highlands providing a suitable environment for land conservation while the lower parts of Kibuon K2 experience unsuitable climatic conditions towards Lake Victoria which do not support growing of trees or vegetation cover to increase land area conserved. Intensive cultivation of land to feed the high population leaves no land bare. About 77.8 percent key informants reported less land area conserved in the sub catchments before project implementation. The results indicated that the upper parts of the catchments; Kibuon 1 and 2, and Tende 1 and 2 suffered from less soil erosion.

Kibuon K1 reported more areas conserved compared to Mogusii T3 sub catchment. This was attributed to the highest mean in the following variables; more area put under agro-forestry, more roadside control, reduced deforestation and less denuded land. These variables resulted in more areas conserved in Kibuon K1 sub catchment. Being high in elevation there was need for more land conservation.

Through Chi square, there was evidence that less area conserved influenced increase in yields for maize, milk and forage in all sub catchments except Kibuon K1 before project implementation. Kasipul K3 (Chi Square = 31.945, df = 12, p value .014) and Mogusii T3 (Chi Square = 24.156, df = 12, p value .019) had a significant relationship (Table 81)

Table 81: *Chi Square Results on Conserved Land and Increase in Maize, Milk and Forage Before Project Implementation*

Sub catchment	Independent variable	Chi square	df	P value (.05)
Kibuon K1	area conserved	24.275	16	.084
Kibuon K2	area conserved	28.129	16	.031
Kasipul K3	area conserved	31.945	12	.001
Tende T1	area conserved	94.959	16	.001
Isanta T2	area conserved	36.997	16	.003
Mogusii T3	area conserved	48.007	16	.001
Total		108.247	16	.000

Less land area conserved had a correlation of r 0-.016 for increase in maize, milk yield had -0.038 while more forage had r-0.076. This showed that less area conserved exposed more land to soil erosion thereby affecting maize, milk and forage yields through soil erosion. This was also reported by Kieti et al. (2016) in their study on biophysical conditions and land use methods which reported that less forage cover exposes the soil to degradation reducing productivity . The findings were also shared with Pangare and Pradesh (2006) in their study on socio economic and policy research on catchments which reported conserved land increasing productivity in catchments.

Chi Square established relationships between more area conserved and an increase in maize, milk and forage yields after project implementation. Kasipul K3 (Chi Square = 30.969, df = 16, p value .014) and Mogusii T3 (Chi Square = 24.156, df = 12, p value = 0.019) had a significant relationship (Table 82).

Table 82: *Chi Square Analysis Results on Land Area Conserved and Increase in Maize, Milk and Forage Yields After Project Implementation*

Sub catchment	Independent variable	Chi Square	df	P value (.05)
Kibuon K1	area conserved after project	17.708	16	.341
Kibuon K2	area conserved after project	17.646	16	.345
Kasipul K3	area conserved after project	30.969	16	.014
Tende T1	area conserved after project	15.041	16	.522
Isanta T2	area conserved after project	4.599	12	.970
Mogusii T3	area conserved after project	24.156	12	.019
Total		40.611	16	.001

The results implied that more area was also conserved in Kasipul K3 and Mogusii T3 which contributed to increased maize, milk yields and more forage. Despite this, other sub catchments did not have a significant relationship. This showed that there was less area conserved in the other sub catchments which did not have a significant relationship implying that due to less areas conserved, soil erosion was still evident. This contributed to low maize, milk and forage yields hence the insignificant relationship. About 77.8 percent of the key informants reported an increase in land area conserved which translated in reduced soil erosion thereby increasing maize, milk and forage yields. Pearson correlation was weak between more land conserved (r 0.138) followed by increase in milk (r 0.057) while forage yield got a strong correlation value of r 0.646. Strong correlations indicated the influence of more conserved land on increase in maize, milk and forage yields. These findings agreed with Pangare and Pradesh (2006) in their study on socio Economic and policy research on catchment which found out that conserved land improved land productivity in watersheds This was also reported by FAO (2017) in their findings on catchments management which established that slope stabilization through vegetative propagation and soil treatment increased areas conserved in watershed improving on productivity.

Before project implementation Kibuon catchment experienced more rill erosion, it had many uncontrolled gullies, less roadside erosion control, few check dams were in use and less area was conserved. Deforestation, absence of vetivar grass strips and inadequate retention ditches were reported in Kibuon and Tende catchments. Tende catchment did not have check dams, less road side erosion control was reported. The middle part of the two catchments reported less Napier grass and more denuded land. Kibuon catchment was more degraded than Tende catchment.

xiii Differences in the Level of Degradation Before and After Project Implementation

Data collected was analyzed using paired samples t-test to establish significant differences in the level of degradation before and after project implementation in the catchments. There were statistically significant differences in the level of degradation between the two periods (before and after) project implementation in terms of; rill erosion, uncontrolled gullies, napier grass planted, denuded land, deforestation, vetiver grass strips, retention ditches, check dams used in gullies, cover crops planted, road side erosion control, water turbidity, area put under agroforestry and land area conserved.

T-test results for the period before and after project implementation were significant. The values for the period before project implementation had high mean differences. Pared samples T-test values indicated reduced levels of degradation after project implementation for example uncontrolled gullies before (M =4.24, SD= 0.780) after project implementation (M = 3.26, SD = 1.147), t (369) = 13.457, p =0.000. There was a mean difference of 0.98 which implied that gullies had reduced in the catchments. This was an indication that through ILWMKTP project interventions, there was some uptake of technologies which controlled soil erosion to some level (Table 83).

Table 83: *A Comparison Table for T- Test Results on Level of Degradation in the Catchments before and after Project Implementation*

	Before project implementation		After project implementation		Before and after project implementation		
Independent variables	Mean	SD	Mean	SD	df	T-value	sign.
Rill erosion	4.37	0.654	3.51	1.151	369	12.442	0.000
Gullies	4.24	0.780	3.26	1.147	369	13.457	0.000
Napier grass	4.03	0.974	3.19	1.202	369	9.913	0.000
Denuded land	4.02	.988	3.54	1.166	369	6.102	0.000
Deforestation	4.09	0.895	3.38	1.173	369	9.721	0.000
Vetivar grass strips	4.33	0.86	3.41	1.161	369	13.426	0.000
Retention ditches	4.14	0.894	3.30	1.102	369	10.932	0.000
Check dams	4.15	0.909	3.14	1.135	369	10.932	0.000
Cover crops	4.11	0.886	3.16	1.119	369	12.351	0.000
Road side erosion	4.095	0.939	3.49	1.228	369	7.880	0.000
Water turbidity	4.69	0.743	2.59	1.712	369	19.809	0.000
Area under agroforestry	4.032	0.764	3.82	0.979	369	3.501	0.001
Area conserved	3.80	0.960	3.37	1.007	369	6.589	0.000

. xiv Summary of Variable Scores on Level of Degradation before Project Implementation

Respondents' scores for the period before project implementation were summarized on a five point likert scale to determine how many respondents scored "agree and strongly agree". The scores were made in terms of presence of catchments degradation in the catchments with reference to: rill erosion, uncontrolled gullies, Napier grass grown, denuded land, deforestation, vetiver grass strips, retention ditches, check dams used in gulley control, cover crops, roadside control, Kibuon and Tende water was being turbid, area put under agro-forestry and area conserved.

Total scores were 4,810 out of which 3,697 (77 percent) scored "agree and strongly agree". This indicated that more than half (3,399) of the respondents reported catchment degradation in Kibuon and Tende catchments before project implementation. The abbreviations in column headings stand for: SD (strongly disagree), D (disagree), N (neutral), A (agree), SA (strongly agree) and A+SA (Agree + Strongly agree).Refer to (Table 84)

Table 84: *A Summary for Scores on Level of Degradation before Project Implementation*

VARIABLE	SD	D	N	A	SA	(A + SA)
Rill erosion	2	5	9	193	161	354
Gullies	2	14	25	183	146	329
Napier grass grown	10	22	44	166	128	294
Denuded land	11	24	39	170	126	296
Deforestation	2	26	42	165	135	300
Vetiver grass strips	1	7	19	186	157	343
Retention ditches	2	24	42	156	146	302
Check dams used	7	17	36	164	146	310
Cover crops available	7	18	31	186	128	314
Roadside erosion	9	21	30	176	134	310
Water was turbid	7	5	5	63	290	353
Area put agroforestry	86	232	36	10	6	16
Area conserved	9	26	83	165	87	252
Total	155	441	441	1,983	1,790	3,697 out of 4,810 (76.86%)

About 77 percent of the scores indicated that there was catchment degradation in the catchments. Significant relationships between technologies and sub catchments, and high mean differences confirmed the presence of catchment degradation in the catchments before project implementation.

xv A Summary for Scores on Level of Degradation After Project Implementation

Scores were summarized using a five point likert scale to determine the number for "agree and strongly agree" variables of the study after project implementation. The variables considered were: rill erosion, controlled gullies in the catchment, Napier grass planted, denuded land, deforestation, vetiver grass strips, retention ditches in the catchments, check dams used in gulley control, cover crops, roadside erosion, Kibuon and Tende water was clear, area put under agroforestry and area conserved.

Total number of scores for the objective was 4,810 out of which 2,197 (46 percent) scores were on: "agree and strongly agree". This indicated that less than fifty percent reported controlled catchment degradation which implied there was some level of technology uptake in the catchments.

Abbreviations in column headings represent the following SD (strongly disagree), D (disagree), N (neutral), (A) agree, (SA) strongly agree and (A+SA) Agree + Strongly agree (Table 85)'

Table 85: *A Summary for Scores on Level of Degradation After Project Implementation*

VARIABLE	SD	D	N	A	SA	(A + SA)
Rill erosion	78	136	66	76	14	90
Controlled Gullies	60	108	87	99	16	115
Napier grass grown	62	99	81	104	24	128
Denuded land	2	26	42	165	135	300
Deforestation	11	98	78	104	79	183
Vetiver grass strips	4	103	90	84	89	173
Retention ditches	5	102	107	88	68	156
Check dams used	13	118	104	76	59	135
Cover crops available	14	111	99	93	53	146
Roadside control	11	97	63	97	102	199
Clear water in the catchments	175	33	21	51	90	141
Area put under Agroforestry	95	160	73	36	6	255
Area conserved	44	132	126	52	16	176
Total	574	1,323	1,037	1,125	751	2,197 out of 4810 (46%)

Data analysis for the period before project implementation showed that 77 percent of respondents agreed that there was catchment degradation in the catchments. After project implementation only 46 percent agreed that catchment degradation in the catchments had been controlled. This indicated a significant difference between the level of degradation of the catchments before and after project implementation. T-test values for the period before and after project implementation showed significant differences for example use of check dams had the following t-test results; before project implementation (M=4.032, SD= 0.764) after project implementation (M= 3.82, SD = 0.979) t (369) = 3.501, p =

0.001 indicating an increase in check dam use. There was some uptake of catchment management technologies in the catchments contributing to a difference in the level of degradation in the catchments and therefore the null hypothesis was rejected.

4.4 Knowledge, Skills and Attitude of Farmers on Catchment Management Technologies

4.4.1 Farmers' Knowledge on Catchment Management Technologies

i Introduction

Objective two determined knowledge, skills, and attitude of farmers on catchment management technologies that were promoted in the catchments which were obtained through an interview schedule, a research test and a questionnaire. Data was analyzed using descriptive statistics to determine means and standard deviations and ANOVA to compare means. The analysis was applied on: cover cropping contributed to catchment management, terraces controlled runoff speed, contour ploughing controlled catchment degradation, check dams controlled soil erosion, grass strips reduced runoff flow and retention ditches increased infiltration thereby reducing soil erosion. Results were discussed and presented in tables.

ii Cover Cropping Contributed to Catchment Management

Through descriptive statistics Kibuon K2 had the highest mean of 3.74 with standard deviation of 0.896, Isanta T1 had a mean of 3.49 and standard deviation of 0.748, Kasipul K3 had a mean of 3.41 and a standard deviation of 0.942. Kibuon K1 had a mean of 3.40 and standard deviation of 1.056, Tende T1 had a mean of 3.23 and standard deviation of .757. The mean for Kibuon K2 was the highest which indicated more knowledge on cover crops contributing to catchment management (Table 86).

Table 86: *Means on Cover Crops Contributed to Catchments Management*

Sub catchment	N	Mean	Standard deviation
Kibuon K1	15	3.40	1.056
Kibuon K2	70	3.74	.896
Kasipul K3	51	3.41	.942
Tende T1	148	3.23	.757
Isanta T2	47	3.49	.748
Mogusii T3	39	3.15	.933
Total	370	3.8	.681

The analysis of variance had a statistically significant difference at F = 4.274 and p = 0.001on the level cover crops contributing to a reduction in catchments degradation in different sub catchments (Table 87).

Table 87: *ANOVA Results on Cover Crops Contributed to Watershed Management*

Variations	Sum of squares	df	Mean square	F	Significant
Between groups	15.168	5	3.034	4.274	.001
Within Groups	258.335	364	.710		
Total	273.503	369			

Multiple comparison showed that Kibuon K2 was significantly different from Tende T1 (mean difference .513 significant at 0.000) and Kibuon K2 was also different from Mogusii T3 (Mean difference 0.589 significant at 0.007). This implied that Level of knowledge on management of catchments by cover crops was different in Kibuon K2, Tende T1 and Mogusii T3.

Homogeneous sub sets were displayed in two levels. Mogusii T3 was significantly different from Kibuon K2 by reporting less on cover crops contributing to catchments degradation compared to Kibuon K1 which reported more on cover crops contributing to catchments management. Tende T1, Kibuon K1, Kasipul K3 and Isanta T2 were not significantly different from any sub catchment in terms of cover crops contributing to catchment management. Kibuon K2 reported more on cover cropping contributing to catchment management than Isanta T2, Kasipul K3, Kibuon K1, Tende T1, and Mogusii T3 (Table 88).

Table 88: *Tukey Post Hoc Results on Cover Crops Contributed to Catchment Management*

Sub catchment	N	1	2
Mogusii T3	39	3.15	
Tende T1	148	3.23	3.23
Kibuon K1	15	3.40	3.40
Kasipul K3	51	3.41	3.41
Isanta T2	47	3.49	3.49
Kibuon K2	70		3.74
Significant			

Kibuon K2 scored the highest on cover crops contributing to catchment management which was attributed to dissemination of soil and water conservation technologies during implementation of ILWMKTP project. To recall by respondents that cover crops contributed to catchment management depended on a respondent's level of knowledge which showed that many respondents had knowledge that cover crops contributed to catchment management. There were more affirming responses in Kibuon K2 followed by Isanta T2 then Kasipul K3. Kibuon K1 followed and lastly Mogusii T3 with the least mean of 3.15. Differences in their means indicated their different levels of knowledge on cover crops contributing to catchment management. Their knowledge contributed to less soil erosion reflected in improved productivity for sub catchments that had higher means.

These findings agreed with a study by Mondal et al. (2013) on decomposition of productivity growth which established that introduction of soil and water conservation technologies including cover crops increased productivity and yield levels in catchments. The findings were further confirmed by Mutuyimana (2015) in his study on effects of integrated soil and water management on livelihoods of smallholders in Burega sector, Rulindo district which established that many farmers in Rwanda cover crops because they controlled soil erosion effectively leading to reduced soil erosion.

iii Terraces Controlled Runoff Speed

Data was subjected to descriptive statistics; Kibuon K2 had the highest mean of 4.09 with a standard deviation of .830. Kasipul K3 had a mean of 3. 80 and 0.939 standard deviation, Kibuon K1 had mean of 3.73 and standard deviation of .884, Mogusii T3 followed with a mean of 3.59 and a standard deviation of 0.993. Isanta T2 had a mean of

3.55 and a standard deviation of .746 and the least mean was 3.43 for Tende T1 and a standard deviation of 0.842 (Table 89).

Table 89: *Means on Terraces Controlled Runoff Speed*

Sub catchment	N	Mean	Standard deviation
Kibuon K1	15	3.73	.884
Kibuon K2	70	4.09	.830
Kasipul K3	51	3.80	.939
Tende T1	148	3.43	.842
Isanta T2	47	3.55	.746
Mogusii T3	39	3.59	.993
Total	370	3.65	.890

The ANOVA test results indicated that there were significant differences at F- 5.986, significant at p = .000 on the level terraces controlled catchment degradation in different sub catchments (Table 90).

Table 90: *ANOVA Test Results on Terraces Controlled Runoff Speed*

Variations	Sum of Squares	DF	Mean Square	F	Significant
Between groups	22.189	5	4.438	5.986	.000
Within Groups	269.836	364	.741		
Total	292.024	369			

In multiple comparisons, the table showed that Kibuon K2 was significantly different from Tende T1 with a mean difference of 0.653 significant at .000 and Isanta which had a mean of 5.33 significant at .014.

This showed that the three sub catchments had different levels of knowledge on runoff speed control using terraces. Homogeneous sub sets were displayed in two columns. Tende T1 reported less (lower mean 3.43) on terraces controlling runoff speed compared to Kibuon K2 which reported high levels on control of runoff speed by terraces. Isanta T2, Mogusii T3, and Kibuon K1 and Kasipul K3 were not significantly different from any sub catchment. Tende T1 scored the least on terraces controlling runoff speed followed by Isanta T2, Mogusii T3, Kibuon K2 and Kasipul K3 (Table 91).

Table 91: *Tukey Post Hoc Results on Terraces Controlled Runoff Speed*

Sub catchment	N	1	2
Tende T1	148	3.43	
Isanta T2	47	3.55	3.55
Mogusii T3	39	3.59	3.59
Kibuon K1	15	3.73	3.73
Kasipul K3	51	3.73	3.73
Kibuon K2	70		4.09
Significant		.402	.072

Kibuon K2 had the highest mean on terraces controlling runoff speed followed by Kibuon K1 and Kasipul K3. Mogusii T3 was third followed by Isanta T2 and Tende T1. Fewer respondents in Tende T1 sub catchment had knowledge on terraces controlling runoff speed while Kibuon K2 had the highest number of respondents with knowledge on terraces controlling runoff speed. About 78 percent of key informants reported that respondents had knowledge on terraces which were used to control soil erosion and improve agricultural productivity. Dejene, Teressa and Guteta (2018) confirmed in their study on effects of community based catchment management on livelihood resources for climate change adaptation which established that terraces controlled runoff speed reducing soil erosion, improving moisture retention hence increased productivity. The study also agreed with findings by Govers et al. (2017) in their study on soil conservation in the 21st century which established that terraces were effective in controlling runoff speed thereby reducing soil erosion.

iv Contour Ploughing Controlled Catchment Degradation

Descriptive statistics presented the following results; Kibuon K2 had the highest mean of 3.80 and a standard deviation of 1.113. Kasipul K3 had a mean of 3.63 and a standard deviation of 1.038, Isanta T2 had a mean of 3.38 and standard deviation 0.898, Mogusii T3 got a mean of 3.36 and standard deviation of 0.989. Kibuon K1 had a mean of 3.33 and standard deviation 1.113. The least mean was for Tende T1 3.30 and standard deviation of 0.914 (Table 92).

Table 92: *Means on Contour Ploughing Controlled Catchment Degradation*

Sub catchment	N	Mean	Standard deviation
Kibuon K1	15	3.33	1.113
Kibuon K2	70	3.80	1.016
Kasipul K3	51	3.63	1.038
Tende T1	148	3.30	.914
Isanta T2	47	3.38	.898
Mogusii T3	39	3.36	.989
Total	370	3.46	.979

ANOVA results indicated statistically significant difference at F= 5.773 p = 0.010 on the level contour ploughing reduced catchment degradation in different sub catchments (Table 93).

Table 93: *ANOVA Results on Contour Ploughing Controlled Catchment Degradation*

Variations	Sum of squares	df	Mean square	F	Significant
Between groups	14.354	5	2.871	5.773	0.010
Within Groups	339.455	364	.933		
Total	353.808	369			

Multiple comparisons indicate Kibuon K2 and Tende T1 being significantly different with a mean difference of .503 significant at .005. This was an indication that level of knowledge on contour ploughing reducing catchment degradation was higher in Kibuon K2 and lowest in Kibuon K1.

