ADDIS ABABA UNIVERSITY

COLLEGE OF NATURAL AND COMPUTATIONAL SCIENCES

DEPARTMENT OF ZOOLOGICAL SCIENCES

THE IMPACT OF SOIL AND WATER CONSERVATION ON PLANT SPECIES DIVERSITY AT KEBELLE SAESIE WOREDA SAESIE TSAEDA EMBA EASTERN ZONE OF TIGRAY REGIONAL STATE

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MSc THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN BIOLOGY

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Declaration

I, Hailekiros Tsegay Lemma here by present for consideration by the Zoological Science Department with in the College of Natural and computational Sciences at Addis Ababa University, my dissertation in partial fulfillment of the department for the degree of Masters on the impact of SWC on plant species diversity. I sincerely declare that this thesis is the product of my own efforts. No other person has published the same study which I might have copied, and at no stage will this be published without my consent and that of the = Zoological Science = Department.

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Table of content

Abbreviations and Symbols

IFPRI	International Food Policy Research Institution
MA	Millennium Ecosystem Assessment
NRCS	Natural Resources Conservation Service
REST	Relief Society of Tigray
SCRP	Soil Conservation Research Project
SWC	Soil and Water Conservation
WOCAT	World Overview of Conservation Approaches and Technology

List of Figures

List of Tables

Title: The impact of Soil and Water Conservation on Plant species diversity at *Kebelle Saesie* Woreda Saesie Tsaeda Emba Eastern Zone of Tigray Regional State

By: Hailekiros Tsegay2019

Abstract

Land degradation is one of the major challenges in the development of plant species diversity in many parts of the world, especially in developing countries like Ethiopia. Even though a number of Soil and water conservation methods were introduced to contest land degradation, there are some areas that do not show significant progress. This study was conducted at kebelle Saesie Woreda Saesie Tsaeda Emba, Eastern zone of Tigray Regional state. The purpose of the study was to evaluate the impact of SWC on the advancement of plant species diversity. Reasonably, it was focused on the methods of SWC, plants that grow after SWC implementation and the variation between conserved and un-conserved areas regarding their plant species diversity. The data was collected by questionnaire, interview and field observation. To collect reliable information, a total of 65(41 male and 24 female) households from the kebelle were considered in the questionnaire administration and another 10(7 male and 3 female) households and one Kebelle agricultural expert were interviewed. In addition to this, several field visit was carefully conducted and 100m^2 area for each 44 plots were demarcated from slopes and plain lands. Then different plant species inside them were counted. The data obtained through questionnaire were computed with frequency and percentage in Microsoft Excel and then discussed in both quantitative and qualitative approaches. The data gathered via interview and field observation were also quantitatively & qualitatively analyzed using the descriptive data analysis method. The result shows that, the common methods of SWC in the study area were dam construction, hillside terracing, hung dung trenches, Water harvesting, contour plough, afforestation, reforestation and over grazing control. Due to those techniques plants developed in type, structure and number. Necessarily, human and animals became beneficiary from the land reclamation. On the other side, the data indicates the presence of un-conserved and conserved but no protected lands with their feeble growth of plant species. From this, the study concluded that plant species diversity cannot enrich unless the area is conserved and protected. Therefore, the careful pursue of stakeholders on natural resources conservation should be a core issue.

***Keywords**: Soil and water Conservation, Conservation methods, Plants species diversity.*

CHAPTER ONE

1. Introduction

1.1 Background of the study

Land is one of the most important assets to people throughout the whole world especially for life basically relied on agriculture (USAID, 2007). But this valuable property is being degraded due to soil erosion and nutrient depletion. Environmental such as potential loss of natural resources are negative effects resulting from the destruction of habitat (Borgerhaff and Coppolillo, 2005). Ethiopia being the land where the first humans have evolved, and its vegetation has been exposed to various human induced impact for a long period than anywhere else (Tesfaye Beshah, 2003). The history of human use and misuse of ecosystem tells the story of adaptation to the changing condition that we create (Folke, 2005).

Environmental and natural resource degradation is a major concern in Ethiopia, because of its devastating effect on economic status of the people which are highly dependent on natural resources. The problem is particularly severe in the rural highlands of Ethiopia (Girma Taddese, 2001).

Ethiopia is a country with great topographic feature and most part of the country consists of high plateau and mountain ranges with precipitous variation dissected by numerous streams which tributaries of major rivers (Dembel, 2002). Soil plant interaction posits that a change in soil condition causes change in the vegetation composition and their diversity which in turn causes further change in the soil and vice versa. In plant soil system, this implies that a plant induced change in the composition and activity of the soil biotic, physical or chemical properties, rate of ecosystem process, directly affect the plants (Ehrenfeld, 2005).

Natural resources degradation and soil erosion are some challenges to Ethiopia where human pressure has increased since the 1950s and has led to degradation, expansion of agriculture and over grazing. As a consequence, the land, especially the hill slopes become degraded in Ethiopia, plant diversity was declined and most areas become margined for crop production (Mahilet Mulatie, 2009).

In most of the developing countries the main factor of land degradation is the improper and unwise use of land due to population pressure land tenure insecurity, land redistribution, limited access to credit and limited education (IFPRI, 2005). The immediate cause of land degradation is reduced crop yield followed by economic decline and social stress. The integrated process of land degradation and increased poverty has been referred to as the "downhill spiral of unsustainability" leading to the "poverty trap" (Green land *etal*, 1994).

Hence, to grapple with the problem of soil erosion massive reforestation and soil and water conservation schemes were launched in Ethiopia. Many generous international donors assisted the program. Since 1960s various conservation strategies have been introduced to enhance agricultural development and rural livelihood (Keeley & Scoones, 2000 cited in Aklilu Amsalu, 2006). However, the success rate has been below expectation (Mushir Ali & Kedru Surrur, 2012). Similarly, in Woreda Saesie Tsaeda Emba Tigray regional state, even though there is a positive progress in natural resources restoration there is a variation from one to another area.

Therefore, my research interest is focused on the role of soil and water conservation on natural resources especially plant species diversity so as to introduce the common agreement among societies, governmental sectors and NGOs on the way of decreasing land degradation and increasing plant species.

1.2 Statement of the problem

All over the world species diversity forms the base of life. Of this, plant species diversity is vital since it laid the foundation upon which other biodiversity exists, as plants remain the dominant creative organisms with capability of converting solar energy into chemical energy through photosynthesis. Plants give beauty to the landscapes and provide enumerable ecosystems services to humans and other creatures. Plants have pervasive role in the economic, environmental and social dimension of the human life and, global deforestation has remained a serious problem leading to environmental degradation. Tree cutting, Charcoal making, overgrazing and agricultural expansions are the livelihood activities of last resort for people in poor countries (Asmare Welde, 2012). Therefore, this hazardous phenomenon should be stopped in order to achieve sustainable development and to implement proper management and utilization of natural resources.

In the early 1980s, the soil conservation research project (SCRP) was initiated to study soil erosion in controlled experimental settings in representative agro-ecological locations in Ethiopia. Moreover, it was aimed at training experts, and thus to improve the countries research and implementation capability in soil conservation (Tesfaye Beshah, 2003). As a result, soil and water conservation was practiced for over 25 years. However, there are significant problems observed in *kebelle Saesie* regarding the natural resources management and thus improvements of plant species diversity is not observed in some parts of the study area due to depletion of nutrients, deforestation, overgrazing and flooding. This study is initiated to investigate the impact of soil and water conservation on plant species diversity. That's why the main focus of the study was on the identification of the soil and water conservation methods in addition to looking the difference of plant species diversity in between conserved and non-conserved slope, river, and plain areas of the *kebelle*.

1.3. Objective of the study

1.3.1. General objective

The general objective of the study was to assess the impact of soil and water conservation on plant species diversity.

1.3.2 Specific objective

The specific objectives of the study were

- ✓ To identify the methods of soil and water conservation practices
- ✓ To identify the plants that grow after soil and water conservation has been implemented
- ✓ To compare the variation of plant species diversity in between conserved and non-conserved areas

1.4 Scope the study

Due to limitation of time and resource, the study was delimited to one *kebelle of Saesie Tsaeda Emba* Woreda located in Eastern zone of Tigray regional state which is kebelle Saesie that holds three villages (village *Awleat*, village *Biera* and village *Addikelebes*). However, the finding of

the study may be use full and applicable to similar Woreda in the region and the country. The study primarily focuses on the impact of soil and water conservation on plant species diversity at Saesie kebelle woreda Saesie Tsaeda Emba Tigray regional state.

1.5 Research questions

The study on assessing the impact of soil and water conservation on plant species diversity at *Kebelle Saesie* Woreda Saesie Tsaeda Emba of Tigray regional state was based on the following main research questions;

1. What are the common methods of soil and water conservation practices in *kebelle Saesie*?

2. What type of plants have grown in *kebelle Saesie* after soil and water conservation has been implemented?

3. What is the difference between conserved and non-conserved areas of *Kebelle Saesie* in the case of plant species diversity?