One level of homogeneous sub set was displayed implying that all sub catchments had closely related responses with regard to knowledge although Kibuon K2 had more responses on contour ploughing controlling catchments degradation while Tende T1 reported the least. All sub catchments had a lot of similarities in their level of knowledge on contour ploughing controlling catchment degradation. Kibuon K2 reported more controlled catchment degradation compared to Kasipul K3, Isanta T2, Mogusii T3, Kibuon K1and Tende T1by using contour ploughing (Table 94).

Table 94: *Tukey Post Hoc Results on Contour Ploughing Controlled Catchment Degradation*

Sub catchment	N	1
Tende T1	148	3.30
Kibuon K1	15	3.33
Mogusii T3	39	3.36
Isanta T2	47	3.38
Kasipul K3	51	3.63
Kibuon K2	70	3.80
Significant		0.198

Tukey post hoc indicated that Kibuon K2 had the highest level of knowledge on contour ploughing controlling catchment degradation compared to Kasipul K3, Isanta T2, Mogusii T3, Kibuon K1 and Tende T1. This may be associated with the ILWMKTP project that was implemented in the two catchments. Tende T1 had the lowest number of respondents who had knowledge on contour ploughing controlled catchment degradation. Although their means deferred, it was evident that the differences were not significant among sub catchments except for Kibuon K2 sub catchment.

These confirmed that there were no wide gaps in their level of knowledge on contour ploughing controlling catchment degradation which was shared with Magombeyi, Taigbenu and Barron (2018) in their study on effectiveness of agricultural water management technologies which established that contour cropping improved soil fertility, controlled nutrient cycle, reduced soil erosion and increased productivity. This was shared by Dejene et al. (2018) in their study on effects of community based catchment management on livelihood resources which established that 68.3 percent implemented contour ploughing in a catchment in Gemechis district to reduce soil erosion.

v Check Dams Controlled Soil Erosion

Data was analyzed using descriptive statistics and various means and standard deviations were achieved. Kibuon K2 had a higher mean of 3.99 and standard deviation of 0.909 followed by Kasipul K3 with a mean of 3.75 and standard deviation of 0.997. Isanta T2 had a mean of 3.70 with a standard deviation of 0.749, Tende T1 had a mean of 3.69 and standard deviation of 0.772, Kibuon K1 had a mean of 3.47 and a standard deviation of 1.246 while Mogusii had a mean of 3.41 and a standard deviation of 1.163 (Table 95).

Table 95: *Means on Check Dams Controlled Soil Erosion*

Sub catchment	N	Mean	Standard deviation
Kibuon K1	15	3.47	1.246
Kibuon K2	70	3.99	.909
Kasipul K3	51	3.75	.997
Tende T1	148	3.69	.772
Isanta T2	47	3.70	.749
Mogusii T3	39	3.41	1.163
Total	370	3.72	.906

The ANOVA results showed significant differences at $F = 2.439$, $p = .034$ on the level at which check dams controlled soil erosion in different sub catchments (Table 96).

Table 96: *ANOVA Results on Check Dams Controlled Soil Erosion*

Variations	Sum of squares	DF	Mean square	F	Significant
Between groups	9.829	5	1.966	2.439	.034
Within Groups	293.374	364	.806		
Total	303.203	369			

Multiple comparisons indicated significant mean difference between Kibuon K2 and Mogusii T3 with a mean difference of 0.575 significant at .018. Homogeneous sub sets displayed one column indicating that although scores may have been slightly different, it was not significant enough to display more than one column. Mogusii T3 reported less knowledge of check dams in controlling catchment degradation while Kibuon K2 had more knowledge on use of check dams. Mogusii T3 reported the least knowledge on check dams controlling soil erosion followed by Kibuon K1, Tende T1, Isanta T2, Kasipul K3 then Kibuon K2 (Table 97).

Table 97: *Tukey Post Hoc Results on Check Dams Controlled Soil Erosion*

Sub catchment	N	1
Mogusii T3	39	3.41
Kibuon K1	15	3.47
Tende T1	148	3.61
Isanta T2	47	3.70
Kasipul K3	51	3.75
Kibuon K2	70	3.99
Significant		.055

Kibuon K2 reported high level of knowledge on check dams controlling soil erosion followed by Kasipul K3 while Mogusii T3 reported less. About 80 percent of key informants reported that farmers had knowledge on control of catchment degradation through check dam use. These findings indicated that levels of knowledge on check dams controlling soil erosion varied within sub catchments although Kibuon K2 reported high levels of check dam use while Mogusii T3 reported low levels. Respondents used the knowledge they had and used check dams to control catchment degradation to improve land productivity in the catchments. This was similar to findings by Adugna and Desta (2012) in their field guide on gulley control which established that check dams controlled runoff velocity encouraging sedimentation which improved agricultural land. This reflected in improved productivity confirmed by Dejene et al. (2018) in their findings on the effects of community based catchment management on livelihood resources for climate change adaptation which established that check dams reduced runoff speed in gullies encouraging siltation which increased agricultural land in the long run.

vi Grass Strips Reduced Runoff Flow

Through descriptive statistics the following means and standard deviations were attained; Kibuon K2 had a higher mean of 3.86 and a standard deviation of 1.107, Kasipul K3 had a mean of 3.86 with a standard deviation of 0.895. Kibuon K1 had a mean of 3.47 and a standard deviation of 0.834, Isanta had a mean of 3.40 and a standard deviation of 1.107 while Mogusii T3 had mean of 3.38 and a standard deviation of 0.935 (Table 98).

Table 98: *Means on Grass Strips Reduced Runoff Flow*

Sub catchment	N	Mean	Standard deviation
Kibuon K1	15	3.47	.834
Kibuon K2	70	3.86	1.107
Kasipul K3	51	3.86	.895
Tende T1	148	3.26	.919
Isanta T2	47	3.40	1.107
Mogusii T3	39	3.38	.935
Total	370	3.49	1.002

Analysis of variance indicated statistically significant differences at F = 5.348, p = 0.000 on the level at which grass strips established reduced runoff flow in different sub catchments (Table 99).

Table 99: *ANOVA Test Results on Grass Strips Reduced Runoff Flow*

Variations	Sum of squares	df	Mean square	F	Significant
Between groups	25.352	5	5.070	5.348	.000
Within Groups	345.137	364	.948		
Total	370.489	369			

In multiple comparisons, Kibuon K2 and Tende T2 were significantly different with a mean difference of 0.600 significant at 0.000. Kasipul K3 was also significantly different from Kibuon K2 with a mean of 0.606 significant at 0.002. This indicated that level of knowledge on grass strips reducing runoff flow was different in the two pairs of sub catchments. On homogenous sub sets, Kasipul K3 reported more knowledge on grass strips reducing runoff flow compared to Tende T1. Tende T1 had the least knowledge compared to Mogusii T3, Isanta T2, Kibuon K1, Kibuon K2 and Kasipul K3 (Table 100).

Table 100: *Tukey Post Hoc Analysis Results on Grass Strips Reduced Runoff Flow*

Sub catchment	N	1
Tende T1	148	3.26
Mogusii T3	39	3.26
Isanta T2	47	3.40
Kibuon K1	15	3.47
Kibuon K2	70	3.86
Kasipul K3	51	3.86
Significant		.069

Tukey post hoc tables showed that Kasipul K3 had more knowledge on grass strips reducing runoff flow which was followed by Kibuon K2, Kibuon K1, Isanta T2, Mogusii T3 and lastly Tende T1. This indicated that many respondents in Kasipul K3 and Kibuon K2 used grass strips to reduce runoff flow reflecting in less catchment degradation. About 77.8 percent of key informants reported respondents using grass strips to control soil erosion in the six sub catchments. This was shared with Ghadiri, Hogarth and Calvin (2000) in their symposium proceeding on the effectiveness of grass strips which established that grass strips controlled soil and water erosion due to the filtering effect, reduction in runoff speed and enhanced soil deposition which translated in improved yields in maize, milk and forage. These findings were similar to research findings by Mutuyimana (2015) in her study on effects of integrated soil and water management on livelihoods of smallholders in Burega sector, Rulindo district which established that grass strips controlled land degradation through reduced soil erosion enhancing agricultural productivity.

vii Retention Ditches Increased Infiltration thereby Reducing Soil Erosion

Through descriptive statistics means and standard deviations were establish. Kibuon K2 had a higher mean of 4.06 with a standard deviation of 0.883, Tende T2 had a mean of 3.68 and a standard deviation of 0.849, Isanta T2 had a mean of 3.62 and a standard deviation of 0.848, Kibuon K1 had a mean of 3.60 and a standard deviation of 1.183, Mogusii T3 had a mean of 3.59 and a standard deviation of 0.966, Kasipul K3 had a mean of 3.57 and a standard deviation of 0.964. Many respondents in Kibuon K2 reported more knowledge on retention ditches increasing infiltration thereby reducing soil erosion while respondents from Kasipul K3 reported less knowledge (Table 101).

Table 101*: Means on Retention Ditches Increased Infiltration and Reduced Soil Erosion*

Sub catchment	N	Mean	Standard deviation
Kibuon K1	15	3.60	1.183
Kibuon K2	70	4.06	.883
Kasipul K3	51	3.57	.964
Tende T1	148	3.68	.849
Isanta T2	47	3.62	.848
Mogusii T3	39	3.59	.966
Total	370	3.72	.909

The analysis of variance indicated significant differences at F= 2.646, p = .023 on the level at which retention ditches increased infiltration thereby reducing catchment degradation in different sub catchments (Table 102).

Table 102: *ANOVA Test Results on Retention Ditches Increasing Infiltration*

Variations	Sum of Squares	DF	Mean Square	F	Significant
Between groups	10.705	5	2.141	2.646	.023
Within Groups	294.498	364	.809		
Total	305.203	369			

Multiple comparisons showed that Kibuon K2 and Kasipul K3 were significantly different with a mean difference of .489 significant at .039 and Kibuon K2 was also different from Tende T1 with a mean of 0.375 significant at 0.049. Analysis produced homogeneous subset levels in one column. This showed that sub catchments had similarities in knowledge on retention ditches increasing infiltration thereby reducing soil erosion hence one subset level. There was more report on retention ditches increasing infiltration and reducing soil erosion from Kibuon K2 compared with Kasipul K3 sub catchment. Kasipul K3 reported less knowledge followed by Mogusii T3, Kibuon K1, Isanta T2 Tende T1 and Kibuon K2 (Table 103).

Table 103: *Tukey Post Hoc Results on Retention Ditches Increasing Infiltration*

Sub catchment	N	1
Kasipul K3	51	3.57
Mogusii T3	39	3.59
Kibuon K1	15	3.60
Isanta T2	47	3.62
Tende T1	148	3.68
Kibuon K2	70	4.06
Significant		.161

Kibuon K2 had a highest number of respondents with knowledge on retention ditches increasing infiltration thereby reducing soil erosion. It was followed by Tende T2, Isanta 2, Kibuon K1, Mogusii T3 and lastly Kasipul K3. The findings showed that many respondents in Kibuon K2 had knowledge on retention ditches increasing infiltration thereby reducing soil erosion while the least number of respondents with that knowledge were from Kasipul K3. About 70 percent of key informants reported that respondents had knowledge on retention ditches increasing infiltration thereby reducing soil erosion. These agreed with findings by Magombeyi, Taigbenu and Barron (2018) in their study on effectiveness of agricultural water management technologies on rain fed cereal crops yield which reported that retention ditches were effective in slowing down runoff speed, enhancing sedimentation, infiltration, increase soil fertility and improve productivity. This was shared with Dollinger, Dagès, Bailly, Lagacherie and Voltz (2015) in their study on managing ditches for agro ecological engineering of landscape which established that retention ditches reduced runoff speed and reduced catchment degradation.

Sub catchments were ranked basing on their mean values in Tukey post hoc tables starting with the highest rank (1) to the lowest (6). Kibuon K2 had the highest level of knowledge on catchment management technologies by ranking first in 5 technologies in column 1; Kasipul K3 ranked first in 3 technologies in column 2; Isanta T2 was ranked first in 3 technologies in column 3; Kibuon K1 and Mogusii T3 were each ranked 1 in two technologies each in column 4. In column 5 Kibuon K1 and Mogusii T3 were ranked first in two technologies each. Tende T1 was ranked first in 3 technologies in column 6 (Table 104).

Table 104: *Ranked Levels of Knowledge for Sub Catchments on Catchment Technologies Promoted in the Catchments*

Variable	1	2	3	4	5	6
Cover cropping contributes to catchments management	Kibuon K2	Isanta T2	Kasipul K3	Kibuon K1	Tende T1	Mogusii T3
Terraces control runoff speed	Kibuon K2	Kasipul K3	Kibuon K1	Mogusii T3	Isanta T2	Tende T1
Contour ploughing controls catchments degradation	Kibuon K2	Kasipul K3	Isanta T2	Mogusii T3	Kibuon K1	Tende T1
Check dams control soil erosion	Kibuon K2	Kasipul K3	Isanta T2	Tende T1	Kibuon K1	Mogusii T3
Grass strips reduce runoff flow	Kasipul K3	Kibuon K2	Kibuon K1	Isanta T2	Mogusii T3	Tende T1
Retention ditches increase infiltration thereby reducing soil erosion	Kibuon K2	Tende T1	Isanta T2	Kibuon K1	Mogusii T3	Kasipul K3

Summary of Sub Catchment Positions on Levels of Knowledge on Soil and Water Conservation Technologies

Data on level of knowledge on catchment management technologies promoted in the catchments was analyzed and results indicated that Kibuon K2 sub catchment had the highest level of knowledge in 5 technologies that controlled catchment degradation followed by Kasipul K3 sub catchment. The third sub catchment was Isanta T2, Kibuon K1 was fourth, Mogusii T3 was fifth while Tende T1 was sixth. The findings indicated that levels of knowledge in the sub catchments were significantly different (Table 105).

Table 105: *Summary for Sub Catchment Positions on Levels of Knowledge on Soil and Water Conservation Technologies*

Sub catchment	Rank orders	Number of technologies	Final position
Kasipul K3	1	1	2
	2	3	
	3	1	
	6	1	
Isanta T2	2	1	3
	3	3	
	4	1	
	5	1	
Tende T1	2	1	6
	4	1	
	5	1	
	6	3	
Kibuon K2	1	5	1
	2	1	
Kibuon K1	3	2	4
	4	2	
	5	2	
Mogusii T3	4	2	5
	5	2	
	6	2	

4.4.2 Farmers' Skills on Catchment Management Technologies Promoted in the Catchments

i Introduction

Data on farmers' skills on catchment management technologies promoted was determined on a five point likert scale in which strongly disagree was represented by 1, 2 was disagree, 3 represented neutral, 4 was agree and 5 represented strongly agree. It was subjected to ANOVA, descriptive statistics and Tukey post hoc methods of analysis in terms of; cover cropping skills, skills to construct terraces, skills to construct retention ditches, skills to construct check dams and contour ploughing skills. Results were analyzed, discussed and presented in Sub catchment means and standard deviation tables, ANOVA and Tukey post hoc tables.

ii Cover Cropping Skills

Descriptive method of analysis determined the following means and standard deviations: Kasipul K3 had a mean of 4.18 and standard deviation.974, Kibuon K2 had a mean of 4.01 and a standard deviation of 1.222, Mogusii T3 had mean of 3.95 and standard deviation of 0.999. Isanta T2 had a mean of 3.49 and standard deviation of 0.856 followed by Tende T1 that had a mean of 3.34 and standard deviation of 0.960 and Kibuon K1 had mean 3.07 and standard deviation1.335 (Table 106).

Table 106: *Means on Cover Cropping Skills*

Sub catchment	N	Mean	Standard deviation
Kibuon K1	15	3.07	1.335
Kibuon K2	70	4.01	1.222
Kasipul K3	51	4.18	.974
Tende T1	148	3.34	.960
Isanta T2	47	3.49	.856
Mogusii T3	39	3.95	.999
Total	370	3.66	1.070

The ANOVA results showed significant differences at F = 8.950, p = 0.000 on the level at which cover cropping reduced catchment degradation in different sub catchments (Table 107).

Table 107: *ANOVA Result on Cover Cropping Skills*

Variations	Sum of squares	DF	Mean square	F	Significant
Between Group	47.010	5	9.950	8.950	.000
Within Groups	382.399	364	1.051		
Total	429.408	369			

Multiple comparisons produced four pairs; Kibuon K2 and Kibuon K1 were significantly different with a mean of .948 significant at .016, Kibuon K2 and Tende T2 were significantly different with a mean of .670 significant at .000. Kasipul K3 and Kibuon K1 were significantly different with 1.110 mean and significant at .004. Kasipul and Tende T1 were significantly different with a mean of .832 significant at .000 while Kasipul K3 and Isanta T2 had a mean of .687 significant at .013.

Homogenous sub sets displayed four columns in which Kibuon K1 was significantly different from Kasipul K3 by reporting low levels of skills in cover cropping compared to Kasipul K3 that reported more skills in cover cropping. Kibuon K1 had fewer cover cropping skills compared to Tende T1, Isanta T2, Mogusii T3, Kibuon K2 and Kasipul K3. Kibuon K1 was similar to Tende T1 and Isanta T2 in cover cropping skills. Isanta T2 and Tende T1was were not significantly different from any sub catchment (Table 108).

Table 108: *Tukey Post Hoc Test Results on Cover Cropping Skills*

Sub catchment	N	1	2	3	4
Kibuon K1	15	3.07			
Tende T1	148	3.34	3.34		
Isanta T2	47	3.49	3.49	3.49	
Mogusii T3	39		3.95	3.95	3.95
Kibuon K2	70			4.01	4.01
Kasipul K3	51				4.18
Significant		.455	.100	.214	.924

Kasipul K3 had more cover cropping skills followed by Kibuon K2, Mogusii T3, Isanta T2, Tende T1 and Kibuon K1. Kibuon K1 had the lowest number of respondents with the skills and was significantly different from Kasipul K3. This indicated that many respondents in Kasipul K3 had skills on cover cropping for control of soil erosion compared to Kibuon K1. Farms which planted many cover crops reduced soil erosion increasing crop and livestock yields which agreed with Dejene et al. (2018) in their study on effects of community based catchment management on livelihood resources who reported an improvement in yields due to better soil health and fertility contributed by cover cropping. The findings were also reported by Govers et al. (2017) in their study on soil conservation in the 21st century which reported cover crops being very effective in controlling runoff speed and improving agricultural productivity.

iii Skills to Construct Terraces

Data collected was subjected to descriptive statistics and the following results were established: Kibuon K2 had a mean of 4.07, and a standard deviation of 1.196, Mogusii

T3 had a mean of 3.92 and standard deviation of 1.061, Kasipul K3 had a mean of 3.82 and a standard deviation of 1.352. Tende T1 had a mean of 3.61 and a standard deviation of 0.734, Kibuon K1 had mean of 3.60 and a standard deviation of 1.183 while Isanta T2 had the least mean of 3.53 and a standard deviation of 0.830 (Table 109).

Table 109: *Means and Standard Deviations on Skills to Construct Terraces*

Sub catchment	N	Mean	Standard Deviation
Kibuon K1	15	3.60	1.183
Kibuon K2	70	4.07	1.196
Kasipul K3	51	3.82	1.352
Tende T1	148	3.61	.734
Isanta T2	47	3.53	.830
Mogusii T3	39	3.92	1.061
Total			

The ANOVA test results showed that there were statistically significant differences at F = 2.850 and p = 0.015 on the level at which skills to construct terraces increased their numbers thereby reducing catchment degradation in different sub catchments (Table 110).

Table 110: *ANOVA Results on Skills to Construct Terraces*

Variations	Sum of squares	df	Mean square	F	Significant
Between Groups	14.228	5	2.846	2.850	.015
Within Groups	363.396	364	.998		
Total	377.624	369			

Multiple comparisons showed that Kibuon K2 and Tende T1 were significantly different at a mean of 0.463 significant at 0.019.

Through Tukey Post hoc, Isanta T2 reported fewer skills in terrace construction compared to Kibuon K1, Tende T1, Kasipul K3, Mogusii T3 and Kibuon K2. Kibuon K2 had the highest skills on terrace construction compared to Isanta (Table 111).

Table 111: *Tukey Post Hoc Analysis Results on Skills to Construct Terraces*

Sub catchment	N	1
Isanta T2	47	3.53
Kibuon k1	15	3.60
Tende T1	148	3.61
Kasipul K3	51	3.82
Mogusii T3	39	3.92
Kibuon K2	70	4.07
Significant		.166

Kibuon K2 reported high level of skills on catchment management technologies. It was followed by Mogusii T3, Kasipul K3, Tende T1, Kibuon K1 and Isanta T2 sub catchment. From the results, there were many respondents in Kibuon K2 who had skills required for catchment management technologies while Isanta T2 had the least number of skilled respondents on catchment management technologies. Respondents who had the skills used them to construct terraces on their farms to control soil erosion and improve agricultural productivity. This was shared with Wolancho (2015) in his research on evaluating catchment management activities of campaign work in Southern nations who found out that adoption of catchment management technologies terraces included improved resources and livelihoods in the catchment. Terraces retain water and reduce the amount of soil erosion in catchments as reported by Abebe (2018) in his study on the impact of soil and water conservation for improved agricultural production in Ethiopia which reported terraces reducing catchment degradation.

iv Skills to Construct Retention Ditches

Through descriptive statistics the following results were achieved: Kibuon K1 had a mean of 2.80 and a standard deviation of 1.424, Tende T1 had a mean of 2. 61 and a standard deviation of 1.000, this was followed by Isanta T2 with a mean of 2.55 and a standard deviation of 1.176. Kibuon K2 had a mean of 2.44 and a standard deviation of 1.48 while Kasipul K3 had mean of 2.27 and standard deviation of 1.576. The mean values were low an indication that many respondents did not have information on contribution of retention ditches therefore very few respondents could construct them without external support (Table 112).

Table 112: *Means on Skills to Construct Retention Ditches*

Sub catchment	N	Mean	Standard Deviation
Kibuon K1	15	2.80	1.424
Kibuon K2	70	2.44	1.48
Kasipul K3	51	2.27	1.576
Tende T1	148	2.61	1.00
Isanta T2	47	2.55	1.176
Mogusii T3	39	1.67	.737
Total	370	2.44	1.244

The ANOVA results showed significant differences at $F = 4.324$, $p = .001$ on the level of skills to construct retention ditches improved on number of retention ditches reducing catchment degradation in different sub catchments (Table 113).

Table 113: *ANOVA Test Results on Skills to Construct Retention Ditches*

	Sum of squares	df	Mean Squares	F	Sig.
Between Groups	31.784	5	6.357	4.324	.001
Within Groups	535.159	364	1.470		
Total	566.943	369			

Multiple comparisons showed that Kibuon K2 and Tende T1 were significantly different from each other with a mean difference of .463 significant at .019, Kibuon K1 was significantly different from Mogusii T3 with a mean difference of 1.133 significant at .027 and Kibuon K2 and Mogusii T3 were significantly different at mean difference of .776 significant at .018. Tende T1 was significantly different from Mogusii T3 with a mean difference of 0.948 at .000 while Isanta T2 was different from Mogusii with a mean difference of 0.887 significant at .011. Homogeneous sub sets displayed two columns with different sub catchments in which Mogusii T3 was significantly different from Kibuon K1 by reporting fewer skills in construction of retention ditches compared to Kibuon K1. Mogusii T3 had the least skills compared with Kasipul K3, Kibuon K2, Isanta T2, Tende T1 and Kibuon K1. Kasipul K3 and Kibuon K2 were not significantly different to any sub catchment (Table 114).

Table 114: *Tukey Post Hoc Analysis Results on Skills to Construct Retention Ditches*

Sub catchment	N	1	2
Mogusii T3	39	1.67	
Kasipul K3	51	2.27	2.27
Kibuon K2	70	2.44	2.44
Isanta T2	47		2.55
Tende T1	148		2.61
Kibuon K1	15		2.80
Significant		.056	.397

Kibuon K1 had a high number of respondents with skills to construct retention ditches. It was followed by Tende T1, Isanta T2 and Kibuon K2. Kasipul was fifth while Mogusii T3 had the least number of respondents with skills. The mean values were very low which indicated that skills needed for retention ditch construction were known to a few respondents.

Those who learnt the skills established retention ditches to reduce soil erosion which agreed with Worku and Tripathi (2015) in their findings on catchment management in highlands of Ethiopia who reported watershed management practices including retention ditches which arrested runoff and soil erosion effects. The findings were also reported by Mutuyimana (2015) in her study on effects of integrated soil and water management on livelihoods of smallholders in Burega Rwanda which established that 77.8% respondents in her study excavated retention ditches because they were effective in controlling runoff and improve productivity.

v Skills to Construct Check Dams

Data collected was analyzed using descriptive statistics and various means and standard deviations were arrived at. Mogusii T3 had a higher mean of 4.03 and standard deviation of .986 which was followed by Kibuon K2 with a mean of 4.00 and standard deviation of 1.228. Kibuon K1 was third highest with a mean of 3.87 and standard deviation 1.125. Kasipul K3 was fourth with a mean of 3.71 and standard deviation of 1.316. Isanta T2 was second lowest with a mean of 3.51 and standard deviation of .856 while Tende T1 scored the least in skills to construct check dams with a mean of 2.99 and standard deviation of 1.037 (Table 115).

Table 115: *Means on Skills to Construct Check Dams.*

Sub catchment	N	Mean	Standard deviation
Kibuon K1	15	3.87	1.125
Kibuon K2	70	4.00	1.228
Kasipul K3	51	3.71	1.316
Tende T1	148	2.99	1.037
Isanta T2	47	3.51	.856
Mogusii T3	39	4.03	.986
Total	370	3.49	1.174

Further analysis of variance showed that there were significant differences at $F = 11.901$, $p = .000$ on the level at which skills to construct check dams contributed to reduced catchment degradation through construction of check dams in different sub catchments (Table 116).

Table 116: *ANOVA Test Results on Skills to Construct Check Dams*

Variations	Sum of squares	df	Mean of squares	F	Sig.
Between Groups	71.443	5	14.289	11.901	.000
Within Groups	437.014	364	1.201		
Total	508.457	369			

Multiple comparisons showed that Kibuon K1 was significantly different from Tende T1 with a mean difference of .880 significant at .038, Kibuon K2 was also different from Tende T1 with a mean difference of .719 significant at .001, while Mogusii T3 was different from Tende T1 with a mean difference of 1.039 significant at .000. The significant differences were due to variations in their scores on skills to construct check dams.

Homogenous sub sets were displayed in two columns based on their similarities in skills to construct check dams. Tende T1 reported fewer skills on check dam construction compared to Isanta T2, Kasipul K3, and Kibuon K1, Kibuon K2 and Mogusii T3. Isanta T2, Kasipul K3 and Kibuon K1 were not significantly different to any sub catchment (Table 117).

Table 117: *Tukey Post Hoc Results on Skills to Construct Check Dams*

Sub catchment	N	1	2
Tende T1	148	2.99	
Isanta T2	47	3.51	3.51
Kasipul K3	51	3.75	3.71
Kibuon K1	15	3.87	3.87
Kibuon K2	70		4.00
Mogusii T3	39	4.03	4.03
Significant		.284	.304

Mogusii T3 had many respondents with skills to construct Check Dams. Kibuon K2 was second, Kibuon K1 was third, and Kasipul K3 was fourth. Fifth position was taken by Isanta T2 and sixth was Tende T1. The findings showed that Mogusii T3 had a high number of respondents with skills to construct check dams while Tende T1 had the lowest number of respondents. Skills in check dam construction contributed to their establishment reducing soil degradation. According to a research by Worku and Tripathi (2015) on catchment management in Highlands of Ethiopia, it was established that check dams were constructed to reduce soil erosion thereby improving productivity and livelihood which agreed with findings by Govers et al. (2017) in their study in soil conservation.

vi Contour Ploughing Skills

Through descriptive statistics,; Tende T1 had a mean of 3.15 and a standard deviation of 1.090, Kibuon K1 had a mean of 2.67 and a standard deviation of 1.447, Kibuon K2 had a mean of 2.60 and standard deviation of 1.583 followed by Isanta T2 which had a mean of 2.47 and a standard deviation of 1.195. Kasipul K3 had a mean of 2.45 and standard deviation of 1.361 which was followed by Tende T1 with a mean of 3.15 and standard deviation of 1.090 while Mogusii T3 had a mean of 1.92 with a standard deviation of 1.06 (Table 118).

Table 118: *Means on Contour Ploughing Skills*

Sub catchment	N	Mean	Standard deviation
Kibuon K1	15	2.67	1.447
Kibuon K2	70	2.60	1.583
Kasipul K3	51	2.45	1.361
Tende T1	148	3.15	1.090
Isanta T2	47	2.47	1.195
Mogusii T3	39	1.92	1.061
Total	370	2.71	1.315

The analysis of variance showed significant differences at F = 7.516, p = .000 on the level at which contour skills were used to reduced catchment degradation in different sub catchments (Table 119).

Table 119: *ANOVA Results on Contour Ploughing Skills*

Variations	Sum of squares	df	Mean square	F	Sig.
Between Groups	59.671	5	11.934	7.516	.000
Within Groups	577.962	364	1.588		
Total	637.632	369			

Multiple comparisons showed pairs of sub catchments that were significantly different. Tende T1 and Kibuon K2 had a mean difference of .549 significant at .034, Tende T1 and Kasipul had .698 mean difference significant at .009, Tende T1 and Isanta T2 had a difference mean of .681 significant at .017 while Tende and Mogusii T3 had 1.226 mean difference significant at .000. The results indicate that the sub catchments were different from each other in terms of skills on contour ploughing.

Homogenous sub sets were displayed in two columns. Mogusii T3 was similar to Kasipul K3, Isanta T2, Kibuon K2 and Kibuon K1 on contour ploughing skills. Mogusii T3 had respondents with fewer skills on contour ploughing compared with Kasipul K3, Isanta T2, Kibuon K2, Kibuon K1 and Tende T1. Kasipul K3, Isanta T2, Kibuon K2 and Kibuon K1 were not significantly different from any sub catchment. Tende T1 had higher report on contour ploughing skills (Table 120).

Table 120: *Tukey Post Hoc Test Results on Contour Ploughing Skills*

Sub catchment	N	1	2
Mogusii T3	39	1.92	
Kasipul K3	51	2.45	2.45
Isanta T2	47	2.47	2.47
Kibuon K2	70	2.60	2.60
Kibuon K1	15	2.67	2.67
Tende T1	148		3.15
Significant		.099	.145

Tende T1 had high number of respondents with skills on contour ploughing compared with Mogusii T3. Mogusii T3 was similar to Kasipul K3, Isanta T2, Kibuon K2, and Kibuon K1. Kibuon K3, Tende T2, Kibuon K2, Kibuon K1 were not significantly different from any sub catchment. The findings indicated that there were many respondents with contour ploughing skills in Tende T1 than Mogusii T3. Magombeyi et al. (2018) in their study on effectiveness of agricultural catchment management technologies on rain fed cereal crop yields reported contour ploughing as an effective way of reducing soil erosion within a watershed and was also reported by Abebe (2018), in his study on impact of soil and water conservation for improved agricultural production in Ethiopia which reported that contour ploughing controlled soil erosion by improving its fertility especially on gently slopes.

vii A Summary for Sub Catchments on Skills on Catchment Management Technologies

There was no individual sub catchment in the first rank in column 1 instead each of the sub catchments was ranked first in different technologies in the same column; Kasipul K3- cover cropping skills, Kibuon K2- skills to construct terraces, Kibuon K1- skills to construct retention ditches, Mogusii T3- skills to construct check dams and Tende T1- contour ploughing skills. This was an indication that each of the six sub catchments reported high levels of skills on one technology. In column 2 Kibuon K2 was ranked first in two technologies while other sub catchments were only ranked once in the same column. In column 3 Mogusii T3, Kasipul K3, Isanta T2, Kibuon K1 and Kibuon K2 were each ranked first in different technologies in the same column. This showed that each sub catchment had skills in different technologies. In column 4 Isanta T2 was ranked first in two technologies; cover cropping skills and contour ploughing skills.

Kasipul was ranked first in two technologies in column 5; skills to construct retention ditches and contour ploughing skills. Mogusii T3 was ranked first in two technologies in column 6; skills to construct retention ditches and contour ploughing skills (Table 121).

Table 121: *Ranked Levels of Skills for Sub Catchments on Catchment Management Technologies*

Variable	1	2	3	4	5	6
Cover cropping skills	Kasipul K3	Kibuon K2	Mogusii T3	Isanta T2	Tende T1	Kibuon K1
Skills to construct terraces	Kibuon K2	Mogusii T3	Kasipul T3	Tende T1	Kibuon K1	Isanta T2
Skills to construct retention ditches	Kibuon K1	Tende T1	Isanta T2	Kibuon K2	Kasipul K3	Mogusii T3
Skills to construct check dams	Mogusii T3	Kibuon K2	Kibuon K1	Kasipul K3	Isanta T2	Tende T1
Contour ploughing skills	Tende T1	Kibuon K1	Kibuon K2	Isanta T2	Kasipul K3	Mogusii T3

Data analysis produced different levels of skills on catchment management technologies promoted in the two catchments. The six sub catchments were presented in various positions based on levels of their skills. Kibuon K2 was ranked first because it had high level of skills in catchments management technologies in two technologies than the other sub catchments. Tende T1 was second while Kibuon K1 attained third position. Kasipul K3 sub catchment was fourth, Isanta T2 was fifth while Mogusii T3 was sixth. The findings confirmed differences in skill levels on catchments management technologies in the six sub catchments. Sub catchments in Kibuon catchment reported more skills on construction of catchment management technologies (Table 122).

Table 122: *Summaries for Sub Catchment Positions on Skills on Catchment Management Technologies*

Sub catchment	Rank orders	Number of technologies	Final position
Kasipul K3	1	1	4
	3	1	
	4	1	
	5	2	
Isanta T2	3	1	6
	4	2	
	5	1	
	6	1	
Tende T1	1	1	2
	2	1	
	4	1	
	5	1	
	6	1	
Kibuon K2	1	1	1
	2	2	
	3	1	
	4	1	
Kibuon K1	1	1	3
	2	1	
	3	1	
	6	1	
Mogusii T3	1	1	6
	2	1	
	6	2	

4.4.3 A Research Test on Farmers' Attitude on Catchment Management Technologies

i Introduction

Farmers' attitude on catchment management technologies was determined on a five point likert scale in which 1 represented strongly disagree, 2 was disagree,3 was neutral, 4 was agree while 5 represented strongly agree. Data was subjected to ANOVA to compare means, descriptive statistics determined means and standard deviations while Tukey post hoc was used to determine significant differences. The analysis was in terms of; productivity reducing because of soil erosion, absence of soil conservation technologies on a farm contributes to low yields, generally yields correspond positively to soil depth, investing in soil and water conservation on your farm is important, property increases on the farm through soil and water conservation and replacement of eucalyptus trees with agroforestry trees in riparian areas would contribute to increased water levels in Kibuon and Tende rivers. Data was analyzed, discussed and presented in mean and standard deviations, ANOVA and Tukey post hoc tables.

ii Productivity is Reducing because of Soil Erosion

The following means and standard deviations were achieved; Kibuon K2 had a mean of 4.30 and standard deviation of 0.709, Kibuon K1 had a mean of 4.20 with a standard deviation of 1.082, Tende T1 had a mean of 4.01 with a standard deviation of .595, Mogusii T3 had a mean of 4.00 with a standard of .795. This was followed by Kasipul K3 with a mean of 3.94 and standard deviation of .785. Sub catchment with the least mean was Isanta T2 with a mean of 3.83 and .601 standard deviation (Table 123).

Table 123: *Means on Productivity Reducing because of Soil Erosion*

Sub catchment	N	Mean	Standard deviation
Kibuon K1	15	4.20	1.082
Kibuon K2	70	4.30	.709
Kasipul K3	51	3.94	.785
Tende T1	148	4.01	.595
Isanta T2	47	3.83	.601
Mogusii T3	39	4.00	.795
Total	370	4.04	.703

ANOVA results showed that there were significant difference at F = 3.277, p = .007 on the level at which productivity is reducing due to soil erosion in different sub catchments (Table 124).

Table 124: *ANOVA Results on Productivity Reducing because of Soil Erosion*

Variations	Sum of squares	DF	Mean square	F	Sig.
Between Groups	7.857	5	1.571	3.277	.007
Within Groups	174.535	364	.479		
Total	182.392	369			

This indicated that sub catchments were significantly different which implied that attitude on soil erosion reducing productivity varied from one sub catchment to the other. Multiple comparisons showed that Kibuon K2 and Isanta T2 had significant mean difference of .470 significant at .005 which indicated that scores on productivity reducing due to soil erosion varied in Kibuon K2 and Isanta T2. Through Tukey post hoc, Isanta T2 was similar to Kasipul K3, Mogusii T3, Tende T1 and Kibuon K1 and significantly different from Kibuon K2. Kibuon K2 had a highest report on productivity reducing due to soil erosion followed by Kibuon K1, Tende T1, Mogusii T3, Kasipul K3 and Isanta T2. Kasipul K3, Mogusii T3, Tende T1 and Kibuon K1 were not significantly different from any sub catchment (Table 125).

Table 125: *Tukey Post Hoc Analysis Results on Productivity Reducing Because of Soil Erosion*

Sub catchment	N	1	2
Isanta T2	47	3.83	
Kasipul K3	51	3.94	3.94
Mogusii T3	39	4.00	4.00
Tende T1	148	4.01	4.01
Kibuon K1	15	4.20	4.20
Kibuon K2	70		4.30
Significant		.174	.203

A high mean value (4.30) of respondents from Kibuon K2 reported productivity reducing because of soil erosion. Kibuon K1 followed closely with a mean difference of 3.20. Tende (mean- 4.01) was third followed by Mogusii T3 (mean- 4.0), Kasipul K3 (3.94) and lastly Isanta T2 (mean of 3.83). Most means were above 4.00 an indication that the respondents were aware that productivity was reducing due to soil erosion which was an indication of positive attitude towards catchment management technologies promoted in the catchments. The positive attitude encouraged implementation of soil conservation technologies improving land productivity. Analyzed data had an average mean running from 3.83 to 4.30 which indicated that many respondents had positive attitude towards catchment management technologies because of soil erosion effects which was confirmed by Worku and Tripathi (2015) in their research on catchment management in highlands of Ethiopia which reported that land degradation, soil erosion and deforestation contributed to reduced productivity and food shortage. Similar findings were also reported by Abebe (2018) in his study on impact of soil and water conservation for improved agricultural production who reported annual yield decreased due to soil erosion.

iii Absence of Soil Conservation Technologies on a Farm Contributes to Low Yields

Data gathered was subjected to descriptive statistics and various means and standard deviations achieved; Kibuon K2 had a mean of 4.04 with a standard deviation of 1.060, Isanta T2 had a mean of 3.77 with a standard deviation of .520, Kasipul K3 had a mean of 3.75 with a standard deviation of .997, Mogusii T3 had a mean of 3.67 with a standard deviation of .662 and Tende T1 had a mean of 3.62 and standard deviation of .654. Kibuon K1 had a mean of 3.47 and a standard deviation of 1.060 (Table 126).