1.6 Organization of the thesis

This thesis was focused on the impact of soil and water conservation on plant species diversity. Mainly, it has given an attention for the overall goals of soil and water conservation, the difference between conserved and non- conserved areas, the role of soil and water conservation on plant species increment and the final outcome and benefit of soil and water conservation to the society. Furthermore, this study argues that soil and water conservation have great role in making the land more fertile and suitable for both plants and animals. In this paper, there are six chapters.

Chapter one consists of introduction, statement of the problem, objectives of the study, scope of the study and research questions and the research organization

Chapter two deals with literature review that includes water conservation, methods of water conservation, goals of water conservation, applications of water conservation, soil conservation, methods of soil conservation and importance of soil and water conservation.

Chapter three presents the general methodology employed in the study. In this chapter, description of study area, methods of data collection, methods of data analysis, population of the study and sampling techniques were included.

Chapter four presents result and discussion of the study. Issues dealt in this chapter include: different tables, pictures and detail explanations of the respondent's response.

Chapter five holds conclusion and recommendation. This chapter consisted of constructive ideas regarding the role of soil and water conservation on plant species diversity

The last chapter six presents the references and indexes of the study.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Soil and water conservations in Ethiopia

Ethiopia is one of the most environmentally troubled countries in the sub-Saharan belts. The principal environmental problem in Ethiopia is land degradation in the form of soil erosion, gully formation, and soil fertility loss (Hurni, 1993). Large parts of the highlands of Ethiopia are severely eroded. The vast majority of the population derives its livelihood from agricultural sectors. This is to mean that under conditions of sustained agriculture, in both the densely populated highlands and sparsely populated low land areas of the country, survival is solely linked to the exploitation of land (World Bank, 1996; Gebremedhin and Swinton, 2002 cited in Mushir Ali & Kedru Surrur, 2012). That's why to contend the cause of soil erosion, different soil and water conservation structures were introduced to Ethiopia since1960s (Keeley & Scoones, 2000 cited in Aklilu Amsalu, 2006). Although the achievements were remarkable in quantitative terms, the impacts of these efforts were far below expectations and the land degradation continued to be a series problem (Azene Bekelle, 1997).

Land degradation in Tigray also attracted increasing awareness during the 1980s. A paradigm shift took place from projects dealing mainly with physical and chemical aspects of degradation towards integration of broader range of discipline. The pre- 1980 period was largely dominated by a "technical fix approach", where a physical problem was identified and a physical solution prescribed (Stocking, 1992).

Before 1988, there was a general lack of commitment and awareness among farmers concerning the soil conservation efforts and benefits. But from 1988-1990, the Tigray People Liberation Front (TPLF) and Relief Society of Tigray (REST) took over the SWC programs in the previously government held areas. The objectives of the program were (1) to promote food security, (2) to prevent environmental degradation and desertification, and (3) to secure water supply for irrigation, livestock, and domestic use. The area of land that was terraced between 1988 &1995 in Tigray amounted to approximately 418, 500 ha, while 800,000 ha of land was terraced in the country as a whole during 15 years of soil conservation (Kejela Kefeni, 1993).

The world over view of conservation approaches and technologies (WOCAT) defines soil and water conservation as local level activities that maintain or enhance the productive capacity of the land in areas affected by or prone to degradation. Those include activities that prevent or reduce soil erosion, compaction and salinity, conserve or drain soil water; and maintain or improve soil fertility (Vanlynden and Liniger, 2002).

2.2 Water conservation

Water conservation includes all the policies, strategies and activities to sustainably manage the natural resources of fresh water, to protect the hydrosphere, and to meet the current and future human demand. Population, household size, and growth and affluence all affect how much water is used. Factors such as climate change have increased pressure on natural water resources especially in manufacturing and agricultural irrigation (DEFRA, 2013). A fundamental component to water conservation strategy is communication and education outreach of different water programs. Developing communication that educates science to land managers, policy makers, farmers, and the general public is another important strategy utilized in water conservation. Communication of the science of how water systems work is an important aspect to conserve that system and is often used for ensuring the right management plan to be put into action (Delgabo *etal*, 2011).

2.2.1 Methods of water conservation

The methods of water conservation are listed as fellows

- ✓ Vegetation cover acts as “living sponge” reduces rain droplets so that more water gradually retained in to the soil
- ✓ Terracing methods
- ✓ Ridge-tie method; Making small depression so hold water
- ✓ Pollution control
- ✓ Educating people to prevent water pollution and not to waste water (Zeru Allelign, 2004E.c).

2.2.2. Goals of water conservation

Some of the water conservation goals can be;

Sustainability; to ensure availability for future generations, the withdrawal of fresh water from an ecosystem should not exceed its natural replacement rate.

Energy conservation; Water pumping delivery and water waste treatment facilities consume a significant amount of energy. In some regions of the world over 15% of total electricity consumption is developed to water management.

Habitat conservation; minimizing human water use helps to preserve fresh water habitats for local wild life and migrating water fowl as well as reducing the need to build new dams and other water diversion infrastructures (Hermoso *etal*, 2016).

2.2.3 Applications of water conservation

2.2.3.1 Households applications

Water serving technology for the home includes;

- Low flow shower heads sometimes called energy efficient shower heads as they also use less energy.
- Low flush toilets and compositing toilets have a dramatic impact in the developed world as environmental western toilets use large volume of water.
- A dual flush toilet created by carom includes two buttons or handles to flush different levels of water. Dual flush toilets use up to 67% less water than conventional toilets (Mayer *etal*, 1999).

2.2.3.2 Commercial applications

Many water saving devices (such as low flush toilets) that are use full in homes can also be use full for business water saving. Other water saving technology for business includes:

- Water less urinals
- Water less car washes

- Infrared or foot operated taps, which can save water by using short bursts of water for rinsing in kitchen or bath room.
- Pressurizing water brooms, which can be used instead of a hose to clean side walks
- X-ray film processor re-circulation systems
- Cooling tower-conductivity controllers
- Water saving steam sterilizers, for use in hospitals and health care facilities
- Rain water harvesting
- Water to water heat exchangers (AMWUA, 1999).

2.2.3.3 Agricultural application

For crop irrigation optimal water efficiency means minimizing loss due to evaporation. Runoff or sub surface drainage while maximizing production an evaporation pan in combination with specific crop correction factors can be used to determine how much water is needed to satisfy plant requirements.

- Flood irrigation; the oldest and most common type is often vary an even in distribution, as part of afield may receive excess water in order to deliver sufficient quantities to other parts.
- Overhead irrigation; using center pivot or lateral moving sprinklers has the potential for much more equal and controlled distribution pattern
- Drip irrigation; is the most expensive and last used type, but offers the ability to deliver water to plant roots with minimal losses. However, drip irrigation is increasingly affordable, especially for the home gardener and in light of rising water rates. There are also cheap effective methods similar to drip irrigation such as the use of soaking hoses that can even be submerged in the growing medium to eliminate evaporation. As changing irrigation system can be a costly undertaking conservation effort often concentrate on maximizing the efficiency of the existing systems (Geerts, 2009).

2.3 Soil conservation

Soil conservation is the prevention of soil loss from erosion or prevention of reduced fertility caused by over usage, acidification, salinization or other chemical soil contamination. Slash and

burn and other unsustainable methods of subsistence farming are practiced in some lesser developed areas. A sequel to the deforestation is typically large scale erosion, loss of soil nutrients and sometimes total desertification. In contrast, tree, shrubs and ground-cover are effective perimeter to treat of soil erosion (Panagos *etal*, 2015). Soil conservation farming involves no till farming, green manures and other enhancing practices. Such farming methods attempt to mimic the biology of barren lands. They can revive damaged soil, minimize erosion, encourage plant growth, eliminate the use of nitrogen fertilizer or fungicide, produce above average yields and protect crops during drought or flooding. The result is less labor that increase farmers profit (Marcel, 1981).

2.3.1 Methods of soil conservation

Soil management is concerned with ways of preparing soil to promote dense vegetative growth and improve its structures so that it is more resistant to erosion. Hudson (1989), classifies soil erosion control measures as either mechanical or non- mechanical where in mechanical measures, mechanical protection works such as earth moving and soil shaping measures are used. Non-mechanical all practices which influences and reduce soil erosion by management of growing crops or animals.

There are well known methods to protect the soil from erosion. Those are listed as follows:

1. Afforestation; is an activity concerned with planting trees in an area where or other bushes have not been there.

2. Reforestation; is an activity concerned with planting trees again in an area which were once covered by forests. Trees can reduce runoff and allows more water to infiltrate in to the ground. Rain drops fall with full force in areas without vegetation.

3. Check dams; in this method small dams are made to control gully erosion. The smaller dams hold back the water and capture the alluvial soil that the water carries along with it.

4. Contour plough; is a form of agriculture where farming activities such as farming, planting, cultivating and harvesting are done across the slop rather than up and down the slope (NRCS, 2006). Stevens *etal*, (2009) evaluated the effect of contour cultivation on soil erosion on experimental field in Leicestershire, England. They found that contour cultivation reduced

surface runoff and sediment yield as compared to up and down cultivation although the trend is not significantly different.

5. Controlled grazing; results from systematic grazing of animals. An area of grazing land can support a certain number of animals without suffering any loss of quality. We can also practice controlled grazing by dividing grazing grounds in to fenced plots. Then each plot can be grazed in to rotation.