Table 126: *Means on Absence of Soil Conservation Technologies on a Farm Contributes to Low Yields*

Sub catchment	N	Mean	Standard deviation
Kibuon K1	15	3.47	1.060
Kibuon K2	70	4.04	.731
Kasipul K3	51	3.75	.997
Tende T1	148	3.62	.654
Isanta T2	47	3.77	.520
Mogusii T3	39	3.67	.662
Total	370	3.74	.744

There were significant differences at F = 3.692, p = .003 through ANOVA results on the levels at which absence of soil conservation technologies contributed to low yields in different sub catchments (Table 127).

Table 127: *ANOVA Results on Absence of Soil Conservation Technologies Contributes to Low Yields*

Variations	Sum of Squares	DF	Mean Square	F	Sig.
Between Groups	9.849	5	1.970	3.692	.003
Within Groups	194.194	364	.534		
Total	204.043	369			

Multiple comparisons showed Kibuon K2 and Tende T1 had significant mean difference (mean difference .421, significant at .001) which implied that respondents in the two sub catchments scored differently on absence of conservation technologies contributing to low yields. Homogenous sub sets displayed results in two columns. Kibuon K1 reported less on absence of soil conservation technologies contributing to low yields in comparison with Tende T1, Mogusii T3, Kasipul K3 and Isanta T2. It was significantly different from Kibuon K2 which reported more absence of soil conservation technologies contributing to reduced yields. Tende T1, Mogusii T3, Kasipul K3 and Isanta were not significantly different from any sub catchment (Table 128).

Table 128: *Tukey Post Hoc Results on Absence of Soil Conservation Technologies Contributing to Low Yields*

Sub catchment	N	1	2
Kibuon K1	15	3.47	
Tende T1	148	3.62	3.62
Mogusii T3	39	3.67	3.67
Kasipul K3	51	3.75	3.75
Isanta T2	47	3.77	3.77
Kibuon K2	70		4.04
Significant		.462	.114

Kibuon K2 was ranked first in responses on absence of soil conservation technologies contributing to low yields. This showed that many respondents in the sub catchment knew that absence of soil conservation technologies contributed to low yields. Isanta T2 was second in the ranking while Kibuon K1 had the least report which implied that a smaller number of respondents knew that absence of soil conservation technologies on a farm contributed to low yields. Sub catchments had means ranging from 3.47 to 4.04 which showed that they agreed to the positive statement which was an indication of positive attitude. Positive attitude contributed to implementation of soil conservation technologies improving yields. Those who did not implement them had low productivity confirmed by Worku and Tripathi (2015) in their report on catchment management in Highlands of Ethiopia which reported that fertile land for agricultural production was reducing due to soil erosion following absence of soil conservation technologies which agreed with findings by Govers et al. (2017) in their study on soil conservation in the 21st century who reported soil erosion contributed to imbalances in the soil thereby outstripping productivity resulting in decreased yields.

iv Generally Yields Correspond Positively to Soil Depth

Data collected was subjected to descriptive statistics and the following means and standard deviations were achieved: Kasipul K3 had the highest mean of 3.92 and a standard deviation of .744. Kibuon K2 had a mean of 3.89 and a standard deviation of 0.843, Kibuon K2 had a mean of 3.89 and a standard deviation of .843, Mogusii T3 had a mean of 3.72 with a standard deviation of 0.759. Isanta T2 had a mean of 3.55 and a standard deviation of.686, Tende T1 had a mean of 3.49 and standard deviation of .778 while Kibuon K1 had a mean of 3.20 and standard deviation of 1.082 (Table 129).

Table 129: *Means on Yields Correspond Positively to Soil Depth*

Sub catchment	N	Mean	Standard deviation
Kibuon K1	15	3.20	1.082
Kibuon K2	70	3.89	.843
Kasipul K3	51	3.92	.744
Tende T1	148	3.49	.778
Isanta T2	47	3.55	.686
Mogusii T3	39	3.72	.759
Total	370	3.65	.808

Further, ANOVA test results indicated significant differences at $F = 4.819$, $p = 0.000$ on the level at which yields correspond positively to soil depth in different sub catchments (Table 130).

Table 130: *ANOVA Results on Yields Correspond Positively to Soil Depth*

Variations	Sum of squares	df	Mean squares	F	Significant
Between Groups	14.939	5	2.989	4.819	.000
Within Groups	225.680	364	.620		
Total	240.619	369			

Multiple comparison presented 4 pairs of sub catchments that were significantly different from each other; Kibuon K2 and Kibuon K1 had significant difference, 686 significant at 0.028, Kibuon K2 was different from Tende T1 with 0.392 mean difference significant at 0.009, Kasipul K3 and Kibuon K1 were significantly different with 0.722 mean difference and .0024 significance while Kasipul K3 was significantly different from Tende T1 with a mean difference of 0.428 mean difference significant at .011.

Homogenous sub sets were in two columns. Kibuon K1 reported less on yields corresponding to soil depth compared to Tende T1, Isanta T2, Mogusii T3, Kibuon K2 and Kasipul K3. Tende T1 and Isanta T2 were not significantly different to any sub catchment (Table 131).

Table 131: *Tukey Post Hoc Analysis Results on Yields Correspond Positively to Soil Depth*

Sub catchment	N	1	2
Kibuon K1	15	3.20	
Tende T1	148	3.49	3.49
Isanta T2	47	3.55	3.55
Mogusii T3	51		3.72
Kibuon K2	70		3.89
Kasipul K3	51		3.92
Significant		.357	.159

Kasipul K3 had higher responses on yield corresponding positively to soil depth while Kibuon K2 was second. Kibuon K1 had the lowest responses on yields corresponding positively to soil depth. Low mean values for sub catchments indicated that some respondents did not know that yield generally corresponded positively to soil depth.

There were high means 3.20 to 3.92 which indicated positive attitude by agreeing that yield corresponded positively to soil depth which agreed with a study by Hirzel and Matus (2013) in their study on effect of soil depth on yield which reported that soil depth was found to affect crop yield, the height and number of tillers. Similar report on the same was given by Jabro, Stevens, Iversen and Evans (2010) in their study on tillage effects on soil physical properties reported that tillage depth loosened soil, increased water infiltration and fertilizer placement which contributed to higher yields than crops grown on shallow soils that reduce water infiltration.

v Investing in Soil and Water Conservation on the Farm is Important

The following means and standard deviations were attained: Kibuon K2 had a mean of 3.97 and a standard deviation of .868. Kasipul K3 had a mean of 3.84 with a standard deviation of 0.903. Mogusii T3 had a mean of 3.72 and a standard deviation of 0.857. Tende T1 had a mean of 3.52 and a standard deviation of 0.884 which was followed by Isanta T2 with a mean of 3.51 and standard deviation of 0.718. Sub catchment with the least mean was Kibuon K1 with a mean of 3.47 and a standard deviation of 1.060. Many farmers in Kibuon K2 responded positively to investing in soil and water conservation on the farm being important thereby showing their positive attitude towards catchments management technologies (Table 132).

Table 132: *Means on Investing in Soil and Water Conservation is Important*

Sub catchment	N	Mean	Standard deviation
Kibuon K1	15	3.47	1.060
Kibuon K2	70	3.97	.868
Kasipul K3	51	3.84	.903
Tende T1	148	3.52	.884
Isanta T2	47	3.51	.718
Mogusii T3	39	3.72	.857
Total	370	3.67	.884

ANOVA test results showed significant differences at F= 3.470, p = 0.004 on the level at which investing in soil and water conservation was important in different sub catchments. Multiple comparisons showed Kibuon K2 and Tende T1 sub catchment were significantly different.451 mean difference significant at 0.005 (Table 133).

Table 133: *ANOVA Results on Investing in Soil and Water Conservation is Important*

Variations	Sum of squares	DF	Mean squares	F	Significant
Between Groups	13.108	5	2.622	3.470	.004
Within Groups	13.108	364	.756		
Total	288.111	369			

Homogenous sub sets were displayed in one column. Few respondents in Kibuon K1 were aware that investing in soil and water conservation on the farm was important compared to Isanta T2, Tende T1, Mogusii T3, Kasipul K3 and Kibuon K2. The sub catchments had more similarities on importance of investing in soil conservation on the farm which placed them in one column (Table 134).

Table 134: *Tukey Post Hoc Results on Investing in Soil and Water Conservation being Important*

Sub catchment	N	1
Kibuon K1	15	3.47
Isanta T2	47	3.51
Tende T1	148	3.52
Mogusii T3	39	3.72
Kasipul K3	51	3.84
Kibuon K2	70	3.97
Significant		.110

There were higher numbers of responses on investment in soil and water conservation being important from respondents in Kibuon K2 followed by respondents in Kasipul K3. Fewer respondents were from Kibuon K1 sub catchment. Means ranged between 3.47 and 3.97 which showed respondents' positive attitude towards investing in soil and water conservation on the farm to be important. Those who had positive attitude invested in soil conservation technologies which controlled soil erosion and improved productivity.

This was reported by (Dollinger et al., 2015) on managing ditches for agro ecological engineering of landscape who reported that through food production agriculture was predisposing land to soil erosion, water pollution and biodiversity reduction which called for control of watershed degradation for continued agricultural production. This was supported by Mutuyimana (2015) in her study on effects of integrated soil and water management on livelihoods of smallholders in Burega District who reported increase in agricultural productivity in Rwanda due to .investment in soil conservation on farms.

vi Property Increase on the Farm through Soil and Water Conservation

Descriptive statistics provided the following means and standard deviations; Kasipul K3 had the highest mean of 4.04 with a standard deviation.916. Kibuon K2 had a mean of 3.96 with a standard deviation of. 875, Mogusii T3 had a mean of 3.64 with a standard deviation of .873. Tende T1 had a mean of 3.55 with a standard deviation of 0.868, Isanta T2 had 3.47 mean and a standard deviation of 0.873. Kibuon K1 had a mean of 3.13 with a standard deviation of 1.246 (Table 135).

Table 135: *Means on Increase in Property on the Farm via Soil and Water Conservation.*

Sub catchment	N	Mean	Standard deviation
Kibuon K1	15	3.13	1.246
Kibuon K2	70	3.96	.875
Kasipul K3	51	4.04	.916
Tende T1	148	3.55	.868
Isanta T2	47	3.47	.873
Mogusii T3	39	3.64	.873
Total	370	3.68	.918

ANOVA test results indicated that there were significant differences at F = 5.327, p = .000 on the level at which property increase on the farm through soil and water conservation in different sub catchments (Table 136).

Table 1366: *ANOVA Results on Increase in Property via Soil and Water Conservation*

Variations	Sum of squares	df	Mean square	F	Significant
Between Groups	21.209	5	4.242	5.327	0.000
Within Groups	289.872	364	.796		
Total	311.081	369			

Multiple comparison showed that: Kibuon K2 and Kibuon K1 had .824 mean difference significant at .016, Kibuon K2 and Tende T1 had .410 mean difference significant at .021, Kibuon K2 and Isanta had 0.489 mean difference significant at 0.045, Kasipul and Kibuon K1 had 0.906 mean difference significant at 0.008 and Kasipul K3 and Isanta T2 had 0.571 mean significant at 0.021. The findings showed that the sub catchments had some differences in their scores with regard to increase in property through investment in soil and water conservation.

Homogenous sub sets were displayed in two columns. Kibuon K1 reported less increase of property through soil and water conservation compared with Isanta T2 Tende T1 Mogusii T3, Kibuon K2 and Kasipul K3. Isanta T2, Tende T1 and Mogusii T3 were not significantly different from any sub catchment. Kasipul K3 reported high increase of property through soil and water conservation (Table 137).

Table 1377: *Tukey Post Hoc Results on Increase in Property on the Farm Through Soil and Water Conservation*

Sub catchment	N	1	2
Kibuon K1	15	3.13	
Isanta T2	47	3.47	3.47
Tende T1	148	3.55	3.55
Mogusii T3	39	3.64	3.64
Kibuon K2	70		3.96
Kasipul K3	51		4.04
Significant		0.124	0.056

Kasipul K3 had a high number of respondents who reported property increase on the farm through soil and water conservation by improving soil fertility to enhance productivity. Improved productivity would be reflected in high income that could be used to buy assets on the farm. Kibuon K2 was second in reporting on the same variable followed by Mogusii T3 and the last sub catchment was Kibuon K1. The results indicated that some respondents in Kibuon K1 were not aware that investment in soil and water conservation could lead to acquisition of more property on the farm. The mean ranged from 3.13 to 4.04 which showed that many respondents agreed that investment in soil and water conservation led to increased property on the farm which was an indication of positive attitude.

The positive attitude encouraged investing in soil conservation technologies and improved agricultural productivity. Wolancho (2015) in his study on evaluating catchment management activities of campaign work in Ethiopia reported catchment management technologies enhancing ecological and environmental conditions of catchments. It improved income for community members who were able to use their income to increase their property on the farm. This was in agreement with findings by Tugizimana (2015) in his study on effects of soil and water conservation techniques which reported that soil conservation technologies reduced soil erosion, increased soil fertility and improved crop yields in Ghana which was reflected in improved income that was used to buy and improve on farm implements.

vii Replacement of Eucalyptus Trees with Agroforestry Trees in the Riparian Areas Contributed to an Increase in Water Levels in Kibuon and Tende Rivers

Data was subjected to descriptive statistics which resulted in different means and standard deviations for the sub catchment. Kibuon K2 had a mean of 3.91 and a standard deviation of 0.794, Kasipul K3 had a mean of 3.84 and a standard deviation was 0.880, Isanta T2 had a mean of 3.79 with a standard deviation 0.657, Tende T1 had a mean of 3.68 with a standard deviation of 0.835, Mogusii T3 had a mean of 3.64 with a standard deviation of 0.843. Kibuon K1 had the least mean of 3.60 with a standard deviation of 0.910 (Table 138).

Table 1388: *Means on Replacement of Eucalyptus with Agroforestry Trees in Riparian Areas*

Sub catchment	N	Mean	Standard deviation
Kibuon K1	15	3.60	.910
Kibuon K2	70	3.91	.794
Kasipul K3	51	3.84	.880
Tende T1	148	3.68	.835
Isanta T2	47	3.79	.657
Mogusii T3	39	3.64	.843
Total	370	3.75	.818

The ANOVA test result did no show significant difference at F= 1.202, p = .308 on the level at which replacement of eucalyptus trees were replaced by agroforestry trees in riparian area in different sub catchments (Table 139).

Table 13939: *ANOVA Results on Replacement of Eucalyptus with Agroforestry Trees in Riparian areas*

Variations	Sum of squares	Df	Mean square	F	Significant
Between Groups	4.014	5	.803	1.202	.308
Within Groups	243.110	364	.668		
Total	247.124	369			

Multiple comparisons failed to show sub catchments that were significantly different which implied similarities among sub catchments. Homogenous sub sets displayed one level that Kibuon K1 had the lowest report on replacement of eucalyptus trees with agroforestry in riparian areas contributed to increased water levels in Kibuon and Tende rivers while Kibuon K2 had the highest report on replacement of eucalyptus with agroforestry increased water in Kibuon and Tende rivers. Kibuon K1 reported less compared to Mogusii T3, Tende T1, Isanta T2, Kasipul K3 and Kibuon K2 (Table 140).

Table 1400: *Tukey Post Hoc Results on Replacement of Eucalyptus with Agroforestry Trees in Riparian Areas*

Sub catchment	N	1
Kibuon K1	15	3.60
Mogusii T3	39	3.64
Tende T1	148	3.68
Isanta T2	47	3.79
Kasipul K3	51	3.84
Kibuon K2	70	3.91
Significant		.535

Kibuon K2 sub catchment had high number of respondents who agreed that replacement of eucalyptus trees with agroforestry trees in riparian areas would contribute to water levels in Kibuon and Tende rivers. They knew that agroforestry trees do not have high water abstraction like eucalyptus which was planted near rivers and in swamps in the catchments. Kasipul K3 also had a fair level of knowledge on replacement of eucalyptus trees with agroforestry trees in riparian areas would increase water levels in rivers

Kibuon and Tende. Kibuon K1 had the least number of responses although the differences were not significant.

Most of the respondents interviewed agreed (mean of above 3) that eucalyptus trees should be replaced with agroforestry trees which agreed with (Kenya Forest Service, 2009) in their guide to on-Farm eucalyptus growing in Kenya which indicated that they should not be planted in riparian areas, along rivers within less than 30 metres, on irrigated farms and areas that receive less than 400 mm of rainfall. This was confirmed by Khonkaen (2011) in his study on application of check dam construction for catchment management in which they determined that when eucalyptus trees were cut down from riparian areas water flow in rivers increased.

viii A Summary of Sub Catchment Ranks on their Attitude on Catchment Management Technologies

Kibuon K2 was ranked first in column I in three technologies; productivity is reducing because of soil erosion, absence of soil conservation technologies on the farm contributes to low yields and investing in soil and water conservation on your farm is important. The sub catchment had more responses on respondents' attitude on catchment management technologies promoted in the catchments. This showed that many respondents in Kibuon K2 sub catchment had positive attitude towards catchment management technologies.

In column 2, Kibuon K2 was ranked first in two technologies; generally yield corresponds positively to soil depth and property increase on the farm through soil and water conservation. In column 3 Mogusii T3 was rank first in three technologies in the same column; generally yield corresponds to soil depth, investing in soil and water conservation on your farm is important and property increase on the farm through soil and water conservation. In column 4 Mogusii T3 and Tende T1 were both ranked first in two different technologies; Mogusii T3- productivity reducing because of soil erosion and absence of soil conservation technologies on the farm contributes to low yields while Tende T1 led in investing in soil and water conservation on the farm is important and property increase on the farm through soil and water conservation. In column 5 Tende T1 and Isanta T2 were ranked first each in two different technologies. Tende T1led in absence of soil conservation technologies on the farm contributes to low yields and generally yield correspondents positively to soil depth while Isanta T2 had investing in soil and water conservation on your farm is important and property increase on the farm through soil and water conservation.

In column 6 Kibuon K1 was ranked first in 4 technologies; absence of soil and water conservation technologies on the farm contributes to low yields, generally yields correspond positively to soil depth, investing in soil and water conservation on your farm is important and property increase on the farm through soil and water conservation. Kibuon K1 had the least responses on respondents' attitude on catchments management technologies promoted in the catchments because it was ranked last in four technologies. This implied that fewer respondents had positive attitude towards catchment management technologies (Table 141).

Table 1411: *Ranked Levels of Attitude on Catchment Management Technologies*

Variable	1	2	3	4	5	6
Productivity is reducing because of soil erosion	Kibuon K2	Kibuon K1	Tende T1	Mogusii T3	Kasipul K3	Isanta T2
Absence of soil conservation technologies on the farm contribute to low yields	Kibuon K2	Isanta T2	Kasipul K3	Mogusii T3	Tende T1	Kibuon K1
Generally yields correspondent positively to soil depth	Kasipul K3	Kibuon K2	Mogusii T3	Isanta T2	Tende T1	Kibuon K1
Investing in soil and water conservation on your farm is important	Kibuon K2	Kasipul K3	Mogusii T3	Tende T1	Isanta T2	Kibuon K1
Property increase on the farm through soil and water conservation	Kasipul K3	Kibuon K2	Mogusii T3	Tende T1	Isanta T2	Kibuon K1

Summary for Sub Catchments on Attitude on Catchment Management technologies

Data on level of attitude on catchment management technologies was analyzed and sub catchments attained different ranks. Kibuon K2 got position first because it appeared in 2 columns. Position 2 was taken by Kasipul K3 which was appeared in four columns and Tende T1 was third by being appearing in 3 columns. Isanta T2 was 4 because it appeared in 3 columns. Mogusii T3 was 5 due to appearing in 2 columns while Kibuon

K1 was in position 6 for appearing 2 columns. The ranks were assigned to sub catchments based their means on their responses to technologies they were tested on. The means indicated differences in the level of attitude on different catchment management technologies promoted in the catchments (Table 142).

Table 1422: *Summaries for Ranks on Attitude on Catchment Management Technologies*

Sub catchment	Rank orders	Number of technologies	Final position
Kasipul K3	1	2	2
	2	1	
	3	1	
	5	1	
Isanta T2	2	1	4
	4	1	
	6	1	
Tende T1	3	1	3
	4	2	
	5	2	
Kibuon K2	1	3	1
	2	2	
Kibuon K1	2	1	6
	6	5	
Mogusii T3	3	3	5
	4	2	

4.4.4 Frequency Table for Responses on Soil and Water Conservation Technologies

i Frequency for Respondents who Agreed to the Positive Statements on Soil Conservation Technologies

A frequency table was drawn to establish how many respondents agreed to the positive statements on soil conservation technologies. About 39 percent of the respondents agreed that cover cropping contributed to catchments management. More than half (59.4 percent) of the respondents agreed that terracing controlled runoff speed while 51 percent reported that contour ploughing controlled catchment degradation.

Majority of the respondents (70 percent) agreed that check dams controlled soil erosion. Grass strips reduced runoff flow was reported by 52.4 percent. About 71 percent agreed that retention ditches increased infiltration thereby reducing soil erosion. The findings showed that more than half of the respondents agreed that soil conservation technologies contributed to catchment management which was an indication of positive attitude. Abbreviations in column heading represent (SD) strongly disagree, (D) disagree, (N) neutral, (SA) strongly agree (Table 143).

Table 1433: *Frequency of Respondents who Agreed to the Positive Statements on Soil Conservation Technologies*

Technology	SD	D	N	A	SA	Total (Agreed)
Cover cropping contributed to catchments management	1.6	8.9	50.3	27.8	11.4	39.2
Terracing controlled runoff speed	1.4	7.8	31.4	43.2	16.2	59.4
Contour ploughing controlled catchments degradation	3.8	11.1	33.8	38.4	13	51.4
Check dams controlled soil erosion	3.2	6.2	21.1	54.6	14.9	69.5
Grass strips reduced runoff speed	3.8	10.8	33	37	15.4	52.4
Retention ditches increased infiltration	2.7	8.6	17.3	57	14.3	71.3

Data analysis indicated different levels based on scores in the sub catchments. Analysis on respondents' knowledge was at different levels in each sub catchment. Data Analysis on skills provided various levels based on ranks attained by each sub catchment running from 1 to 6. Responses to test attitude were also analyzed and results displayed at various levels (1-6). A frequency table for those who agreed to positive statements on soil and water conservation technologies ranged from 39.2 to 71.3 percent. The findings on knowledge, skills and attitude on different catchment management technologies showed various levels which were an indication of significant differences in knowledge, skills and attitude of the respondents on catchment management technologies hence the null hypothesis was rejected.

4.5 The Level of Uptake of Catchment Management Technologies in Kibuon and Tende Catchments

4.5.1 Introduction

Analysis of variance was used to analyze data for the third objective on the level of uptake of catchment management technologies in Kibuon and Tende catchments. ANOVA, Tukey post hoc, descriptive statistic and Pearson correlation methods of analysis were applied on the following variables; number of soil conservation technologies each farmer was able to construct without technical assistance, number of grass strips established, number of terraces constructed on the farm, number of cover crops grown and acreage under agroforestry. Results were discussed and presented in tables.

4.5.2 Number of Soil and Water Conservation Technologies Constructed without Technical Assistance

Descriptive statistic was used to establish the following means and standard deviations; Kibuon K1 had a mean of 2.93 and a standard deviation of 1.100, Kibuon K2 had a mean of 2.89 and a standard deviation of .790, Kasipul K3 had a mean of 2.76 and a standard deviation of 0.862. Mogusii T3 had a mean of 2.54 and a standard deviation of 9.13, Tende T1 had a mean of 2.43 and a standard deviation of 0.630 while Isanta had a mean of 2.23 with a standard deviation .913 (Table 144).

Table 1444: *Means on Number of Technologies Constructed without Technical Assistance*

Sub catchment	N	Mean	Standard deviation
Kibuon K1	15	2.93	1.100
Kibuon K2	70	2.89	.790
Kasipul K3	51	2.76	.862
Tende T1	148	2.43	.630
Isanta T2	47	2.23	.520
Mogusii T3	39	2.54	.913
Total	370	2.57	.770

The analysis of variance table indicated significant differences at F = 6.941, p = .000 on the level at which farmers constructed different number of soil conservation technologies without external assistance in different sub catchments (Table 145).

Table 1455: *ANOVA Results on Number of Technologies Constructed Without Technical Assistance*

Variation	Sum of squares	df	Mean square	F	Significant
Between Groups	19.035	5	3.807	6.941	0.000
Within Groups	199.638	364	.548		
Total	218.673	369			

Multiple comparisons showed four pairs of sub catchments that were significantly different from each other. Kibuon K1 and Isanta T2 had a mean difference of .699 significant at .020, Kibuon K2 and Tende T1 had .453 mean difference significant at .000, Kibuon K2 and Isanta T2 had a mean of .653 significant at .000 while Kasipul K3 and Isanta T2 had 5.31 mean difference significant at .006. These results showed that respondents from different sub catchments were able to construct different numbers of soil and water conservation technologies without external technical assistance.

Test results through Tukey post hoc produced three subset levels of sub catchments in which farmers who constructed soil and water conservation technologies. The sub catchment was similar to Tende T1 and Mogusii T3 but significantly different from Kibuon K1. Isanta reported an average of two technologies constructed without external technical assistance, Mogusii T3, Kasipul K3, Kibuon K2 and Kibuon K1 constructed about three technologies on their own (Table 146).

Table 1466: *Tukey Post Hoc Results on Number of Technologies Constructed without Technical Assistance*

Sub catchment	N	1	2	3
Isanta T2	47	2.23		
Tende T1	148	2.43	2.43	
Mogusii T3	39	2.54	2.54	2.54
Kasipul K3	51		2.76	2.76
Kibuon K2	70		2.89	2.89
Kibuon K1	15			2.93
Significant		.459	.078	.176

The mean values were very low which meant that respondents were able to establish very few technologies on their own. However, Kibuon K1 had the highest mean compared with other sub catchments. This was an indication that respondents in Kibuon K1 constructed relatively many technologies on their own without external technical assistance compared with other sub catchments. Isanta T2 had the least number of technologies constructed on their own which could be attributed to personal initiative since farmers in all sub catchments were trained on how to construct them through ILWMKTP project. Number of technologies varied from one respondent to the other basing on their knowledge and skills, and attitude.

Data was also analyzed using Pearson correlations to find out how soil conservation technologies correlated with maize, milk and fodder yields in the catchments. Correlation results showed a positive increase in maize r = 0.673 P value = 0.000, milk yield increase r =.310 P = .000 and forage yields was r = .230 P = .000.The findings indicated that an increase in number of technologies constructed increased maize, milk and forage yields. This was in line with findings by Pangare and Pradesh (2006) in their research on socio economic and policy research on catchments management in India whose findings were also reported by Tugizimana (2015) in his research on effects of soil and water conservation techniques.

4. 5. 3 Number of Grass Strips Established

The following means and standard deviations achieved through descriptive statistics; Kibuon K2 had the highest mean of 3.11 and standard deviation of .956, Kibuon K1 had a mean of 3.00 with a standard deviation of 1.195, Isanta T2 had a mean of 2.77 with standard deviation of .729. Mogusii T3 had a mean of 2.74 and a standard deviation of 1.272, Kasipul K3 had mean of 2.51 with a standard deviation.987 while Tende T1 had a mean of 2.46 and standard deviation .684 (Table 147).

Table 1477: *Means on Number of Grass Strips Established*

Sub catchment	N	Mean	Standard deviation
Kibuon K1	15	3.00	1.195
Kibuon K2	70	3.11	.956
Kasipul K3	51	2.51	.987
Tende T1	148	2.46	.684
Isanta T2	47	2.77	.729
Mogusii T3	39	2.74	1.272
Total	370	2.68	.917

Further analysis through ANOVA showed there were significant differences in the number of grass strips established at F = 6.079, p = 0.000 on the level at which number of grass strips established varied in sub catchments (Table 148).

Table 1488: *ANOVA Results on Number of Grass Strips Established*

Variations	Sum of Squares	DF	Mean Squares	F	Significant
Between Groups	23.919	5	4.784	6.079	.000
Within Groups	286.449	364	.787		
Total	310.368	369			

Multiple comparisons showed that Kibuon K2 had a mean difference of .604 significant at 0.003, Kibuon K2 and Tende T1 had a mean difference of 0.655 significant at 0.000. Homogenous sub sets were displayed in two categories in which Tende T1 constructed an average of two grass strips, Kasipul K3, Mogusii T3, Isanta T2 constructed three grass strips while Kibuon K1 and Kibuon K2 constructed three and above grass strips (Table 149).

Table 14949: *Tukey Post Hoc Test Results on Number of Grass Strips Established*

Sub catchment	N	1	2
Tende T1	148	2.46	
Kasipul K3	51	2.51	
Mogusii T3	39	2.74	2.74
Isanta T2	47	2.77	2.77
Kibuon K1	15	3.00	3.00
Kibuon K2	70		3.11
Significant		.080	.439

Kibuon K2 had a higher number of grass strips established compared with other sub catchments. This could be associated with higher acreage per household in Kabondo and Kasipul which allowed for construction of many grass strips. Tende T1 had the least number of technologies constructed because of land size and stable rainfall in Kisii County which enhances vegetation growth hence controlled soil erosion.

There was a positive correlation between number of grass strips established and increased maize, milk and forage yields. Increase in maize had r = 0.670, P value = 0.000, milk yield had r = 0.139, P value = 0.008 while forage yields had r =. 166, P value = 0.001. The positive correlations were an indication of increase in maize, milk and forage yields with an increase in number of grass strips. The findings indicated that number of grass strips established influenced increase in maize, milk and forage yields and it was easy to establish grass strips which is in line with findings by Kangogo, (2016) in his research on farmers' perception of the impact of soil erosion on maize production who established that grass strips were highly taken up since they controlled soil erosion, served as fodder crops for livestock and increased land productivity which was also reported by Tugizimana (2015) in his report on effects of soil and water conservation techniques which reported soil conservation technologies reducing soil erosion, increased soil fertility and improved crop yields which resulted in high maize yields in Ghana.

4. 5. 4 Number of Terraces Constructed on the Farm

Data collected was subjected to descriptive statistics to determine means and standard deviations and the following results were achieved; Kibuon K2 had the highest mean of 2.99 and a standard deviation of 0.940, Kibuon K1 had a mean of 2.80 and standard deviation of 1.082 and Mogusii T3 had a mean of 2.77 and standard deviation of 1.135. Isanta T2 had a mean of 2.74 and a standard deviation of .765, Kasipul K3 had mean of 2.47 and a standard deviation of .902 while Tende had a mean of 2.24 and a standard deviation of 0.765 (Table 150).

Table 1500: *Means for Number of Terraces Constructed on the Farm*

Sub catchment	N	Mean	Standard Deviation
Kibuon K1	15	2.80	1.082
Kibuon K2	70	2.99	.940
Kasipul K3	51	2.47	.902
Tende T1	148	2.24	.765
Isanta T2	47	2.74	.765
Mogusii T3	39	2.77	1.135
Total	370	2.55	.842

ANOVA test results showed significant differences F = 10.425, p = .05 on the number of terraces constructed on the farm (Table 151).

Table 1511: *ANOVA Results on Number of Terraces Constructed on the Farm*

Variations	Sum of Squares	DF	Mean Square	F	Significant
Between Groups	32.745	5	6.549	10.425	.000
Within Groups	228.674	364	.628		
Total	261.419				

Multiple comparisons showed four pairs that were significantly different from each other. Kibuon K2 and Kasipul K3 had a mean difference of .515 significant at 0.006, Kibuon K2 and Tende T1 had .749 mean difference significant at .000, Isanta T2 and Tende T1 had .508 mean difference significant at 0.002 while Mogusii T3 and Tende had .533 mean difference significant at 0.003. These sub catchments differed in number of terraces that were constructed.

There were three subset levels in which Tende T1 and Kasipul K3 constructed about two terraces. Isanta T2, Mogusii T3, Kibuon K1 and Kibuon K2 constructed an average of 3 terraces. Kibuon K2 had the highest number of terraces constructed without technical assistance (Table 152).

Table 1522 *Tukey Post Hoc Results on Number of Terraces Constructed on the Farm*

Sub catchment	N	1	2	3
Tende T1	148	2.24		
Kasipul K3	51	2.47	2.47	
Isanta T2	47	2.74	2.74	2.74
Mogusii T3	39		2.77	2.77
Kibuon K1	15		2.80	2.80
Kibuon K2	70			2.99
Significant		.055	.446	.762

The mean values were low an indication of fewer number of terraces established in sub catchments. The results also indicated that number of constructed terraces varied from one sub catchment to the other. Kibuon K2 had more than Tende T1 due to household land sizes. Differences in number could be attributed to farm sizes and personal initiative since farmers in the sub catchments were trained on terrace construction. Number of terraces constructed were found to influence increase in maize, milk and forage as indicated through Pearson correlation findings; (increased maize yields r = 0.671, p value = 0.000, increase in milk yield- r = 0.310, p value = 0.000 and forage yields- r =.233, p value = 0.000). Positive correlations implied that an increase in number of terraces resulted in increase in maize, milk and forage yields.

The findings showed that although expensive to construct, the number of terraces constructed on farms had an influence on productivity in relation to maize, milk and forage which was agreed by Kangogo (2016) in his study on farmers' perception of the impact of soil erosion on maize production which reported construction of terraces influenced level of productivity although costly to excavate and maintain. These findings were shared with Tugizimana (2015) in his study on effects of soil and water conservation techniques which reported terraces being effective in controlling runoff in catchments but more investment is needed for their construction.

4. 5.5 Number of Cover Crops Grown

Data collected was analyzed using descriptive statistic to establish means and standard deviations for cover crops in the sub catchments. Isanta T2 had a mean of 3.00 with a standard deviation of .626, Mogusii T3 had a mean of 2.97 and standard deviation of 0.778, Kasipul K3 had a mean of 2.71 and a standard deviation of 0.756. Kibuon K2 had a mean of 2.71 with a standard deviation of 0.725. Tende T1 had a mean of 2.70 with a standard deviation of 0.517 while Kibuon K1 had a mean of 2.47 with standard deviation of 0.915 (Table 153).

Table 1533: *Means on Number of Cover Crops Grown*

Sub catchment	N	Mean	Standard deviation
Kibuon K1	15	2.47	.915
Kibuon K2	70	2.71	.725
Kasipul K3	51	2.71	.756
Tende T1	148	2.70	.517
Isanta T2	47	3.00	.626
Mogusii T3	39	2.97	.778
Total	370	2.76	.666

The analysis of variance showed that there was significant differences at F= 3.105, p =.009 on establishment of cover crops without external assistance in different sub catchments (Table 154).

Table 1544: *ANOVA Results on the Number of Cover Crops grown*

Variations	Sum of Squares	DF	Mean Square	F	Significant
Between Groups	6.693	5	1.3339	3.105	.009
Within Groups	156.899	364	.431		
Total	163.592	369			

Multiple comparisons did not present pairs that were significantly different. The results indicated that all sub catchments grew cover crops although the numbers varied. There were two homogenous subsets based on their characteristics. Kibuon K1 planted two types of cover crops while Tende T1, Kasipul K3 and Kibuon K2 planted three cover crops. Isanta T2 had the highest number of cover crops grown compared with Kibuon K1. The least number was from Kibuon K1 followed by Tende T1, Kasipul K3, Kibuon K2, Mogusii T3 and Isanta T2 (Table155).

Table 1555: Tukey Post Hoc Results on Number of Cover Crops Grown

Sub catchment	N	1	2
Kibuon K1	15	2.47	
Tende T1	148	2.70	2.70
Kasipul K3	51	2.71	2.71
Kibuon K2	70	2.71	2.71
Mogusii T3	39		2.97
Isanta T2	47		3.00
Significant		.557	.320

Isanta T2 and Mogusii T3 had a higher number of cover crops grown which was associated with suitable climate in the sub catchments and some dairy production since most of the cover crops were fodder crops used by livestock. Kibuon K1 had less cover crops grown because of land sizes. Number of cover crops grown had a positive relationship with maize, milk and forage yields r = .672, p value = .000 and r = .308 p value = .000 respectively while forage had r =. .233, P value = .000.

This confirmed that number of cover crops influenced increase in maize, milk and forage yields. Farmers planted different types of cover crops cheaply which agreed with a study by Dereje (2019) on soil and water conservation practices and its contribution to smallholder farmers' livelihoods who reported planting of cover crops being effective in soil erosion control and cheaper to establish. This findings agreed with a report by Alufah, Shisanya and Obando (2012) in their findings on analysis of factors influencing adoption of soil and water conservation technologies who reported that many farmers establishing cover crops because of low cost element and were effective in controlling soil erosion.

4. 5.6 Acreage under Agroforestry

Data gathered was analyzed and the following means and standard deviations were achieved in each sub catchment. Mogusii T3 had a mean of 2.69 and a standard deviation .977, Kibuon K1 had a mean of 2.60 and a standard deviation of 1.183, Kasipul K3 had a mean of 2.57 and a standard deviation of 1.063, Kibuon K2 had a mean of 2.50 and a standard deviation of .864, Tende T1 had a mean of 2.36 with standard deviation of .775 while Isanta T2 had a mean of 2.36 and a standard deviation of .705 (Table 156).

Table 1566: *Means on Acreage Under Agroforestry*

Sub catchment	N	Mean	Standard deviation
Kibuon K1	15	2.60	1.183
Kibuon K2	70	2.50	.864
Kasipul K3	51	2.57	1.063
Tende T1	148	2.36	.775
Isanta T2	47	2.36	.705
Mogusii T3	39	2.69	.977
Total	370	2.46	.871

The ANOVA test results showed that there were no significant differences F =1.298, p = .264 on the acreage under agroforestry in different sub catchments which implied that all sub catchments had some acres under agroforestry although limited hence no significant difference (157).

Table 1577: *ANOVA Results on Acreage under Agroforestry*

Variations	Sum of squares	df	Mean of squares	F	Significant
Between Groups	4.904	5	.756	1.298	.264
Within Groups	275.066	364	.756		
Total	279.970	369			

The sub catchments were displayed in one subset level which indicated that although they had different acreages under agroforestry, the differences were not significant to place them in different subset levels. Mogusii T3 had the highest acreage under agroforestry while Isanta T2 had the lowest. Isanta T2 had the least acreage compared to Tende T1, Kibuon K2, Kasipul K3, Kibuon K1 and Mogusii T3 (Table 158).

Table 15858: *Tukey Post Hoc Results on Acreage under Agroforestry*

Sub catchment	N	1
Isanta T2	47	2.36
Tende T1	148	2.36
Kibuon K2	70	2.50
Kasipul K3	51	2.57
Kibuon K1	15	2.60
Mogusii T3	39	2.69
Significant		.548

Mogusii T3 had a bigger area under agroforestry because of the suitable climate which supports their growth and land size. Kibuon K1 was second in area under agroforestry due to regular rainfall providing a suitable environment. Kasipul K3 was third in area under agroforestry because there was more land and the sub catchment shared suitable climatic conditions experienced in Kisii which supports tree growth but the lower part of the catchment is dry. Isanta sub catchment had a smaller area under agroforestry which was attributed to smaller land sizes that caused a competition between food production and growing of trees.

Through Pearson correlation, increase in maize, milk and forage yields had positive correlations, maize yield had r = r 0.671 P value = 0.000, correlation for milk yield was r = 0.308, P value = 0.000) while forage yields had r = 0.232, P value = 0.000. The findings confirmed contribution of agroforestry to yield increase in maize, milk and forage. Agroforestry trees conserved the catchments, provided wood fuel and improved soil fertility.