6. Crop rotation; refers to the cultivation of different crops alternatively. To grow the same crop in the same field for successive years will exhaust one particular kind of nutrient. For example potatoes require much potash but wheat requires nitrates.

7. Fallowing; this is also a method in which much used and over cultivated land is allowed to rest. During this time, the nutrients lost are regained in most parts of high land areas of Ethiopia. Farmers allow the farm lands to remain fallow for one or two years. As soon as the soil fertility improves and cultivation will start again.

8. Green manure; some farmers are committed enough to use certain green plants as fertilizers, usually leguminous plants, such as beans, peas and lentils. Before the plants become manure, the field is ploughed and their parts are mixed with soil adding fertility to it.

9. Mulching; involves covering the surface with grass, crop residue or other materials to reduce evaporation and erosion. Covering soil surface with crop residue can reduce soil loss by 50% or more. This depends on the amount of rainfalls, soil type and other characteristics. Leaving crop residue on the soil surface protects by catching rain drops.

10. Strip cropping or multiple cropping; this system allows the growing of more than one crop in the same pieces of land. Some crops are grown in strips at right angle to the slope of land. Some crops are erosion resistant while others are not. Therefore, different crops are planted alternatively to reduce the speed of running water Because of this, the amount of water that sinks into the soil increases.

11. Terracing; terraces are conservation structures which comprise of series horizontal ridges made on a hillside (Neitsch *etal*, 2005). There are three types of terraces. They are broad based, narrow based and bench terraces. Broad based terraces are used on gently slops and narrow

based terraces are used on much steeper slops. Bench terraces are constructed on steeper slops where the ridge is steep and not cultivated. They are made up of re-shaping a steep slope to create flat or nearly flat ledges or beds, separated by vertical or nearly vertical risers (Mati, 2007).

2.4 Importance of soil and water conservation

2.4.1 Soil fertility

Studies have been conducted to assess the effect of soil conservation on soil fertility. Weigel (1986) determined some physical and chemical characteristics of soil from the soil lose zone directly below contour bunds and the soil accumulation zone above contour bunds in the Maybar/Wello area. The concentration of plant available phosphorus was higher in the soil accumulation zone than in the soil lose zone down to 50 cm depth. Vagen (1996) also studied soils in a top sequence of terraced (down-and mid-slope) and non-terraced land (up-slope) in the Hagere Selam up lands in Degua Tembien, Tigray. Surface soils from terrace benches and the soil loss zone of terraces had highest clay contents, while soils from non- terraced land were sandy. This critical issue of soil fertility is the backbone of plant species diversity increasing in an area.

2.4.2 Crop yield

Yohannes Gebremichael (1989), compared barley crop and biomass yields above the bund (soil accumulation area) and below the bund (soil loss area) of *fanya juu* terraces in the Andit Tid area of northern shoa during three cropping seasons from 1986 to 1987. The average barley yield was 1650 kg/ha above the bund which is 43% higher than below the bund. This indicated that, soil and water conservation is unquestionably the guaranty of survival of both plants and animals.

CHAPTER THREE

3. MATERIALS AND METHODS

3.1. Description of the study area

Woreda *Saesie Tsaeda Emba* is located in the eastern zone of Tigray. It is bordered by Afar region and *Atsbiwenberta* Woreda in the east, by *Erobe* woreda in the north, by *Ganta afeshum* woreda in the northwest, by *Hawzen* woreda in the southwest and by *kltawlaelo* woreda in the south. It accommodates 27 *Kebelles*. *Kebelle Saesie* is one of the 27 *Kebells*. It has 10841 total populations. Among them 48% are females. The *Kebelle* is also bordered by western part *Kebelle Komasbuha*, by northern part *Kebelle Marwa* and *Tahtay zban*, by Eastern part *Kebelle Mesahul* and by Southern part *Kebelle Hadsh hiwet and Emba Asmena*. It has an elevation of 1400-3000m above sea level. The average temperature of the *Kebelle* is between20-27^{0}c.

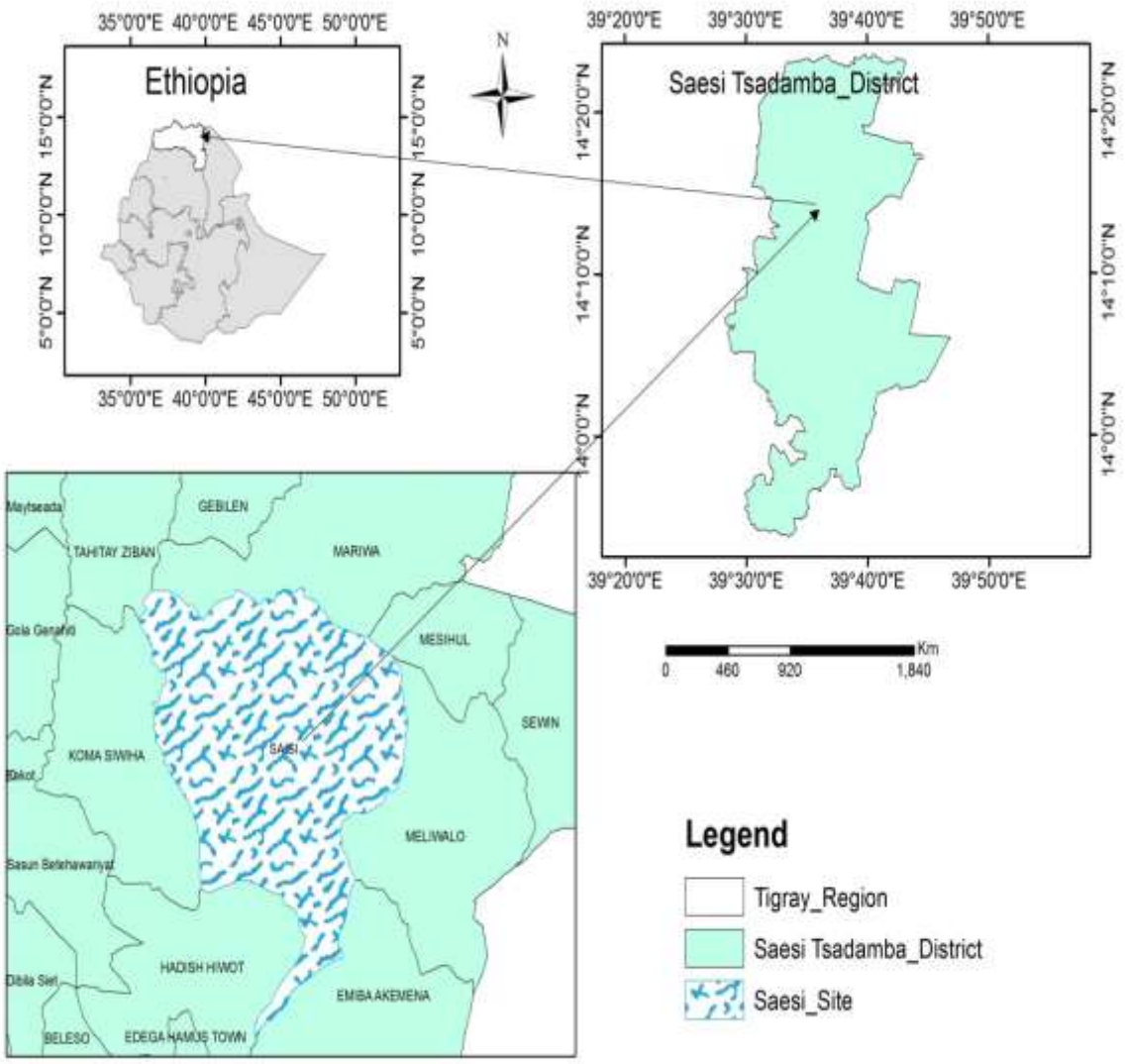

Figure 1: Topographic Map of Woreda Saesie Tsaeda Emba and Kebelle Saesie

3.1.1 Vegetation type

This area has sparsely vegetated with higher plants like olive and junipers and mostly it is covered by shrubs.

3.1.2 Soil type

Based on the geographical location, *Kebelle Saesie* has different types of soil. The plain area has clay soil in majority and sand soil in same extent. The rest slope and river area have also both silt and sandy soils.

3.1.3 Rain Fall Size

The range of annual rain fall of *Kebelle Saesie* is 400-450 mm. The area gets rain usually during summer season.

3.2 Methods of Data Collection

The data required for this study was collected through different mechanisms; namely, field observation, questionnaire, and interview. The survey questionnaire and interview were comprised of both close and open-ended questions. The questions of the questionnaire were translated from English to the local language, Tigrigna. And also, the interview was conducted in Tigrigna. But before the data collection administration, a detail discussion was executed with the selected farmers concerning the purpose of the study, meaning of plant species diversity and its benefit for the society and other animals. Thus, they have developed trust to answer the questions. The questionnaire and interview generated information on the impact of soil and water conservations on plant species diversity in reference to place of soil and water conservation, goals of soil and water conservation, plants that grow after SWC practices, changes that came due to soil and water conservation, benefits of soil and water conservation for the society and others. The other way of data obtaining was direct observation of the field. It was focused on methods of SWC, the difference among conserved and protected, conserved but not protected and not conserved not protected areas regarding their plant species diversity. To perform that using the quadrat method, in each nine slope and two plain lands $100m^2$ of four separated spaces were demarcated systematically and the plant species inside those total 44 defined areas were counted. After that the average number of the species was taken for discussion.