This agreed with findings by Dawson et al. (2014) in their study on agroforestry, livestock, fodder, production and climate change adaptation which reported services and products as benefits derived from agroforestry trees. A similar report was by Tugizimana (2015) in his research on effects of soil and water conservation techniques that an increase in agroforestry through increase in acreage by planting of trees closely on contours controlled soil erosion.

Positive correlation values between maize, milk and forage yields indicated that an increase in establishment of the technologies contributed to enhanced yields in maize, milk and forage (Table 159).

Table 15959: *Relationship Between Soil Conservation Technologies and increase in Maize, Milk and Forage Yields*

Soil and water conservation technologies	Dependent variables	r	Significant (2-tailed)
Number of grass strips established	Increase in maize yields	0.673	0.000
	Increase in milk increase	.310	0.000
	More forage	.230	0.000
Number of terraces constructed	Increase in maize yields	0.671	0.000
	Increase in milk increase	0.310	0.000
	More forage	0.233	.0000
Number of cover crops established	Increase in maize yield	.672	0.000

	Increase in milk yield	.308	0.000
	More forage	.233	0.000
Acreage under agroforestry	Increase in maize yields	0.671	0.000
	Increase in milk yields	0.308	0.000
	Increase in forage yields	0.232	0.000

4.5.7 Summary of Technologies that were Established without Technical Assistance

All the six sub catchments were ranked in different technologies at different levels running from 1 -6 where by 1 represented high uptake and 6 represented least uptake of technologies. Therefore the sub catchment that was ranked first had a higher uptake rate compared to the one ranked sixth. Kibuon K1, Kibuon K2, Isanta T2 and Mogusii T3 were each ranked first in one technology in column 1. Kibuon K1 ranked first in number of grass strips established, Kibuon K2 was first in number of terraces constructed, Isanta T2 was first in number of cover crops established while Mogusii T3 was first in acreage under agroforestry.

In column 2, Kibuon K1 had the highest uptake since it was ranked second in two technologies in the same column; number of terraces constructed and acreage under agroforestry. In column 3 Kasipul K3 had the highest uptake by being ranked third in two technologies; number of grass strips established and acreage under agroforestry while the other sub catchments led in one technology. Mogusii T3, Isanta T2, Kasipul K3 and Kibuon K2 were ranked fourth in column 4 in different technologies; Mogusii T3- number of grass strips established, Isanta T3- number of terraces constructed, Kasipul K3- number of cover crops established and Kibuon K2- acreage under agroforestry.

In column 5 Tende T1 had the highest uptake by ranking fifth in three technologies; number of grass strips established, number of cover crops established and acreage under agroforestry while in column 6 Isanta T2 was ranked sixth in number of grass strips established and acreage under agroforestry (Table 160).

Table 1600: *Summary of Uptake of Technologies Established without Technical Assistance.*

Variable	1	2	3	4	5	6
Number of grass strips established	Kibuon K1	Kibuon K2	Kasipul K3	Mogusii T3	Tende T1	Isanta T2
Number of Terraces constructed	Kibuon K2	Kibuon K1	Mogusii T3	Isanta T2	Kasipul K3	Tende T1
Number of cover crops established	Isanta T2	Mogusii T3	Kibuon K2	Kasipul K3	Tende T1	Kibuon K1
Acreage under agroforestry	Mogusii T3	Kibuon K1	Kasipul K3	Kibuon K2	Tende T1	Isanta T2

4.5.8 Summary for Ranks in Uptake of Catchment Management Technologies

The findings indicated high uptake of catchment management technologies in Kibuon K2 and Mogusii T3, followed by Kibuon K1 in position 3, and Kasipul K3 was in position 4, Isanta T2 got position 6 while Tende T1 was position 6. The results indicated that respondents in Kibuon K2 and Mogusii T3 had high uptake and establishment of technologies on their own compared to Kibuon K1, Kasipul K3, Isanta T2, and Tende T1. The least uptake of technologies was in Tende T1which got sixth position (Table 161)

Table 1611: *Positions Attained in Uptake of Catchments Management Technologies*

Sub catchment	Rank orders	Number of technologies	Final position
Kasipul K3	3	2	4
	4	1	
	5	1	
Isanta T2	1	1	5
	6	2	
Tende T1	5	3	6
	6	1	
Kibuon K2	1	1	1
	2	1	
	3	1	
	4	1	
Kibuon K1	1	1	3
	2	2	
	6	1	
Mogusii T3	1	1	1
	2	1	
	3	1	
	4	1	

Through analysis of variance, it was evident that respondents were able to establish different numbers of soil and water conservation technologies in the 6 sub catchments without external technical assistance. All the catchment management technologies in objective three had a significant positive correlation with increase in maize, milk and forage yields. Uptake of the technologies in the 6 sub catchments varied widely through some sub catchments ranking highly in uptake of the technologies while others were ranked low for example 5th and 6th.

The findings indicated significant differences in the level of technology uptake and number of technologies that were constructed without external technical assistance in the 6 sub catchments therefore the null hypothesis was rejected.

4.6 The Level of Implementation of Integrated Project Extension Approach in Dissemination of Catchment Management Technologies

4.6.1 Aggregation of Scores on Level of Implementation of Integrated Project Extension Approach.

Data aggregation covered grand total sum, mean, minimum, maximum, standard deviation and variance for the scores made for each technology implemented. This was done on a five point likert scale that was used to measure variations in the scores. The grand total sum constituted all the scores that were made by 370 respondents. About 1539 respondents reported using terraces on their farms before project implementation while 1051 used them after project implementation. Planting of fruit trees for provision of fruits without knowing they conserved the environment before project implementation was reported by 1502 while 1062 reported planting fruit trees to provide fruits and conserve the catchments after project implementation. Respondents who planted vegetation cover before project implementation were 1468 while 1055 reported planting after project implementation. Use of check dams before project implementation was reported by 1392 while after project implementation 1020 used them. The analysis presented mean values which were between 3 and 4 based on five point likert scale. The technologies had a standard deviation of one. This indicated that distance for the scores away from the mean was one unit. The technologies also had a variance of one unit which showed that variation among variables was one unit. The results showed that farmers used many technologies after project implementation which they did not use before project implementation (Table 162).

Table 16262: *Aggregation of Scores on Level of Implementation of Integrated Project Extension Approach*

Technology	Grand Total sum	Mean	Minimum	Maximum	Standard deviation	Variance
Terraces used on farms before	1539	4	1	5	1	1
Terraces used on farms after	1051	3	1	5	1	1
Fruit trees planted before	1502	4	1	5	1	1
Fruit trees planted after	1062	3	1	5	1	1
Vegetation cover planted before	1468	4	1	5	1	1
Vegetation cover planted after	1055	3	1	5	1	1
Check dams used before	1392	4	1	5	1	1
Check dams used after	1020	3	1	5	1	1

4.6.2 Analysis of Variance on Soil Conservation Technologies in Sub Catchments

i Introduction

Analysis of variance was used to analyze data for the fourth objective on level of uptake of catchments management technologies in Kibuon and Tende catchments. Descriptive statistics was used to establish means and standard deviations while Tukey post hoc determined significant differences. The methods of analysis was applied on the following technologies; farmers used terraces on their farms before project implementation, farmers used terraces on their farms after project implementation, Farmers planted fruit trees to provide fruits without knowing the trees conserved the environment, farmers planted fruit trees to provide fruits and protect catchments after project implementation, farmers planted vegetation cover before project implementation, farmers planted more vegetation cover after project implementation, farmers used check dams to control gullies before and after project implementation and farmers used check dams to control gullies after project implementation.

ii Farmers who used Terraces on their Farms before Project Implementation

Descriptive statistics was used to determine means and standard deviations. The following means and standard deviations were achieved; Kibuon K2 had a mean of 4.57 with a standard deviation of 0.910, Kibuon K1 had a mean of 4.40 with a standard deviation of 1.121, Kasipul K3 had a mean of 4.33 with a standard deviation of 1.013. Mogusii had a mean of 4.05 with a standard deviation of 0.999. Isanta T2 had a mean of 4.04 and a standard deviation of 0.509 while Tende T1 had a mean of 3.95 and a standard deviation of .745 (Table 163).

Table 1633: *Means for Farmers who Used Terraces on their Farms*

Sub catchment	N	Mean	Standard deviation
Kibuon K1	15	4.40	1.121
Kibuon K2	70	4.57	.910
Kasipul K3	51	4.33	1.013
Tende T1	148	3.95	.745
Isanta T2	47	4.04	.509
Mogusii T3	39	4.05	.999
Total	370	4.16	.870

The analysis of variance showed there were significant differences at F = 6.259, p = .000 on the level at which few farmers used terraces on their farms in different sub catchments (Table 164).

Table 1644Table 165: *ANOVA Results for Farmers who used Terraces on their Farms*

Variation	Sum of squares	df	Mean square	F	Significant
Between Groups	22.136	5	4.427	6.259	0.000
Within Groups	257.456	369	.707		
Total	279.592	369			

Further analysis through Tukey post hoc analysis showed three pairs that were significantly different. Kibuon K2 and Tende T1 were different (0.625 mean difference significant at 0.000), Kibuon K2 was different from Isanta T2 with a mean difference of 0.529 significant at 0.012 while Kibuon K2 was different from Mogusii T3 with a mean difference of 0.520 significant at 0.026 on few farmers using terraces on their farms. The results showed that although few farmers used terraces on their farms before project implementation, there were differences in scores from Kibuon K2, Tende T1 and Mogusii T3.

Tukey post hoc tests showed that sub catchments were divided in two subsets. Tende T1 had the least number of terraces used on the farm compared to Isanta T2, Mogusii T3, Kasipul K3, Kibuon K1 and Kibuon K2. Isanta T2, Mogusii T3, Kasipul K3 and Kibuon K1 were not significantly different to any sub catchment. Kibuon K1 used terraces fairly higher than Kasipul K3, Mogusii T3 and Isanta T2 (Table 165).

Table 1665: *Tukey Post Hoc results for Farmers who used Terraces on their Farms*

Sub catchment	N	1	2
Tende T1	148	3.95	
Isanta T2	47	4.04	4.04
Mogusii T3	39	4.05	4.05
Kasipul K3	51	4.33	4.33
Kibuon K1	15	4.40	4.40
Kibuon K2	70		4.57
Significant		.166	.064

The findings indicated that Kibuon K2 reported use of many terraces before project implementation compared to Tende T1. This could be attributed to big land sizes in Kibuon K2 compared with Tende T1. Similar findings were reported by Manjunath, (2014) in his study on adoption of catchments management practices who established that various soil conservation technologies had different uptake percentages based on how easily they were established, size of land and the cost of terrace construction because of the skills and cost involved. This was also reported by Mazengia, Gamiyo, Amede, Daka and Mowo (2007) in their study on challenges of collective action in soil and water conservation who established that farmers in Gununo watershed adopted few terraces due to smaller land sizes that could not allow construction of many terraces.

iii Farmers who Used Terraces on their Farms After Project Implementation

Descriptive statistics established the following means and standard deviations; Kasipul K3 had a high mean of 3.08 and standard deviation of 1.398, Kibuon K1 had a mean of 2.87 and standard deviation of 1.125, Kibuon K2 had a mean of 2.86 with a standard deviation of 1,254. Tende T1 had a mean of 2.85 with a standard deviation of .928 while Mogusii T3 had a mean of 2.69 with a standard deviation of 1.173 and Isanta T2 had a mean of 2.64 with a standard deviation of .845 (Table 166).

Table 1676: *Means on Farmers who Used Terraces on their Farms*

Sub catchment	N	Mean	Standard deviation
Kibuon K1	15	2.87	1.125
Kibuon K2	70	2.86	1.254
Kasipul K3	51	3.08	1.398
Tende T1	148	2.85	.928
Isanta T2	47	2.64	.845
Mogusii T3	39	2.69	1.173
Total	370	2.84	1.094

Further test indicated that the analysis of variance was not significantly different on the number of farmers who used terraces on their farms in different sub catchments. This implied that most respondents had similar scores on use of terraces by many farmers after project implementation hence no significant difference (Table 167).

Table 16867: *ANOVA Results for Farmers who used Terraces on their Farms*

Variation	Sum of squares	df	Mean square	F	Significant
Between Groups	5.712	5	1.142	.954	.446
Within Groups	435.880	364	1.197		
Total	441.592	369			

Tukey post hoc table displayed all sub catchments in one column which confirmed that most respondents reported using terraces on their farms. Isanta T2 had the least number of terraces after project implementation compared with Mogusii T3, Tende T1, Kibuon K2, Kibuon k1 and Kasipul K3 and it was similar to Mogusii T3, Tende T1, Kibuon K2, Kibuon K1 and Kasipul K3. High number on terrace use was from Kasipul K3 compared to Kibuon K1, Kibuon K2, Tende T1, Mogusii T3 and Isanta T2 (Table 168).

Table 16968 *Tukey Post Hoc Results for Farmers who used Terraces on their Farms*

Sub catchment	N	1
Isanta T2	47	2.64
Mogusii T3	39	2.64
Tende T1	148	2.85
Kibuon K2	70	2.86
Kibuon K1	15	2.87
Kasipul K3	51	3.08
Significant		.484

The findings indicated that there were fairly many terraces used in Kasipul K3 compared with Isanta T2 because of the high mean (3.08). Isanta T2 covers areas that receive regular rainfall enhancing vegetation cover which conserves the soil effectively and has smaller land sizes which do not allow use of many terraces. The lower part of Kasipul boarders areas near Lake Victoria which experience drought and erratic rainfall which calls for construction of more terraces to reduce runoff speed during rainy seasons to improve water percolation into the soil which agrees with findings by Alufah et al. (2012) in their study on analysis of factors influencing adoption of soil and water conservation technologies which reported terraces being popular to many farmers although dictated by size of land. This was confirmed by Muchangi, (2016) in his study on influence of farmers' characteristics, on adoption of organic farming technologies in Embu who established that farmers with more land were able to adopt terraces than those with smaller land sizes.

iv Farmers who Planted Fruit Trees to Conserve the Catchments before Project Implementation

Descriptive statistics was used to determine the following means and standard deviations; Kasipul K3 got 4.25 mean and .981 standard deviation, Kibuon K2 got a mean of 4.27 and standard deviation of 1.179, Isanta got a mean of 3.98 and a standard deviation of .642, Tende T1 got a mean of 3.95 with a standard deviation of .668 and Kibuon K1 had a mean of 3.93 and a standard deviation of 1.280 (Table 169).

Table 17069: *Means for Farmers who Planted Fruit Trees to Conserve the Catchments*

Sub catchment	N	Mean	Standard deviation
Kibuon K1	15	3.93	1.280
Kibuon K2	70	4.27	1.179
Kasipul K3	51	4.27	.981
Tende T1	148	3.95	.668
Isanta T2	47	3.98	.642
Mogusii T3	39	3.97	.903
Total	370	4.06	.888

Results on analysis of variance indicated that there were no significant differences on number of farmers who planted fruit trees without knowing they protected catchments in different sub catchments. Lack of significant differences meant that scores made did not have major differences and fruit trees protected the environment although the farmers did not know that trees protected the environment (Table 170).

Table 1710: *ANOVA Results for Farmers who Planted Fruit Trees to Conserve the Watershed*

Variation	Sum of squares	df	Mean square	F	Significant
Between Groups	8.238	5	1.648	2.123	.062
Within Groups	282.454	364	.776		
Total	290.692	369			

Multiple comparisons showed no sub catchments with significant difference. The results implied that respondents had same characteristics. Homogeneous subsets displayed 1 column indicating similarities in the scores. Few respondents in Kibuon K1 planted trees for fruit provision without knowing they also protected the catchments. Kasipul K3 had many farmers who planted fruit trees for fruit provision compared to Kibuon K2, Isanta T2, Mogusii T3, Tende T1 and Kibuon K1(Table 171).

Table 1721: *Tukey Post Hoc Results for Farmers who Planted Fruit Trees to Protect the Catchments*

Sub catchment	N	1
Kibuon K1	15	3.93
Tende T1	148	3.95
Mogusii T3	39	3.97
Isanta T2	47	3.98
Kibuon K2	70	4.27
Kasipul K3	51	4.27
Significant		.527

Kasipul had a higher number of respondents who planted fruit trees to provide income from fruits only before project implementation compared to few respondents in Kibuon K1. This was attributed to bigger land sizes and hot climate suitable for fruit production in Kasipul K3. They planted fruit trees to earn an income from the fruits and fuel wood without knowing that trees also conserved the catchments and provided aesthetic services which agreed with findings by Mawuli (2016) in her study on determinants of agroforestry technologies in Kenya who reported that tree planting provided many services; conserve the soil, timber and recreation. This agreed with findings by Alufah et al. (2012) in their research on analysis of factors influencing adoption of soil and water conservation technologies who reported that farmers who grew fruit trees earned income from fruits and timber.

v Farmers who Planted Fruit Trees to Protect the Catchments after Project Implementation

Descriptive statistics determined means and standard deviations; Kasipul K3 had a mean of 3.35 and a standard deviation of 1.383, Tende T1 had a mean of 2.86 with a standard deviation of .911, Kibuon K2 had a mean of 2.81 with a standard deviation of 1.365, Kibuon K2 had a mean of 2.80 with a standard deviation of 1.082, Isanta got a mean of 2.68 with a standard deviation of .911 and Mogusii T3 had mean of 2.62 with a standard deviation of 1.115 (Table 172).

Table 1732: *Means for Farmers who Planted Fruit Trees to Protect the Catchments*

Sub catchment	N	Mean	Standard deviation
Kibuon K1	15	2.80	1.082
Kibuon K2	70	2.81	1.365
Kasipul K3	51	3.35	1.383
Tende T1	148	2.86	.911
Isanta T2	47	2.68	.911
Mogusii T3	39	2.62	1.115
Total	370		

The analysis of variance indicated that there were significant differences at F = 2.599, p = .025) on the number of farmers who planted fruit trees to provide fruits and protect the catchments after project implementation in different sub catchments (Table 173).

Table 1743: *ANOVA Results for Farmers who Planted Fruit Trees to Protect Watershed*

Variation	Sum of squares	df	Mean square	F	Significant
Between Groups	16.399	5	3.280	2.599	.025
Within Groups	459.374	364	1.262		
Total	475.773	369			

Multiple comparisons indicated two pairs of sub catchments that were significantly different. Kasipul K3 and Isanta T2 had a mean difference of 0.672 significant at .038 while Kasipul K3 again had a mean difference of 0.738 significant at 0.026 with Mogusii T3.

The findings showed that most scores from the sub catchments indicated that many farmers planted fruit trees to protect the catchments and provide fruits after project implementation apart from Kasipul K3, Isanta T2 and Mogusii T3. Tukey Post hoc test displayed two subset levels which showed Kasipul K3 to be significantly different from Mogusii T3. Kasipul K3 had many respondents who planted fruit trees to provide fruits and conserve the catchments after project implementation compared to Tende T1, Kibuon K2, Kibuon K1 Isanta T2 and Mogusii T3 sub catchment. Mogusii T3 planted fewer fruit trees to conserve the catchments (Table 174).