3.3Methods of Data Analysis

The collected data was computed and explained by using both quantitative and qualitative approach of data analysis. Based on the instrument employed and the nature of questions set, data collected through questionnaires were analyzed quantitatively by using frequency and percentage in tables and figures for close ended questions and by qualitative description for open ended questions. The data obtained from interview was again analyzed qualitatively by narration.

The data collected via observation was also analyzed quantitatively and qualitatively in consideration to the average number of plants species existed in $100m^2$ area.

3.4 Population of the study

The total households in *Kebelle Saesie* (*Awleat, Biera* and *Addikelebes* villages) are 1670 of which were1289 headed by males and 381 by females. Totally 10841 peoples live there. The average family size is 6.49. For this study, 70 farmers were randomly selected and taken for questionnaire and 10 farmers and one Kebelle agricultural expert were purposely selected for interview. All of the selected farmers have owned their own land. During interview, the interviewee reported that the households in *Kebelle Saesie* possessed from 0.5-1.5 hectare of crop land for each. The majority of the farm land productivity is during the summer (rainy) season except very small areas that are suitable for irrigation.

3.5 Sampling technique

The site of the study is one *Kebelle* that holds three villages namely *Awleat, Biera* and *Addikelebes*. Using the formula (Kothari, 2004) systemic random sampling technique for dispersal population, 70 house holders out of 1670 total households of the district were taken. The sample size was found to be sufficient considering the time and budget available for the study. Generally, the total sample sizes considered for this study were 81 respondents (11 of them were purposely selected for interview and 70 randomly selected for questionnaire distribution). The sample size was calculated using the following formula of sample size determination (Kothari, 2004 systemic random sampling technique for dispersed population).

$$n = \frac{NZ^2pq}{e^2(N-1) + Z^2pq} = \frac{1670*(1.96)^2 0.05*0.95}{(0.05)^2(1670-1) + (1.96)^2 0.05*0.95}$$

$$n = 69.985 = 70$$

Where n= sample size required

N= Total population size (1670)

z=value of standard at a given confidence level (1.96)

p= sample proportion of success (.05)

e= acceptable error/ precision level (.05)

q= confidence level (.95)

To take proportion from the three villages that was taken (*Awleat, Biera and Addikelebes*) the formula taken from Kothari, 2004 systematic random sampling technique for dispersed population was also used.

$n_h = nN_h/N$ Where n_h=sample size from each village

N_h =total householders in each village

N=total householders in the selected *Kebelle*

n = total sample size from the study population.

Based on this formula, the sample size from the three villages of the *Kebelle* is

n_1 =70*453/1670=18.99=19 ----from *Awleat* village

n_2=70*610/1670=25.56=26-----from *Biera* village

n_3=70*607/1670=25.44=25-----from *Addikelebes* village

.

CHAPTER FOUR

4. RESULTS AND DISCUSSIONS

4.1 Response rate

Table 1: Number of targeted households and response rate per village

Villages	household targeted	Questionnaire issued	Response rate
Awleat	19	19	100%
Biera	26	24	92.30%
Addikelebes	25	22	88%
Total	70	65	93%

The study targeted a total of 70 households who live in the study area for questionnaire. However, 65 questionnaires were successfully administered yielding a response rate of 92.86%. The remaining questionnaires could not be administered due to different reasons. In some cases, three households were not voluntary to fill the questionnaire and the remaining two households were unavailable to return the questionnaire. Nonetheless, Mugenda (2003) cited that a response rate of 72% and over is considered as very good and adequate for analysis and reporting. In light of this assertion, 92.86% of response rate is therefore sufficient to make conclusions for this study.

4.2 Background of questionnaire respondents

Table 2: Sex of the respondents

Villages	Male	Female	Total
Awleat	12	7	19
Biera	15	9	24
Addikelebes	14	8	22
Total	41	24	65

Table 2, shows that from the total respondents, 41 (63.8%) male respondents were taken from the three villages where as the rest 24(36.02%) were females.

Table 3: Age of the respondents

Villages	≤18	19-55	≥56	Total
Awleat	0	19	0	19
Biera	0	23	1	24
Addikelebes	1	19	2	22
Total	1	61	3	65

Table 3, indicates that most of the respondents 61 (93.84%) were at the age of 19-55 years old. And also, actively they have been participated in the soil and water conservation since they are

more productive and powerful peoples. That's why they have a lot of valuable information about the importance of SWC practices. The rest were 1(1.54%) under nineteen and 3(4.62%) above fifty-five.

Table 4: Educational level of the respondents

Edu.level	Male	Female	Total
Under Certificate	41	24	65
Certificate	0	0	0
Diploma	0	0	0
Degree	0	0	0
Total	41	24	65

Table 4, shows that the educational level of the respondents was under- certificate. But through formal and informal learning 51 respondents have the skill to read and write in their local language Tigrigna. Thus, they filled the questionnaire by themselves. The rest 14 respondents have no the reading and writing skills and they give their response in front of the researcher by the help of other voluntary literate peoples. However, both the literate and illiterate peoples follow changes on their land eagerly and they provide constructive ideas and recommendations.

4.3 General back ground of interview respondents

Table 5: Village, Sex, Age, and Educational level of the respondents

	Sex		Age			EL		
Villages	male	Female	≤18	19-55	≥56	Illiterate	Primary	Secondary
Awleat	2	0	0	0	2	2	0	0
Biera	3	2	0	0	5	3	2	0
Addikelebes	2	1	0	0	3	1	2	0
Total	7	3	0	0	10	6	4	0

Table 5, reflects that, from the total 10 farmer respondents, 7(70%) were male respondents and the remaining 3(30%) were females. Regarding their age again all of them (100%) were 56 years old and above. Because, they were purposely selected in order to remember the former features of the study area and to give full and reliable information since they are elders. Academically, 6 (60%) of the respondents were illiterate in essence, they have no the skill to read and to write. But four farmers (40%) have the two basic skills (reading and writing). Because they have learned in Elementary schools and churches. And one agricultural expert was taken.

4.4: Questionnaire

Table 6: Farmers' response to the area where SWC is takes place repeatedly

Landscape	Frequency	Percentage
Plain	1	1.54
Mountain and slope	58	89.23
River	6	9.23

According Table 6, 58 (89.23 %) of the respondents respond that in *Kebelle Saesie*, most of the time soil and water conservation has been practiced in the mountain and slope areas. For this reason, the farmers clarified that those areas are more exposed to the fast running of flood. As a result, the area loses very much soil per a year. In the same way other studies reflected that longer and steeper slopes (especially those without vegetation cover) are more susceptible to very high rates of erosion during heavy rain than less and short slopes (Blanco *etal*, 2010). Next to this, the government and people gave more emphasis for the river lands as mentioned by 6 (9.23 %) of the respondents. This repeated soil and water conservation action has its own effect on the reduction of soil erosion, landslide and land degradation. But it does not mean that soil and water conservation did not practice in plain area. The difference is the rate of repetition. In general, the soil and water conservation has been carried out by giving priority for the land with high chance to damage.

4.5 Farmers' response to the overall goal of soil and water conservation

According to the response of respondents, the soil and water conservation measures were very helpful for the erosion control and better to improve soil productivity. Farmers use terraces, stone bund, soil bund, stone check dam, gabion check dam and others to prevent their land from

erosion. This leads to increase the diversity of an ecosystem. Because those different mechanisms of soil and water conservation assured the humidity, soil fertility and water catchment of the land. As a result, variety of plant species were grew through time. This is not only in number but also plants became well developed and attractive in structure. The presence of such like plants in an area is vital to have healthy and inclusive ecosystem and environment. Thus, the area has different types of animals like reptiles, birds, mammals, and decomposers because of existence of serviceable plant species. In general soil and water conservation has make the surrounding cyclic and continuous by itself.