Table 1754: *Tukey Post Hoc Results for Farmers who Planted Fruit Trees to Conserve Catchments*

Sub catchment	N	1	2
Mogusii T3	39	2.62	
Isanta T2	47	2.68	2.68
Kibuon K1	15	2.80	2.80
Kibuon K2	70	2.81	2.81
Tende T1	148	2.86	2.86
Kasipul K3	51		3.35
Significant		.924	.091

Many respondents in Kasipul K3 planted many fruit trees for income and catchments conservation. Mogusii T3 had less compared to Kasipul K3 because land sizes are smaller in Mogusii T3 with cool climate which may not support fruit trees compared to Kasipul K3. The respondents who planted many fruit trees had a higher income and conserved the catchments which shared with Garrity, Mercado and Stark (1998) in their research findings on building the smallholder into successful natural resource management who established that farmers in Claveria watershed in Indonesia planted mangoes, pineapples and bananas to conserve the watershed and those who grew on a large scale earned more income from the fruits and timber. The findings agreed with a study by Gebregziabher, Dereje, Girmay, Giordano and Langan (2016) in their study on assessment of integrated catchment management in Ethiopia who reported that many farmers in Goho- Cheri watershed in Ethiopia planted many fruit trees to enhance watershed management and earn income from fruits.

vi Farmers who Planted Vegetation Cover before Project Implementation

The following means and standard deviations were established; Kibuon K2 had a mean of 4.24 mean with a standard deviation of 1.268, Kasipul K3 had a mean of 4.10 with a standard deviation of 1.100, Mogusii T3 had a mean of 3.97 with a standard deviation of 1.087, Tende T1 had a mean of 3.89 and a standard deviation .770, Isanta T2 had a mean of 3.77 with a standard deviation of .686 and Kibuon K1 had a mean of 3.73 with a standard deviation of 1.387 (Table 175).

Table 1765: *Means for Farmers who Planted Vegetation Cover*

Sub catchment	N	Mean	Standard deviation
Kibuon K1	15	3.73	1.387
Kibuon K2	70	4.24	1.268
Kasipul K3	51	4.10	1.100
Tende T1	148	3.89	.770
Isanta T2	47	3.77	.686
Mogusii T3	39	3.97	1.087
Total	370		.990

The analysis of variance indicated that there were no significant differences at F = 1.999, p = 0.078 on vegetation cover planted in different sub catchments before project implementation (Table 176)

Table 1776: *ANOVA Results for Farmers who Planted Vegetation Cover*

Variation	Sum of squares	df	Mean square	F	Significant
Between Groups	9.666	5	1.933	1.999	.078
Within Groups	351.945	364	.967		
Total	361.611				

Tukey post hoc test result on homogenous subset displayed 1 column. This showed that the sub catchments shared many characteristics on vegetation cover planted before project implementation hence one column. A high number of respondents in Kibuon K1 established vegetation cover compared with Mogusii T3, Tende T1, Isanta T2, and Kasipul K3 and Kibuon K2 (Table 177).

Table 17877: *Tukey Post Hoc Results for Farmers who Planted Vegetation Cover*

Sub catchment	N	1
Kibuon K1	15	3.73
Mogusii T3	3.77	3.77
Tende T1	148	3.89
Isanta T2	47	3.91
Kasipul K3	51	4.10
Kibuon K2	70	4.24
Significant		.203

There was less vegetation cover planted in Kibuon K2 compared to Kibuon K1 before project implementation. Climatic conditions in Kibuon K1 are more conducive for vegetation growth compared to a hotter climate in lower parts of Kibuon K2 towards Lake Victoria. Vegetation cover reduced soil erosion on steep slopes by the roots binding the soil together and the canopy reducing impact of rain drops on soil which was similar to findings by Kammer (2014) in his study on factors influencing the adoption of Soil and water conservation technologies who reported that vegetation cover contributed to watershed management through keeping the soil together and protecting it from rain drop impact by use of roots and canopy.

vii Farmers who Planted Vegetation Cover After Project Implementation

Data collected was subjected to descriptive statistics to establish means and standard deviations for the variables. Kasipul K3 had a mean of 3.22 and a standard deviation of 1.205, Kibuon K1 got mean of 3.13 with a standard deviation of 1.356, Kibuon K2 had a mean of 2.94 with a standard deviation1.306, Tende T1 got a mean of 2.83 with a standard deviation of 1.006, Isanta got mean of 2.62 with a standard deviation of .874 and Mogusii T3 had a mean of 2.46 with a standard deviation of .996 (Table 178).

Table 17978: *Means for Farmers who Planted Vegetation Cover*

Sub catchment	N	Mean	Standard deviation
Kibuon K1	15	3.13	1.356
Kibuon K2	70	2.94	1.306
Kasipul K3	51	3.22	1.205
Tende T1	148	2.83	1.006
Isanta T2	47	2.62	.874
Mogusii T3	39	2.46	.996
Total	370	2.85	1.110

The analysis of variance table indicated that there were significant differences at F = 2.847, p = .015 on number of farmers who planted vegetation cover after project implementation in different sub catchments (Table 179).

Table 18079: *ANOVA Results for Farmers who Planted Vegetation Cover*

Variation	Sum of squares	df	Mean square	F	Significant
Between Groups	17.116	5	3.423	2.847	.015
Within Groups	437.708	364	1.202		
Total	454.824	369			

Multiple comparisons showed one pair that was significantly different. Kasipul K3 and Mogusii T3 had a mean difference of .754 significant at .017. Among the six sub catchments only the two had some differences in relation to vegetation cover after project implementation. Tukey post hoc produced two subset levels; Mogusii T3 reported few farmers planting vegetation cover after project implementation compared with Isanta T2, Tende T1, Kibuon K2, Kibuon K1 and Kasipul K3 while Kasipul K3 reported more vegetation cover planted after project implementation compared to Kibuon K1, Kibuon K2, Tende T1, Isanta T2 and Mogusii T3. Isanta T2, Tende T1, Kibuon K2 and Kibuon K1 were not significantly different to any sub catchment (Table 180).

Table 1810: *Tukey Post Hoc Analysis Results for Farmers who Planted Vegetation Cover*

Sub catchment	N	1	2
Mogusii T3	39	2.46	
Isanta T2	47	2.62	2.62
Tende T1	148	2.83	2.83
Kibuon K2	70	2.94	2.94
Kibuon K1	15	3.13	3.13
Kasipul K3	51		3.22
Significant.		.077	.156

Mogusii T3 had fewer farmers with vegetation cover than Kasipul K3 sub catchment. This was contributed by large land sizes in Kasipul K3 which provide more room for vegetation growth as opposed to Mogusii T3 that had small land sizes. This information was also reported by Kammer (2014) in his study on factors influencing adoption of soil and water conservation technologies which reported that vegetation cover being easy to establish and effective in reducing water speed for surface were used by many famers although more space was needed. The findings were confirmed by Liu, Gao and Jiao (2018) in their study on effects of vegetation on runoff and soil loss which reported that vegetation cover controls soil erosion through their canopy, liter layers and roots.

viii Farmers who Used Check Dams to Control Gulley Erosion Before Project Implementation

Data analysis was done using descriptive statistics to establish means and standard deviations for each sub catchment; Kibuon K2 had a mean of 3.96 with a standard deviation1.297, Isanta T2 had a mean of 3.94 and a standard deviation of .673, Kasipul had a mean of 3.75 with a standard deviation of 1.339, Tende T1 had a mean of 3.75 with a standard deviation of .991, and Kibuon K1 had a mean of 3.73 with a standard deviation of 1.280 (Table 181).

Table 1821: *Means for Farmers who used Check Dams to Control Gullies*

Sub catchment	N	Mean	Standard deviation
Kibuon K1	15	3.73	1.280
Kibuon K2	70	3.96	1.279
Kasipul K3	51	3.75	1.339
Tende T1	148	3.75	.991
Isanta T2	47	3.94	.673
Mogusii T3	39	3.72	1.146
Total	370	3.76	1.101

The ANOVA test results failed to show significant difference at F = 1.087, p = .367 on the number of farmers who used check dams to control gulley erosion in different sub catchments before project implementation (Table 182).

Table 1832: *ANOVA Results for Farmers who used Check Dams to Control Gullies*

Variation	Sum of squares	df	Mean square	F	Significant
Between Groups	6.576	5	1.315	1.087	.367
Within Groups	440.494	364	1.210		
Total	447.070	369			

This was an indication that most respondents reported use of check dams in gulley control hence no significant differences. Further tests showed one homogeneous subset level. There were many farmers in Kibuon K2 who used check dams to control gullies before project implementation compared with Isanta T2, Kasipul K3, Kibuon K1, Mogusii T3 and Tende T1 although the difference between Kibuon K2 and Tende

T1were not significant indicating that the use of check dams in gulley control was not very high (Table 183).

Table 1843: *Tukey Post Hoc for Farmers who Used Check Dams to Control Gullies*

Sub catchment	N	1
Tende T1	148	3.64
Mogusii T3	39	3.72
Kibuon K1	15	3.73
Kasipul K3	51	3.75
Isanta T2	47	3.96
Kibuon K2	70	3.96
Significant		.790

Key informants (78.8 percent) reported a few check dams having been used in control of gulley erosion before project implementation. Tende T1 had a lower number of farmers who used check dams to control gulley erosion on their farms while Kibuon K2 had a higher number. This was attributed to more rainfall received in Tende T1 which supported more vegetation growth protecting the soil because of its location in Kisii highlands. Kibuon K2 needed many check dams due to increased soil erosion and flash floods towards Lake Victoria. These findings were reported by Liu, Mu, Zhao, Gao and Sun (2018) in their study on effects of vegetation on runoff and soil loss who reported that many check dams contributed to a reduction in annual runoff and increased sediment load in the gullies which was also reported by Khonkaen (2011) in his study on application of check dam construction in catchments who confirmed that they reduced water speed and intercepted sediments in gullies thereby reducing soil erosion.

ix Farmers who used Check Dams to Control Gullies after Project Implementation

Data collected was subjected to descriptive statistics to determine means and standard deviations. Kibuon K2 had a mean of 3.01 and a standard deviation1.291, Kasipul K3 got a mean of 2.98 with a standard deviation of 1,291, Kibuon K1 had a mean of 2.93 and a standard deviation of 1.335, Tende T1 got a mean of 2.67 and standard deviation of 1.013, Mogusii T3 had a mean of 2.59 with a standard deviation of 1.044, and Isanta T2 got a mean of 2.49 with a standard deviation of .688 (Table 184).

Table 1854: *Means for Farmers who Used Check Dams to Control Gullies*

Sub catchment	N	Mean	Standard deviation
Kibuon K1	15	2.93	1.335
Kibuon K2	70	3.01	1.291
Kasipul K3	51	2.98	1.291
Tende T1	148	2.67	1.013
Isanta T2	47	2.49	.688
Mogusii T3	39	2.59	1.044
Total	370	2.76	1.090

The analysis of variance table failed to show significant difference at F = 6.941, p = .047 on farmers who used check dams in different sub catchments after project implementation (Table 185).

Table 1865: *ANOVA Results for Farmers who used Check Dams to Control Gullies*

Variation	Sum of squares	df	Mean square	F	Significant
Between Groups	13.251	5	2.650	2.271	.047
Within Groups	424.857	364	1.167		
Total	438.108	369			

This indicated that most respondents reported use of check dams after project implementation although the level of usage was low because of low means (2.49 to 3.01) attained. Homogeneous subsets displayed one column which confirmed that the sub catchments had a lot in common in terms of using check dams to control gullies after project implementation. Kibuon K2 had many farmers who used check dams to control gulley erosion while Isanta T2 had fewer. Isanta T2 had the least check dams compared with Mogusii T3, Tende T1, Kibuon K1, Kasipul K3 and Kibuon K3 (Table 186).

Table 1876: *Tukey Post Hoc Results for Farmers who Used Check Dams to Control Gullies*

Sub catchment	N	1
Isanta T2	47	2.49
Mogusii T3	39	2.59
Tende T1	148	2.67
Kibuon K1	15	2.98
Kasipul K3	51	2.98
Kibuon K2	70	3.01
Significant		.268

About 66.6 percent key informants reported the use of many check dams in control of gulley erosion after project implementation. Isanta T2 had fewer check dams because the

sub catchment had favourable climate that supported many types of vegetation which enhance conservation of the sub catchment. Kibuon K2 experienced dry climatic conditions in areas towards Lake Victoria thereby having more denuded land which was aggravated by free range type of livestock rearing hence the need for many check dams.

A study by Kammer (2014) on factors influencing the adoption of soil and water conservation technologies established that check dams were used by many farmers in Ethiopian Highlands since they were effective in reducing runoff speed and could be made from locally available materials. This agreed with findings by Liu et al. (2018) in their research on effects of vegetation on runoff and soil loss which reported that check dams retained water from floods by reducing its speed, encouraged sedimentation and increased agricultural land.

x Summary on Level of Implementation of Integrated Project Extension Approach

Sub catchments were ranked basing on positions they attained in uptake of soil and water conservation technologies before and after project implementation. The ranks ran from first to sixth for the periods before and after project implementation. The ranks indicated technologies which were popular and less popular based on their uptake by respondents.

First rank had the highest level of technology uptake while the sixth one had the least uptake rate. The technologies included; farmers used terraces on their farms before, farmers used terraces on their farms after, farmers planted fruit trees to fruit trees before project implementation, farmers planted many fruit trees to conserve the catchments after, farmers planted vegetation cover before, farmers planted vegetation cover after, farmers used check dams to control gulley erosion before and after programme implementation. Kibuon K2 led in technology uptake in use of terraces, vegetation cover planted and use of check dams in control of gullies while Kasipul K3 led in planting of fruit trees to provide fruits before project implementation. Low uptake of technologies was in Tende T1and Kibuon K1 before project implementation.

In the period after project implementation, Kasipul K3 led in use of terraces in the farms, planting of fruit trees to provide fruits and conserve environment, planting of vegetation cover while Kibuon K2 led in use of check dams. Basing on the results there was more use of the technologies in Kibuon K2 catchment before and after project implementation (Table 187).

Table 18887: *Summary of Level of Implementation of Integrated Project Extension Approach in Dissemination of Catchment Management Technologies*

Technologies	Positions before project implementation						Position after project implementation					
	1	2	3	4	5	6	1	2	3	4	5	6
Terraces used	Kibuon K2	Kibuon K1	Mogusii T3	Mogusii T3	Isanta T2	Tende T1	Kasipul K3	Kibuon K1	Kibuon K2	Tende T1	Mogusii T3	Isanta T2
Fruit trees planted	Kasipul K3	Kibuon K2	Isanta T2	Mogusii T3	Tende T1	Kibuon K1	Kasipul K3	Tende T1	Kibuon K2	Kibuon K1	Isanta T2	Mogusii T3
Vegetation cover	Kibuon K2	Kasipul K3	Isanta T2	Tende T1	Mogusii T3	Kibuon K1	Kasipul K3	Kibuon K1	Kibuon K2	Tende T1	Isanta T2	Mogusii T3
Check dams used	Kibuon K2	Isanta T2	Mogusii K3	Kibuon K1	Mogusii T3	Tende T1	Kibuon K2	Mogusii K3	Kibuon K1	Tende T1	Mogusii T3	Isanta T2

xi Relationship Between Soil and Water Conservation Technologies and Increase in Maize, Milk, and Forage yields

Data was analyzed using Pearson correlation to establish relationships and direction between soil and water conservation technologies and increase in maize, milk, and forage yields (Table 188).

Table 18988: Relationship Between *Soil and Water Conservation Technologies and Increased in Maize, Milk and Forage yields*

Soil and water conservation technologies	Dependent variables	r	Significant (2-tailed)
Cover cropping	Increase in maize yields	.263	.000
	Increase in milk increase	.120	.021
	More forage	.191	.000
Terraces	Increase in maize yield	.088	.088
	Increase in milk yield	.007	.887
	More forage	.048	.361
Contour ploughing	Increase in maize yields	.204	.000
	Increase in milk yields	.067	.201
	More forage	.069	.183
Check dams	Increase in maize yield	.218	.000
	Increase in milk yield	.110	.035
	More forage	.205	.000
Grass strips	Increase in maize yield	.175	.001
	Increase in milk yield	.032	.544
	More forage	.063	.230
Retention ditches	Increase in maize yield	.211	.000
	Increase in milk yield	.179	.001
	More forage	.119	.022

There were significant correlations between soil conservation technologies and increased maize, milk and forage yields. The findings indicated that any increase in cover cropping resulted in increased maize, milk and forage yields. Correlation between terraces and increase in maize, milk and forage had positive correlation values which were an indication that an increase in terrace use contributed to an improvement in maize, milk and forage yields. Contour ploughing and an increase in maize, milk and forage had positive correlations which indicated that increase in contour ploughing contributed to increase in maize, milk and forage yields.

There were positive and significant correlations between use of check dams in gulley control and increase in maize, milk and forage which implied that an increase in use of check dams contributed to a rise in maize, milk and forage. Correlation between grass strip use and increase in maize, milk and forage provided positive correlation values indicating contribution of grass strips to improvement in yields in maize, milk and forage yields. Retention ditches had significant positive correlations with increase in maize, milk and forage yields. The significant positive correlations implied that more use of retention ditches contributed to increase in maize, milk and forage yields. ANOVA results showed different levels of technology uptake. Kibuon K2 and Kasipul K3 led in technology uptake before and after project implementation respectively. This indicated that the use of integrated project extension approach in dissemination of technologies was at different levels. There were positive correlations between technologies and increase in maize, milk and forage yields which showed their contribution to increase in yields. The findings indicated that the use of integrated project extension approach in dissemination of catchments management technologies was significant at different levels in the sub catchments therefore the null hypothesis was rejected.

CHAPTER FIVE

5.0 Summary, Conclusions and Recommendations

5.1 Introduction

This chapter presents a summary of different areas that were covered in the study. Study findings were analyzed, discussed and presented based on objectives and hypotheses formulated. It covers introduction of the research, literature reviewed, study design, study area, target population, sample size, instrumentation, data collection procedure and research findings. Conclusions, recommendations and suggestion for further research were made. Catchment conservation technologies were introduced in Kenya during colonial regime. It was aimed at reducing and preventing catchment degradation to increase base flow, water quality and productivity in catchments. Later a project on soil and water conservation supported by Kenyan and Swedish Governments (SIDA) was implemented country wide to restore soils in degraded catchments. High population in the upper parts of Kibuon and Tende contributed to an increase in the catchment degradation due to economic activities farmers were engaged in. There was need for more food to feed the population through intensive land cultivation in the hills which affected water quantity and land productivity in the catchment.

5.2 Summary of the Study

The study assessed the level of implementation of selected soil and water conservation technologies in the catchments to determine differences in uptake of the technologies by sub catchments before and after project implementation in Kibuon and Tende catchments. The purpose of the study was to assess farmers' response to catchment management technologies that were used in the catchments.

Literature review focused on the following objectives: to establish the level of degradation in Kibuon and Tende catchments before and after project implementation, to determine knowledge, skills, and attitude of farmers on selected watershed management technologies promoted in the catchments, to establish the level of uptake of selected watershed management technologies in Kibuon and Tende catchments and to determine the level of implementation of integrated project extension approach in disseminating selected catchment management technologies to reduce degradation. It facilitated understanding and application of concepts that were used in the study. The independent variable was implementation of catchment management technologies while the dependent one was level of catchment rehabilitation.

Purposive sampling was used by picking on two catchments which were divided into six sub catchments where Integrated Land and Water Management Project (ILWMKTP) was implemented. The study used *ex-post facto* design since it was done after implementation of ILWMKTP project and used cross sectional survey to establish farmers' response on catchment management technologies. Both qualitative and quantitative data were used to establish farmers' response on soil and water conservation technologies.

The research was carried out in Homa Bay, Kisii and Nyamira Counties in South West Kenya. Through simple random sampling procedures respondents were picked from each sub catchment. The technologies under study included terraces, cover crops, contour ploughing, agroforestry, check dams and retention ditches. The study interviewed 370 respondents and nine key informants who participated in implementation of ILWMKTP project in the catchments. Data was collected using interview schedules for respondents and a questionnaire for key informants. There was triangulation of data provided by key informants and respondents to avoid errors.

Majority (63.2 percent) of the respondents interviewed were men who were aged between 50-60 years and 99.5 percent were married. Farmers who attained primary level of education constituted 52.2 percent followed by secondary level at 35.1 percent. The respondents with more than 5 household members were 70 percent followed by 5 household members who comprised of 23.8 percent. About half (49.7 percent) of the respondents had more than 1 acre of land followed by 39.5 percent who owned 1 acre.

On level of degradation before project implementation, scores made were measured on a five point likert scale to determine how many respondents scored “agree and strongly agree”. About 67 percent reported presence of catchment degradation before project implementation. High mean differences indicated presence of degradation before project implementation.