4.6 Farmers' response to the difference in the area before and after the soil and water conservation practices

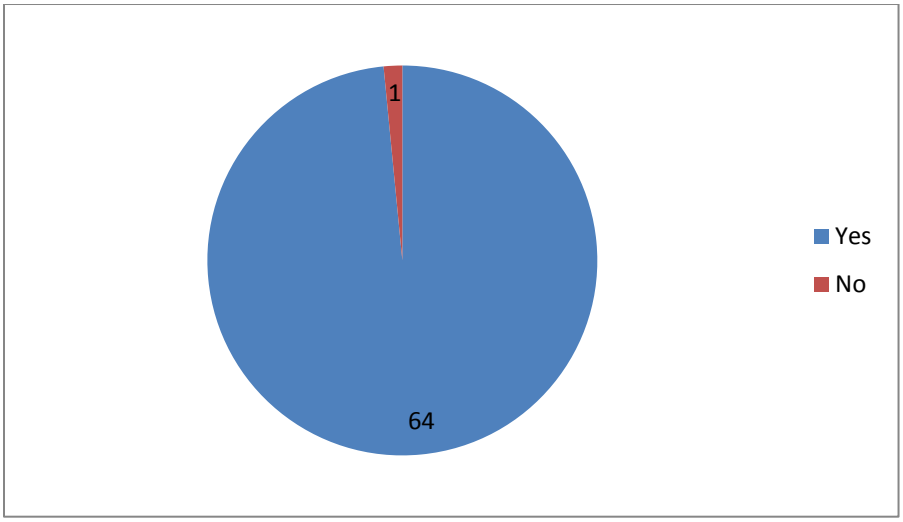

Figure 2: Farmers' response to the difference in the area before and after the soil and water conservation is takes place

Based on the above graph, 64 (98.46%) of the respondents respond that, there is an observable difference in their land before and after the implementation of soil and water conservation. Depending on their explanation, in *Kebelle Saesie* there was rapid flood running, their land was highly eroded and rocky, their farm land was less productive, there were few and weak plant species before the practice of soil and water conservation because the most important top soil for crop production activity was deteriorating over time due to erosion processes and soil depth decreases or the un productive soil was remained. This has also been observed elsewhere. (FAO, 2001), defined degradation as changes within a forest that affect the structure and function of the

site and thereby lower its capacity to supply products or services. But after soil and water conservation was practiced, the flood running was approached to zero, rill erosion, gully erosion and sheet erosion was decreased and several kinds of plants were growing. The conserved rivers and their surrounding were changed in to grass land and totally the whole area was become green. As a result, crop yield was also increased. Finally, almost all respondents answered that soil and water conservation was the key factor in making the land to be healthy, more productive and attractive.

4.7 Farmers' response to the role of soil and water conservation on increasing plant species diversity

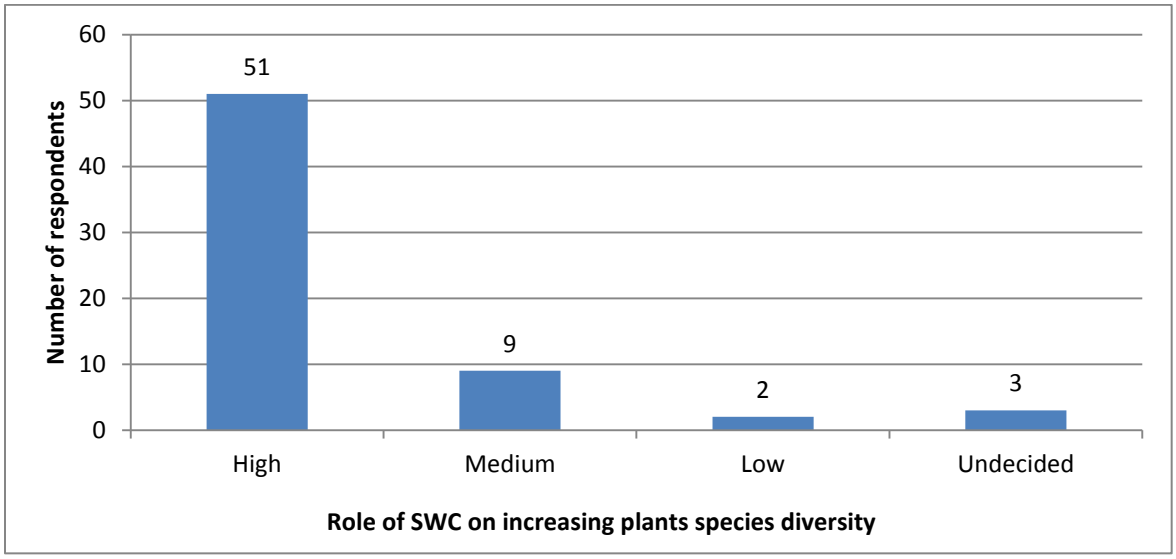

Figure 3: Farmers' response to the role of soil and water conservation on increasing plant species diversity

As the graph indicates, 51(78.46%) of the respondents reflect that the soil and water conservation is highly important to increase plant species diversity and 9 (13.85%) of the respondents respond that SWC has medium importance. Having understood the meaning of diversity which is the existence of variety of species in a given area, together their deep narration shows that land scape of the study area was not good before 1980s because at that time government and peoples of the locality did not care about natural resources. Inordinately, there was un-wise cutting of trees,

overgrazing, expansion of cultivation, and expansion of settlements. Due to those reasons, rarely plants were available. However, since 1985E.c well organized soil and water conservation, afforestation, reforestation and controlling overgrazing was begun. Consequently, the area became more stable and has fertile soil. Interestingly a lot of plant species have grown there. For instance, land plants like trees, herbs, bushes, and shrubs, hydrophytes (watery plants), xerophytes (desert plants like cactus), epiphytes like mosses and other climbing plants became the main constituents of the land. At present, the area is covered by gymnosperm and angiosperm plants such as *Dodnia angustifolia, Bacium grandifolium, Rumex nervosus, Argemone mexicana, Juniperus procera, Olea europaea* and other spiny plants. Other study also shows that, the concentration of plant available phosphorus was higher in the soil accumulation zone than in the soil lose zone (Weigel, 1986). On top of this, the area has high agricultural potential because it is more conserved and has productive soil. Thus, most of the time the farmers use the principal crops including *Eragrostis tef, Hordeum vulgare, Sorghum bloolor, Triticum app, Vicica faba*, *Pisum sativum, Zea mays* and the productivity is on the way of maximizing from time to time.

4.8 Farmers' response to the mechanisms of increasing plant species diversity in addition to soil and water conservation

According to the idea of respondents to increase the diversity of plants, the society of the area uses not only physical activities of soil and water conservation but also biological conservation techniques. For instance, in the summer season, afforestation and reforestation of both indigenous and exotic trees are the main issues of the people. Similarly, farmers have different measures of soil and water conservation mechanisms like contour plough, fallowing, green manure, mulching, and strip cropping (to some extent) and planting of different types of grasses at every border of their farm land. Other studies have also found that ecological restoration includes a wide scope of projects including erosion control, reforestation, removal of nonnative species and weeds, re-vegetation of disturbed areas, reintroduction of native species, and habitat and range improvement for targeted species (Dobson *etal*, 1997). The main factors that decline the diversity of the plant species were deforestation, overgrazing, farmland expansion, building construction and selling of wood and charcoal for economic purposes. A similar result was reported by EFAP (1994) and Feoli *etal* (2002), that shows the leading cause of forest and vegetation destruction include expansion of agricultural land, increasing demand for

construction, fuel wood, charcoal, and economic dependence of rural households on forest and its product. Having understood those negative human interventions, peoples of the study area have decided to struggle against them. As a result, all young and old peoples have protected and prevented their land as a rule. Then after the area, both primary and secondary successions take place and number of plant species increases continuously.

4.9 Farmers' response to the role of soil and water conservation beside plant species diversity increment

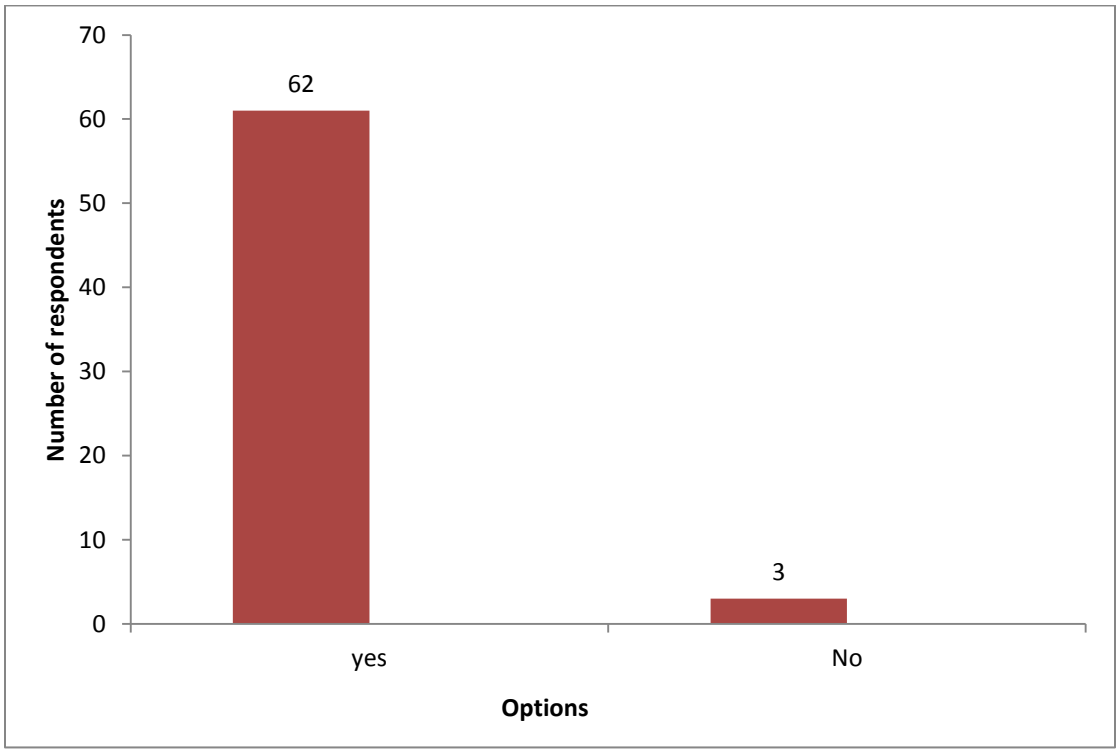

Figure 4: Farmers' response to the role of soil and water conservation beside of plant species diversity increment

As Figure 4 shows, 62 (95.38) of the respondents reflect that soil and water conservation has another role beside of the plant species increment. According to their explication, elements of the natural environment cannot exist unless they cooperate with each other. Because of soil and water conservation, the duration, volume, and areal coverage of rain fall became moderate. In addition to this, due to the prevention of soil erosion, the level of ground water and moisture of the land increased. Therefore, the area is conducive for the survival of living organisms starting

from small to the larger plants and animals. The presence of small animals like decomposers and other animals refers to the presence of diversity. For instance, there are herbivores and carnivores organisms like apes, monkeys, foxes, rats, rabbits, buffalos that depend on plant species to survive. Other reports have also suggested that local approaches to natural resources management are well suited to complex and dynamic environments (Reij *etal*., 1996). Generally, soil and water conservation have vital role in the complete and successful recycling of nature beside to the development of plant species.

4.10 Farmers' response to farmers' economic benefit from soil and water conservation

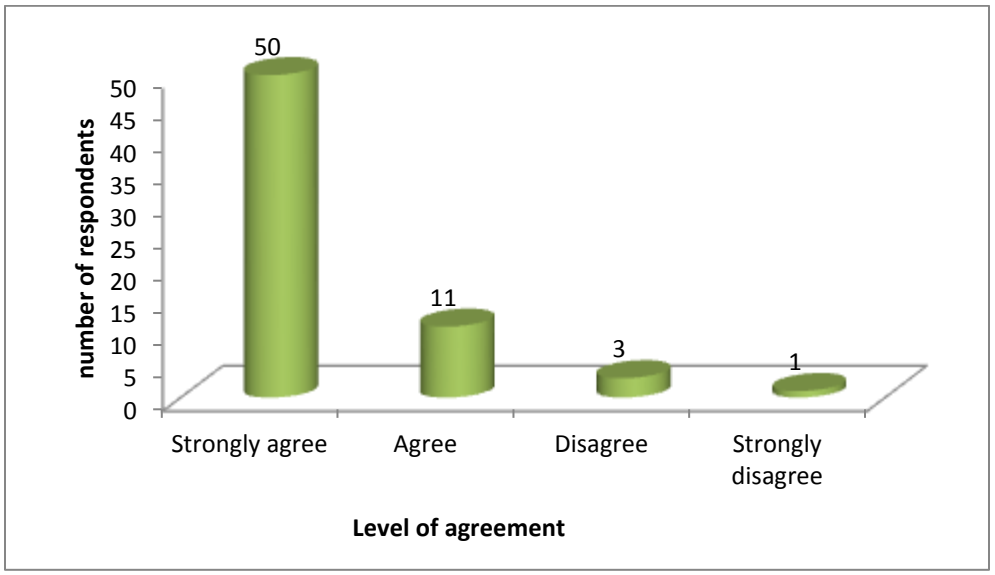

Figure 5: Farmers' response to the farmer's economic benefit from soil and water conservation

According to Figure 5, most of the respondents agreed that farmers were beneficiary from soil and water conservation practices. Concerning to this they revealed since they live depending on agriculture, soil and water conservation is alternative less for the crop productivity increment as well as livestock reproduction. When plant species diversity increases due to soil and water conservation, directly the plants became source of food, medicine, pure air for animals, construction materials, and fuel. And also, they are important for economic profits like selling woods and honey production. In similar way, after the farmlands of the peasants were conserved properly, yield of the common crops like *Eragrostis Tef, Zea maize, Triticum spp, Hordeum*

volgare, *Surghum bicolar* and other pulses has been maximized from time to time. To some extent again, the area has become suitable for irrigation. Thus, farmers produce potato, onion, tomato, garlic, pepper, cabbage, salad and other gardens like *Rhamnus prinoides* (gesho), *Coffea arabica* and others. Hence, the hand to mouth tradition is changed and they begin to supply products to the market. In consistent with this, earlier study has been proposed that conservation and forest restoration seek to bring greater social and economic benefits to local community (Allen *etal*, 2001). Yohannes (1989) also postulated that when the barley yields above and below the bund is compared, yield above the bund is 1650 kg/ha which is 43% higher than below the bund. Therefore, this assured that conservation of natural resources is still the base for life on the earth economically.

Table 7: Farmers' response to the importance of SWC on keeping both human and animal

Level of agreement	Frequency	Percentage
strongly agree	9	13.85
Agree	53	81.53
Undecided	3	4.62
Disagree	0	0

The finding in table 6 reveals that, soil and water conservation has a positive impact on keeping the health of human and animal together. Regarding to this, farmers were asked to respond on how SWC is important to keep animal and human health in open ended question way. Almost all the respondents explain that the health of the society is dependent on the constituents of the land. Because to cure from diseases the majority of the people in rural areas use the cultural drugs obtained from the land instead of going to clinics and hospitals. Therefore due to soil and water

conservation activities, different medicinal plants like *Thymus serrulatus, Withania somnifera, Datura stramonium, Aloe megalacantha*, *Cucumis dipsaceusehrenb*, *Eucalyptus globulus* and *Nicotiano glauca* are available in the area and they are mostly needed species of plants for drug preparation for both animals and human.

To summarize, when the respondents gave an idea regarding soil and water conservation, they inform that before 1980s many plant species were on the way of extinction because of lack of soil and water conservation. The area was changed in to rocky and there was gully erosion, there was nutrient depletion, there was unwise use of natural resources. Consequently, famine and drought were resulted. This relates to the finding of (MEA, 2003) which underlined that changes in ecosystem services affect human wellbeing through impacts on security, the basic material for a good life, healthy, social and cultural relations. But recently, due to the well-organized soil and water conservation practices, land scape of the area is mostly converted in to green. The recovery of natural resources on the area is leading to have wide ranging ecosystem. This is happened because of conservation, protection and restoration of habitat areas for wild plants and animals especially conservation of reliant species and prevent their fragmentation or reduction in range. Generally, soil and water conservation embraces a broad range of concerns in what is known as multiple use management including the provision of timber, fuel wood, wild life habitat, natural water quality management, recreation, land scape and community protection employment, aesthetically appealing land scape, biodiversity management, water shed management, erosion control and preventing forests as sinks for atmospheric carbon dioxide. Similar with this result other studies also stated that comprising of trees and grasses could offer benefits like timber production, carbon di oxide sequestration, aesthetics (Borine *etal*, 2010), increasing the biodiversity of flora and fauna and providing habitat for wild life (Lovell and Sullivan, 2006).

Table 8: The general numerical data obtained from questionnaire

Questionnaire Items			Selected sites				
			Awleat	Biera	A/kelebes	Total	%
Soil and water conservation repeatedly take place in	Frequency	Plain	0	1	0	1	1.54
		Mountain & slop	17	22	19	58	89.23
		River	2	1	3	6	9.23
There is difference between conserved and non-conserved areas	Frequency	Yes	19	24	21	64	98.46
		No	0	0	1	1	1.54
The importance of SWC on increasing plant species diversity	Frequency	High	13	19	19	51	78.46
		Medium	5	2	2	9	13.85
		Low	1	1	0	2	3.08
		Undecided	0	2	1	3	4.61
SWC has another role beside to increase plant species diversity	Frequency	Yes	17	23	22	62	95.38
		No	2	1	0	3	4.62
The society is beneficiary from soil and water conservation economically	Frequency	Strongly agree	13	19	18	50	76.92
		Agree	5	3	3	11	16.92
		Disagree	1	2	0	3	4.62
		Strongly disagree	0	0	1	1	1.54
SWC has importance on keeping the health of both human and animals	Frequency	Strongly agree	3	6	0	9	13.85
		Agree	14	17	22	53	81.54
		Undecided	2	1	0	3	4.61
		Disagree	0	0	0	0	0

4.11: Interview

The research findings were further augmented by semi structured interviews carried out with elder peoples who remember the feature of the study area before and after the implementation of soil and water conservation and the *Kebelle* agricultural expert. The following tables show the name of the slop, the river and the plain areas of the villages with their conservation year and their feature before SWC.