Data on level of degradation after project implementation was measured on a five point likert scale to establish how many respondents scored “agree and strongly agree”. Controlled catchment degradation in the watersheds was reported by 34.5 percent of the respondents. This indicated that less than half of the respondents reported control of watershed degradation in the catchments which implied that degradation in the catchment had not fully been controlled.

Findings on level of knowledge, skills, and attitude for farmers' on catchment management technologies indicated that Kibuon K2 had the highest knowledge on soil and water conservation technologies compared to Kasipul K3, Isanta T2, Kibuon K1, Mogusii T3 and Tende T1sub catchments. High level of skills was reported by Kibuon K1 compared to Tende T1, Kibuon K2, Kasipul K3, Isanta T2 and Mogusii T3. More positive attitude towards catchment management technologies was reported by Kasipul K3 compared to Kibuon K2, Isanta T2, Tende T1, Mogusii T3, and Kibuon K1.

Research findings on level of uptake of watershed management technologies in Kibuon and Tende catchments indicated high uptake of technologies in Kibuon K2 and Mogusii T3, followed by Kibuon K1, Kasipul T3 and Isanta T2 while the least uptake was in Tende T1. Therefore there were different levels of technology uptake in the sub catchments.

Findings on level of implementation of integrated project extension approach in dissemination of catchment Management Technologies established that Kibuon K2 and Mogusii T3 had higher uptake of technologies before and after project implementation which showed that there were different levels of implementation of the technologies among sub catchments.

5.3 Conclusions

The following conclusions were drawn in relation to this study:

1. There was more degradation in the sub catchments in the period before compared to after project implementation period.

2. Respondents had different levels of knowledge, skills, and attitude in the sub catchments despite having been taken through same trainings on technology construction and establishment.
3. Respondents in sub catchments constructed and established different numbers of technologies on their own.
4. Implementation of Integrated Project Extension approach in disseminating different soil conservation technologies was at different levels of implementation per sub catchment.

5.4 Contribution to the World of Knowledge

The study established existence of different levels of knowledge, skills and attitude among respondents despite being taken through same trainings. Therefore to improve on catchment technology uptake, one needs to present a variety of technologies from which respondents can select based on their knowledge, skills and attitude levels.

5.5 Recommendations

1. There is need for more sensitization of farmers on effects of catchment degradation for many to accept it as a constraint to increase technology uptake in catchments.

2. Farmers still need more capacity building on soil and water conservation technologies to bring them to the same level in knowledge, skills and attitude, for increased uptake of soil conservation technologies.
3. There is need for building farmers capacity for enhanced technology uptake'
4. There is need for extension service providers in Agricultural sector to continue using Integrated Project Extension approach in dissemination of catchment management technologies compared to conventional extension approach to enhance technology uptake aimed at controlling catchment degradation.
5. Farmers need trainings in entrepreneurship for better management of their alternative economic enterprises to reduce the fear of losing funds invested in soil and water conservation technologies for enhanced uptake.

5.3 Suggestion for Further Studies

There is an opportunity for another research on contribution of alternative economic enterprises to farmers' socio-economic status after ILWMKTP project implementation in Kibuon and Tende catchments.

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APPENDICES

Appendix 1.0 Sample Size Table for a Known Population

A table for determining a sample size of a known population

N	S	N	S	N	S	N	S	N	S
10	10	100	80	280	162	800	260	2800	338
15	14	110	86	290	165	850	265	3000	341
20	19	120	92	300	169	900	269	3500	346
25	24	130	97	320	175	950	274	4000	351
30	28	140	103	340	181	1000	278	4500	354
35	32	150	108	360	186	1100	285	5000	357
40	36	160	113	380	191	1200	291	6000	361
45	40	170	118	400	196	1300	297	7000	364
50	44	180	123	420	201	1400	302	8000	367
55	48	190	127	440	205	1500	306	9000	368
60	52	200	132	460	210	1600	310	10,000	370
65	56	210	136	480	214	1700	313	15,000	375
70	59	220	140	500	217	1800	317	20,000	377
75	63	230	144	550	226	1900	320	30,000	379
80	66	240	148	600	234	2000	322	40,000	380
85	70	250	152	650	242	2200	327	50,000	381
90	73	260	155	700	248	2400	331	75,000	382
95	76	270	159	750	254	2600	335	1,000,000	384

Note: N is population size, S is sample size

Source: Adopted from Krejcie and Morgan sample size table (1970).

Appendix 2.0 Interview Schedule for Respondents in Kibuon and Tende Catchments

County……………………………………

Sub county……………………………….

Sub-catchment……………..…………

CBO's name……………………………..

Introduction

This research collected data on farmers' response to catchments management technologies used in Kibuon and Tende catchments in Homa Bay, Kisii and Nyamira Counties. The study examined the level of degradation in Kibuon and Tende rivers catchments before and after the project, knowledge skills and attitude of farmers on catchment management technologies promoted in the catchments, level of uptake of different catchments management technologies in Kibuon and Tende catchments, level of implementation of Integrated Project Extension approach in disseminating different catchments management technologies to reduce catchments degradation and constraints that farmers faced during implementation of catchments management technologies in the catchments. A report compiled from the data may be used by academicians, Policy makers and Government Departments. Data provided is treated with high level of confidentiality.

Section A. Demographic and education data

1. Gender?

    (a). Male ☐

(b). Female ☐

2. Farmer's age

(a). 20-30 years ☐

(b). 30-40 years ☐

(c). 40-50 years ☐

(d). 50-60 years ☐

(e). Above 60 years ☐

3. Marital status

(a). Married ☐

(b). Single ☐

4. Farmer's level of education. Tick from the option below:

i. Not gone to school ☐

ii. Primary level ☐

iii. Secondary education ☐

iv. Middle level college ☐

v. Tertiary education ☐

5. Size of family

(a). 2 ☐

(b). 3 ☐

(c). 4 ☐

(d). 5 ☐

(e). Above 5 ☐

6. What is the size of your farm?

(a). Less than ¼ acre ☐

(b). ½ acre ☐

(c). ¾ acre ☐

(d). 1 acre ☐

(e). More than an acre ☐

Section B. Level of degradation in Kibuon and Tende basins before and after the project period

Statements listed below are on level of degradation in Kibuon and Tende catchments before Integrated Land and Catchments Extension Project. Rank them using Likert scale provided below.

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	**2**	**3**	**4**	**5**

S/NO.	Variables	1	2	3	4	5
7	There was a lot of rill erosion in the catchment before ILWMKTP					
8	There were uncontrolled gullies in the catchments before ILWMKTP					
9	There was less napier grass established in the catchments before before					
10	There was more denuded land before ILWMKTP project					
11	There was more deforestation before ILWMKTP project					
12	There were no vetiver grass strips before ILWMKTP project					
13	No retention ditches constructed before project implementation					
14	No check dams used in gulley control before ILWMKTP					
15	Few cover crops planted before project implementation					
16	No roadside erosion control before project implementation					
17	Kibuon and Tende water being turbid					
18	Less area put under agroforestry before project implementation					
19	There was less forage before project implementation					
20	Less land area conserved before project implementation					

Statements listed below are on level of degradation in Kibuon and Tende catchment after Integrated Land and Catchments Management Project. Rank them using Likert scale provided below.

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	**2**	**3**	**4**	**5**

S/NO.	Variables	1	2	3	4	5
21	There is less rill erosion after the project					
22	There were many controlled gullies after ILWMKTP project					
23	More napier grass grown after ILWMKTP project					
24	There is less denuded land after ILWMKTP					
25	Reduced deforestation after ILWMKTP project					
26	Presence of many vetiver grass strips after project implementation					
27	Many retention ditches constructed after project implementation					
28	Many check dams used in gulley control after project implementation					
29	Many cover crops planted after project implementation					
30	Kibuon and Tende water being clear after project implementation					
31	Spring protection provided clean water					
32	More area put under agroforestry after project implementation					

33	More land was conserved after project implementation					

SECTION C

i. Farmers' knowledge on catchments management technologies promoted in the catchment.

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	**2**	**3**	**4**	**5**

S/NO.	Variables	1	2	3	4	5
34	Cover cropping contribute to catchments management					
35	Terraces control run off speed					
36	Contour ploughing controls catchments degradation					
37	Check dams control soil erosion					
38	Grass strips reduce runoff flow					
39	Retention ditches increased infiltration thereby reducing soil erosion					

ii. Farmers' skills on catchments management technologies promoted in the catchment.

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	**2**	**3**	**4**	**5**

S/NO.	Variable	1	2	3	4	5
40	Cover cropping skills					
41	Skills to construct terraces					
42	Skills to construct retention ditches					
43	Skills to construct check dams					
44	Contour cropping skills					

i. A research test on farmers' attitude towards catchments management technologies promoted in the catchment.

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	**2**	**3**	**4**	**5**

S/NO.	Variable	1	2	3	4	5
45	Productivity is reducing because of soil erosion					
46	Absence of soil conservation technologies on your farm will contribute to low yields					
47	Generally yields correspond positively to soil depth					
48	Investing in soil and water conservation on your farm is important					

49	There will be property increase on your farm through soil and water conservation					

Section D. The level of uptake of catchments management technologies in Kibuon and Tende catchments

50. Through ILWMKTP project interventions, how many soil and water conservation technologies did you learn to construct and establish on your own?

(a). 1 ☐

(b). 2 ☐

(c). 3 ☐

(d). More than 3 ☐

51. How many grass strips have you established on your farm after ILWMKTP project?

(a). None ☐

(b). 1 ☐

(c). 2 ☐

(d). 3 ☐

(e). above 3 ☐

52 How many terraces have you constructed on your farm?

(a). None ☐

(b). 1 ☐

(c). 2 ☐

(d). 3 ☐

(e). More than 3 ☐

53. How many cover crops do you grow on your farm?

(a). None ☐

(b). 1 ☐

(c). 2 ☐

(d). 3 ☐

(e). Above 3 ☐

54. What acreage do you have under agroforestry?

(a). None ☐

(b). 1/8 ☐

(c). ¼ ☐

(d). ½ ☐

(e). More than ½ ☐

Section D. The level of implementation of Integrated Project Extension Approach in disseminating different catchments management technologies to reduce catchments degradation

Statements below are on level of implementation of Integrated Project Extension approach in dissemination of different catchments management technologies in Kibuon and Tende rivers catchments. Use the Likert scale below to rate them.

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	**2**	**3**	**4**	**5**

S/NO	Variables	1	2	3	4	5
55	Fewer farmers used terraces on their farms before ILWMKTP					
56	Many farmers use terraces on their farms after ILWMKTP					
57	No farmer planted fruit trees to conserve the catchments before ILWMKTP					
58	Many farmers planted fruit trees to conserve the catchments after ILWMKTP					
59	Few farmers planted vegetation cover to protect the catchments before ILWMKTP					
60	Many farmers planted vegetation cover after ILWMKTP project					
61	Few farmers used check dams to control gullies before ILWMKTP project					
62	Many farmers used check dams to control gullies after ILWMKTP project					

Appendix 3.0 Interview Schedule for Key Informants

County……………………………………

Sub-County………………………………

Introduction

This research was collected data on farmers' response to catchments management technologies used in Kibuon and Tende rivers catchments in Homa Bay, Kisii and Nyamira Counties. The study examined the level of degradation in Kibuon and Tende catchments before and after the project, knowledge and skills, and attitude of farmers on catchments management technologies promoted in the catchment, the level of uptake of different catchments management technologies in Kibuon and Tende catchments, level of implementation of Integrated Project Extension Approach in disseminating selected catchment management technologies to reduce degradation and constraints that farmers faced during implementation of catchments management technologies in the catchments. A report compiled from the data may be used by academicians, Policy makers and Government Departments. Data provided is treated with high level of confidentiality.

Section A. Demographic and education data

1. Gender?

   (a). Male ☐

   (b). Female ☐

2. Respondent's age

   (a). 20-30 years ☐

   (b). 30-40 years ☐

(c). 40-50 years ☐

(d). 50-60 years ☐

(e). Above 60 years ☐

3. Marital status

(a). Married ☐

(b). Single ☐

4. Respondent's highest level of education. Tick from the options provided below:

provided

(1). Certificate ☐

(2). Diploma level ☐

(3). Degree ☐

(4). Masters ☐

(5). PhD ☐

B. Level of degradation in Kibuon and Tende rivers catchments before and after The project period

Statements listed below are on level of degradation in Kibuon and Tende basins before and after ILWMKTP project. Rank them using Likert scale provided below.

Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
1	**2**	**3**	**4**	**5**

S/NO.	Variables	1	2	3	4	5
5	More rill erosion existed before ILWMKTP project					
6	There was less rill erosion after ILWMKTP project					
7	The basins had many uncontrolled gullies before ILWMKTP project					
8	Most gullies in the basins were controlled after ILWMKTP project					
9	Many farmers had denuded farms before ILWMKTP project					
10	Few farmers had denuded farms after ILWMKTP project					
11	There was more deforestation before ILWMKTP projects					
12	Deforestation reduced after ILWMKTP project					
13	Few farmers planted trees on their farms before ILWMKTP project					
14	Many farmers planted many trees on their farms after ILWMTP project					
15	There was less napier grown before ILWMKTP project					
16	There was more napier grown after project implementation					
21	There were fewer cover crops in the basins before ILWMKTP project					
22	Many cover crops were established after ILWMKTP project					

Section C. Knowledge and Skills and Attitude of Farmers on Catchments Management Technologies promoted in a Catchment

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	**2**	**3**	**4**	**5**

S/NO.	Variables	1	2	3	4	5
23	Farmers were aware that soil erosion causes catchments degradation					
24	Farmers had some information on terracing before ILWMKTP					
25	Farmers did not know how to construct check dams before ILWMKTP					
26	Before ILWMKTP project fish farming was not active in the catchments					
27	Farmers did not have skills in controlling roadside erosion before ILWMKTP project					
28	Farmers lacked skills to establish and manage tree nurseries before ILWMKTP project					
29	They are now able to establish and manage tree nurseries					
30	Farmers were not able to practice contour farming on their farms before ILWMKTP project					
31	Farmers now practice contour farming on their farms					
32	Farmers use retention ditches to control heavy runoff					
33	Farmers use grass strips to reduce runoff in their farms					
34	Farmers had positive attitude towards catchments management					

	technologies					

Section D. The level of uptake of different catchments management technologies in Kibuon and Tende rivers catchments

35. Through ILWMKTP project interventions, how many soil and water conservation technologies did farmers learn to construct on their own?

(a). 1 ☐

(b). 2 ☐

(c). 3 ☐

(d). More than 3 ☐

The statements below are on level of uptake of catchments management technologies in Kibuon and Tende rivers catchments. Rank them using Likert scale below.

Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
1	**2**	**3**	**4**	**5**

S/NO.	**Variables**	**1**	**2**	**3**	**4**	**5**
36	There was less acreage on agro-forestry before ILWMKTP project					
37	Agroforestry acreage increased after ILWMKTP project					
38	There were few cover crops planted before ILWMKTP project					
39	Many cover crops were established after ILWMKTP project					
40	Less land was conserved before ILWMKTP project					
41	More land was conserved after ILWMKTP project					
42	There were few grass strips established before ILWMKTP project					

43	There were many grass strips after ILWMKTP project					

Section E. The level of implementation of Integrated Project Extension Approach in disseminating different catchments management technologies to reduce catchments degradation

Statements below are on level of implementation of different catchments management technologies in Kibuon and Tende rivers catchments. Use the scale below to rate them.

Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
1	**2**	**3**	**4**	**5**

S/NO.	**Variables**	**1**	**2**	**3**	**4**	**5**
44	Few farmers used terraces before ILWMKTP project					
45	Many farmers used terraces after ILWMTP project					
46	Few farmers planted fruit trees to conserve the basins before ILWMKTP project					
47	Many farmers grew fruit trees to conserve the basins after ILWMKTP project					
48	Few farmers used vegetation cover before ILWMKTP project					
49	Many farmers use vegetation cover after ILWMKTP project					
50	No check dams were used to rehabilitate gullies before ILWMKTP project					
51	Many check dams have been used to rehabilitate gullies after ILWMP project					
52	Water was turbid in Tende and Kibuon rivers before ILWMKTP projects					
53	Water is less turbid after ILWMKTP project					

Appendix 4.0 Introductory Letter

FONS SCIENTIAE

KISII UNIVERSITY

Telephone: +254 773452323
Facsimile: +254 020 2491131
Email: research@kisiiuniversity.ac.ke

P O BOX 408 – 40200
KISII
www.kisiiuniversity.ac.ke

OFFICE OF THE REGISTRAR RESEARCH AND EXTENSION

KSU/R&E/ 03/5/vol.1/198 **Date:** 27th October, 2018

The Head, Research Coordination
National Council for Science, Technology and Innovation (NACOSTI)
Utalii House, 8th Floor, Uhuru Highway
P. O. Box 30623 – 00100
NAIROBI - KENYA.

Dear Sir/Madam

RE: MULWALE ATHANASA CATHERINE REG. NO. DAN/50032/15

The above mentioned is a student of Kisii University currently pursuing Doctorate of Philosophy (PhD) in Agricultural Extension, in the Faculty of Agriculture and Natural Resource Management. The topic of her research is, ***"Farmers' Response to Watershed Management Technologies: Case of Tende and Kibuon Basins in South West, Kenya".***

We are kindly requesting for assistance in acquiring a research permit to enable her carry out the research.

Thank you.

KISII UNIVERSITY
27 NOV 2018
REGISTRAR RESEARCH & EXTENSION

for Prof. Anakalo Shitandi, PhD
Registrar, Research and Extension
Cc: DVC (ASA)
Registrar (AA)
Director SPGS

AS/mm

KISII UNIVERSITY IS ISO 9001:2008 CERTIFIED

SGS

Appendix 5.0 Research Permit

THIS IS TO CERTIFY THAT:
MS. CATHERINE ATHANASA MULWALE
of KISII UNIVERSITY, 0-40300 Homa Bay,has been permitted to conduct research in *Nyamira County*

on the topic: *FARMERS RESPONSE TO WATERSHED MANAGEMENT TECHNOLOGIES CASE OF TENDE AND KIBUON BASINS IN SOUTH WEST KENYA*

for the period ending:
17th January,2020

Permit No : NACOSTI/P/19/45863/27645
Date Of Issue : 17th January,2019
Fee Recieved :Ksh 2000

Applicant's Signature

Director General
National Commission for Science Technology & Innovation

Appendix 6.0 Authorization Letter

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone:+254-20-2213471, 2241349,3310571,2219420
Fax:+254-20-318245,318249
Email: dg@nacosti.go.ke
Website : www.nacosti.go.ke
When replying please quote

NACOSTI, Upper Kabete
Off Waiyaki Way
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No. **NACOSTI/P/19/45863/27645**

Date: **17th January, 2019**

Catherine Athanasa Mulwale
Kisii University
P.O. Box 408-40200
KISII

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on **"*Farmers response to watershed management technologies. Case of Tende and Kibuon Basins in South West Kenya*"** I am pleased to inform you that you have been authorized to undertake research in **Nyamira County** for the period ending **17th January, 2020.**

You are advised to report to **the County Commissioner and the County Director of Education, Nyamira County** before embarking on the research project.

Kindly note that, as an applicant who has been licensed under the Science, Technology and Innovation Act, 2013 to conduct research in Kenya, you shall deposit **a copy** of the final research report to the Commission within **one year** of completion. The soft copy of the same should be submitted through the Online Research Information System.

GODFREY P. KALERWA MSc., MBA, MKIM
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Nyamira County.

The County Director of Education
Nyamira County.

Appendix 7.0 Thesis Plagiarism Turnitin Report

FARMERS' RESPONSE TO CATCHMENT MANAGEMENT TECHNOLOGIES: A CASE OF TENDE AND KIBUON CATCHMENTS IN SOUTH WEST, KENYA

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