Table 9: The slop areas of the villages, year of conservation and their feature before SWC

No	Name of the slop area	Year of SWC	Feature of the land before SWC
1	Himhamo	1984	It was eroded, topsoil was washed away, and there were few plant species like *Hypoestee farskaolii*.
2	Dakalo	1985	It was eroded, topsoil was washed away, and there were few plant species like *A.megalacantha* & Elala grass
3	Liani	1989	There was fast flood running, and has few plants like *B. grandifolium*
4	Adedna	1997	Rocky, eroded, and there were few plants like Sisal, and *H.farskaolii*
5	Endatara	1998	Rocky, eroded, and there were few plants like *B.grandifolium, R.nervosus* and *A.megalacantha*
6	Mengedha	2002	Rocky, eroded, there was fast flood running and there were few plants like *H.farskaolii* and *A.megalacantha*
7	Kasahity	Not conserved	Still now, it is too dry and eroded, there is only one type of plant called Elala grass
8	Graamdi	Not conserved	it is too dry and eroded, there is fast flooding, there are plants like *B. grandifolium* & *A. megalacantha*
9	Laelay Adi	Not conserved	It is dry and it has few and weak plants like *R. nervosus* & *H. farskaolii*

Table 10: The river areas of the villages, year of conservation and their feature before SWC

No	Name of the river	Year of SWC	Feature of the land before SWC
1	Liani	1995	Deep gully, eroded, no plants
2	Enda Mariam	1997	Highly eroded, dry, deep gully, no plants Except some grasses
3	Mai messanu	1997,2009	Wide & deep gully, dry, grass
4	Laelay golgol	1999	Wide & deep gully, dry, grass
5	Elamadaro	2008	Eroded, sandy, dry, no plants

Table 11: The plain areas of the villages, year of conservation and their feature before SWC

No	Name of the plain land	Year of SWC	Feature of the land before SWC
1	Enda tsebeleity	2005	Too dry, has few plants like *Olea europaea, Juniperus procera* and *Sida schimperiana*
2	Meshal	2008	Dry and highly degraded land, some plants like *B. grandifolium* & grass

In an interview, the selected key informants have been remembered that the slope, river and plain areas had poor plant species before the time of soil and water conservation. Almost the whole landscapes were changed in to dry and degraded state since 1977E.c because of severe drought, over cultivation, overgrazing, cutting trees for construction, for firewood and charcoal and other complex problems. For instance, in most of the slope areas, there were few types of plants like *Hypoestes farskaolii*, *Sida schimperiana*, *Aloe megalacantha*, *Bacium grandifolium* and *Rumex nervosus* with their very small coverage. Similarly, in the river areas, deep gullies were formed due to the fast running of flood from slope land. The grassy plain area was also converted in to dry, sandy and degraded land. Subsequently, both human and animals were exposed to famine because of lack of plants that are important for soil fertility, soil erosion control and sources of food. As a result of that harsh condition miracle plants like *Euclea rasemosa*.Murr (Kuliow) which was the source of food and medicine was totally extinct from the surrounding and residents sincerely they feel sad. This is related to the study of Ethiopian farmers' attitude to land degradation and conservation by Yeraswork Admassie (1985) that indicates farmers were aware and appreciate the problem of land degradation.

4.12: Observation

4.12.1 The Common Methods of soil and water conservation in

Kebelle Saesie (Awleat, Biera and Addikelebes)

4.12.1.1 Hillside terrace

According to the data gathered through interview and observation; in *Kebelle Saesie*, hillside terracing is mostly applied in the slope land in order to leveled for tree planting and prevent damage from flooding below steep slopes. Hillside terraces are up to 1m wide and constructed at about 2-5m vertical intervals. This method helps to retain run off and sediment on steep slope and to accommodate the seedlings planted on them. They are also effective for conserving water on badlands and in areas with low rain fall. Most of the time line levels, digging instruments and stones are important materials used for construction. (See index 4)

4.12.1.2 Hillside terrace and trenches

This technique is also used to level the slop land for tree planting and prevent damage from flooding similarly with hillside terraces. The difference is the digging of trench that collects water. Hillside terraces with trench are important to protect run off and sediment on steep slope land. In addition to this, it helps to collect water for the proper growth of tree seedlings. Line levels, digging instrument, stones, measuring instruments like meter are important to construct this type of SWC method.

Figure 6: Hillside terraces & trenches in *Awleat*

Source: Field survey

4.12.1.3 Permeable rock dams

In *Kebelle Saesie*, the permeable rock dam is a technique constructed in gullies by using stones and sometimes rain forced with gabions. A filtering layer is laid in a foundation trench. Next layers of a medium and large sized stone lay on top. Based on the agricultural expert reflection, they are between 0.50 & 3.50 meters high, and the width of the foundation and the crest depends

on the volume of water flow. The structure built across the gully is extended to the sides with the construction of wing walls. The dam can be constructed with or without a spill way. As spill way is required when water flow is stronger. Check dams can be easily applied in all gullies less than 4m deep and 5m wide larger or steep gullies in normal standard and require more attention and careful design for treatment. For this method construction, large boulders, Gabions, line level, measuring instruments, digging materials, grasses and trees for re- vegetation are important for the construction of check dams.

Generally, in *Kebelle Saesie* check dams prevent the widening and deepening of a gully and help to fill it up with sediment. They reduce the velocity of run-off water in the gully. The potential energy is absorbed below the vertical drops of the over all. Sediments are deposited behind the check dams so that the slop gradient of the gully is also reduced.

Figure 7: Check dam in *Awleat*

Source: Field survey

4.12.1.4 Small scale dams

According to the data collected through interview and observation small scale dams constructed in *Kebelle Saesie* are moderately sized barriers built across valley bottoms to retain water from permanent water courses or seasonal flow. In normal standard the range in length is from 15 to 25m, and the wall 2 and 4 m high. But in *Kebelle Saesie* due to narrow size of gullies, most of the dams' length is from 7 to 15m. Small scale dams impound permanent or seasonal water behind them. They are built with buttresses & stilling basin. Most of the time, the dam wall is made of quarry stone jointed with mortar or concrete and cement. The effect on the water table depends on the depth at which the dam is attached. The deeper the foundation, the more water is retained. The small scale dams create water reserves. When there is no enough rain, the dam retains enough water for crops and other plants throughout their growth time. In the rainy season, the dams also regulate the flow of water. As a result, they prevent the damage of the land due to the heavy flooding and drought. In addition to this, they have good economic value due to irrigational practices in the *Kebelle*. In general, this SWC method has both social and environmental significance.

Figure 8: Small scale dam in *Biera*

Source: Field survey

4.12.1.5 Hand-dug trenches

Depending on the data obtained from *Kebelle Saesie* agricultural expert, this method involves manually excavating trenches 3 to 3.5m long and 0.6m deep, spaced 4m apart in staggered rows normally. But if it is deep trench, its depth reaches up to 1m. The excavated earth is piled downhill of the trenches, which are aligned perpendicular to the slop. In the middle of each trench, a 0.4m high step is left on which the tree seedling is planted. This enables the tree to receive the water it needs from the trench where it collects. The main purpose of this technique is to restore tree cover and prevent water erosion on slops by reducing the flow of water that threatens land downstream. Trenches are good techniques to plant trees, particularly in dry places due to the water they collect. In *Kebelle Saesie* those techniques are mostly constructed in plain and slope areas and they assured the improvement of soil fertility and plant species in the area (See index 4).

4.12.1.6 Tree planting

According to the data obtained from *Kebelle* agricultural expert, tree planting is an activity of improving vegetative ground cover by reducing runoff water and erosion and producing wood. This technique supports other conservation activities when combined with them. In *Kebelle Saesie* Tree planting is usually carried out during the rainy season summer and by itself it is a soil and water conservation measure. Because, the tree roots stabilize the soil and the tree protects the ground from the impact of raindrops. In case minimal amount of soil may move through pitting. But the rest ground became stable and resistant against erosion. (See index 4)

4.12.1.7 Water harvesting

Water harvesting is another common method of soil and water conservation in *Kebelle Saesie* that collects and uses runoff water from various sources for farming and domestic use. In that case, the water is harvested from the ground and then taken where it is needed for farming and/or domestic use. According to the idea of interviewees, it increases production when rain fall is irregular and often not sufficient to satisfy the demand for crops and livestock of the area.

Figure 9: Water harvesting techniques in *Addikelebes*

Source: field survey

4.12.1.8 Grazing Controlled

According to the data collected based on interview and observation this SWC method is the wise utilization of grassland with livestock that protects the severe degradation of vegetation and soils. It also allows the grasses and trees to recover and retain on the land. At the same time, it provides a better animal fodder. In *Kebelle Saesie* the technique is continuous and rotational conditionally. At present, many grasslands of *Kebelle Saesie* are controlled from grazing. As a result, there is tangible enrichment of plants species and their structural quality (See index 4).

4.12.2 The conserved and non-conserved places of *Kebelle Saesie* (*Awleat, Biera* and *Addikelebes*)

4.12.2.1 Slope areas of the villages

According to the data collected via interview and field observation, the most known slope lands of *Kebelle Saesie* are; *Himhamo, Dakalo, Liani, Adedna, Endatara, Mengedha, Laelay Adi, Graamdi and Kasahity*. Before the time of soil and water conservation, their overall feature was rocky and highly degraded, there were no more plants except few species like *Aloe megalacantha, Rumex nervosus, Hypoestes farskaolii, Sida schimperiana and Echinops kebericho*. As a result, there was fast flood running and top soil was washed away. However after conservation starting from 1984E.c. by using the hillside terraces, soil erosion was highly reduced and most of the lands become rehabilitated. This is necessarily related to the finding of Arabi *etal* (2008) that indicates terraces reduce the length of the slope which reduces the peak runoff rate. Interestingly there is good increment of plant species there.

Table 12: Number of different plant species per unit area ($10m \times 10m = 100m^2$) and their average in four demarcated plots of each slope areas

Villages name (Got)	Land scape name	Land scape	Plots				Average
			A	B	C	D	
Awleat	Himhamo	Slope	9	12	6	13	10
Biera	Dakalo	Slope	8	11	7	9	9
Awleat	Liani	Slope	6	9	10	13	10
Awleat	Adedna	Slope	9	8	5	11	8
A/Kelebes	Endatara	Slope	15	4	9	11	10
Biera	Mengedha	Slope	8	3	7	6	6
Biera	Laelay Adi	Slope	5	4	8	6	6
Awleat	Graamdi	Slope	4	3	2	3	3
Awleat	Kasahity	Slope	2	1	1	3	2

As the above table indicates, still now there is a variation among the slope areas of *Kebelle Saesie* regarding to their plant species diversity. Out of the nine slope areas; the first six slopes are conserved and well protected, the next one *(Laelay Adi)* is conserved but not protected and the last two (*Graamdi & Kasahity)* are not conserved not protected slope areas. At present, from the four demarcated land trials of each conserved and protected areas, the researcher has obtained an average of maximum ten and minimum six species of plants per $100m^2$ space. The most common plants of the areas are; *Rhus retinorrhoea, Juniperus procera, Eucalyptus globulus, Grevillea robusta, Acacia abyssinica, Phytolacca dodecandra, Dodonia angustifolia, Bacium grandifolium, Gomphocarpus fruticosus, Argemone Mexicana L., Withania somnifera, Rumex nervosus, Aloe megalacantha, Mytenus arbiyufolia, Gomphocarpus purpurascens, Calpurnia aurea, Hypoestes farskaolii* and grasses . In addition to them, the area has very important plant called cactus which is the main source of food for many animals including human being. The other good aspect of those areas is all plant species are well developed in structure and they serve as source of food, medicine and shelter for both human and animals. That's why, arboreal animals like apes, monkeys, rabbit, rat, fox and other reptiles live there and the entire land is too attractive and remarkable. Therefore, the conservation and protection measures of natural resources are the ultimate reasons for plant species diversity increment due to succession and restoration of the area.

Himhamo slope land

Liani slope land

Dakalo slope land

Adedna slope land

Endatara slope land

Mengedha slope land

Figure 10: Conserved and protected slope lands of *Kebelle Saesie*

Source: field Survey

On the other hand, in the conserved but not protected slope land (*Laelay Adi*); inside $100m^2$ of four separately demarcated lands of the area, maximum of 6 and minimum 4 plant species were counted. The most obtainable plant species are; *Rumex nervosus, Juniperus procera, Aloe megalacantha and Sida schimperiana*. Therefore there is no good improvement of plant species there. Even the existed species are few in number and weak in structure. This is due to large herds of cattle arising from unwillingness of livestock owners and the fact that most of the extinct plants are not reversible. Other studies also proposed that overgrazing can leads to many negative impacts including decline in vegetation cover, biomass, species diversity and increase in undesirable vegetation. For example, grazing can destroy the structure and composition of the plant communities due to plant consumption and trampling caused by livestock (Kraaij and Milton, 2006). This shows us, soil and water conservation is not enough to increase plant species diversity as needed as possible unless the area is protected.

Even more again, *Kasahity* and *Graamdi* are the two not protected and not conserved slope lands in the study area. consequently those are on the way of severe degradation and erosion instead of restoration and reclamation. As an evidence, averagly from the four defined$100m^2$ sites of the slope areas two and three plant species were obtained respectively. Namely the plant species are *A. megalacantha, S.schimperiana*, *G.purpurascence* and one unnamed plant. The amazing point here is that Himhamo and Kasahity are the two adjasent slope areas in which the former has more plant species diversity due to soil and water conservation and protection whereas the later is still degraded and denuded because of lack of coservation and protection. Therefore the natural resources conservation and protection activities are trustworthy for plants species diversity enlargement.

Kasahity *Graamdi*

Figure 11: Not conserved and not protected slope lands of *Kebelle Saesie*

Source: field survey

4.12.2.2 River areas of the villages

4.12.2.2.1 *Maimessanu*

Maimessanu is the low land area of *Addikelebes* village. According to the data obtained through interview, before 1981E.c. it was a straight land and grassy. However, in 1982E.c. due to the heavy rain, it was highly eroded and it became deep gully up to 4m depth. Because of that reason, the area was changed in to dry and sandy land. In 1997E.c. the Catholic Church Institute has constructed the permeable rock dam rain forced with gabion to repair the eroded land. In addition to that, stone and cement check dam was constructed in 2002E.c. After those conservation techniques have done, the area hold water. From this, the data of the field observation indicates that, at present there are different plants that grow inside the water. Similarly, plants like *Rumex nervosus*, *Eucalyptus globulus*, *Nicotiano glauca*) and grasses grow in the border of the river and they extend their roots towards the water. And also the land is

treated from flooding and erosion. Generally, the land is on the way of returning to its former good feature because of conservation (See index 4).

4.12.2.2.2 *Endamariam*

Endamariam River is located in *Awleat* village. According the interview respondents information, since 1983E.c. it was too dry and highly eroded gully. Its depth was up to 5m. Depending on different points of view, the river was conserved in 1997E.c. by the help of Catholic Church Institute. From the beginning, the technique was gabion check dam and later on due to the shortage of gabion, the construction was completed with stone. Therefore the conservation mechanism is the mixture of the former gabion check dam and the later "shilat" check dam. At this time, the data of the observation shows that the river encompasses different plant species such as *Rumex nervosus, Ricinus communis, Bacium grandifolium, Grevillea robusia, Eucalyptus globulus, Chenopodium murale* L, and *N.glauca, D.angustifolia* and grasses. They have good structural complexity. On top of this, the flood running and soil erosion have been stopped and becomes green.

Figure 12: *Endamariam* River in *Awleat* village

Source: Field survey

4.12.2.2.3 *Laelay Golgol*

Laelay Golgol is the low land area in *Biera* village. From an interview, due to the fast running of flood from slope areas it was highly eroded in 1985E.c. and changed into deep gully. Its depth was 4m. Starting from the time of erosion, there were no plants except some grasses, it was too dry and sandy. For that reason it was conserved in 1999E.c. by using the permeable stone dam (Dereja dam). As a result the data collected through field observation shows that the area is covered with many plants like *Opuntiaficus indica, Rumex nervosus, Acacia abyssinica, Bacium grandifolium, C. murale, G. purpurascence, H. farskaolii and* other small grasses. Therefore, the soil and water conservation activities are the rudimentary solutions for the recovery of natural resources in general and the development of plant species diversity in particular.

Figure 13: ***Laelay Golgol*** **River in** ***Biera***

Source: field survey

4.12.2.2.4 *Elamadaro*

Elamadaro is the river in *Biera* village. According to the interview respondents, it was conserved in 2008E.c. Before the time of conservation, it was sandy, dry and degraded gully. But after the small scale check dam was constructed there, the river holds a lot of water. Interestingly, the surrounding area became wet and humid and various plant species were grown in the edge of the river. From part of the observation, some of the most important plants are *Juniperus procera, B. grandifolium, A. megalacantha, R. nervosus, Eucalyptus globulus, N. glauca, Merendra bengalensis* and other small watery plants. Totally, the entire area is on the way of covering with plants by the help of soil and water conservation.

Figure 14: *Elamadaro* River in *Biera*

Source: field survey

4.12.2.2.5 *Liani*

Liani is another low land area in *Addikelebes* village. The data from an interview indicates that before conservation, it was deep gully. During that time, the land was dry, rocky, eroded and no plants except *Aloe megalacantha* and *Calpurnia aurea*. However, after the "Dereja" type of

stone check dam was applied, moisture of the river and its boundary increases from time to time. As a result, the field observation shows that plants like; *Eucalyptus globulus, Juniperus procera, D.angustifolia, B.grandifolium, R.nervosus, A.abyssinica* Hochst.ex Benth, has been grown around the river. And also central part of the river is changed in to grassy. Now the total land scape of the area is stable, green and charming for observer (See index 4).

4.12.2.2.6 *Gerebgirhan*

Gerebgirhan River runs to the low land area in *Addikelebes* village. As the interviewees' reflection, in 1980s, it was narrow and deep gully and there were, *Aloe megalacantha and Juniperus procera* plants only around the river. Later on the river was conserved in 1997E.c. using the stone check dam. Now according to the field survey there are several kinds of plant species such as *A. abyssinica, A. megalacantha, Ferula communis, Bacium grandifolium, Argemone Mexicana, Dodonia angustifolia, Gomphocarpus fruticosus, Hypoestes farskaolii, Clutia abyssinica, and* Fern. Not only the river but also the two left and right sides of the river have giant trees called *Olea europaea, Juniperus procera, Rhus retinorrhoea* and *Euphorbia abyssinica.* Generally, the overall observation of the land assures it is free from flooding and converted in to remarkable forest land due to SWC practices.

Figure 15: *Gerebgirhan* River in *Addikelebes*

Source: field survey

4.12.2.3 The plain areas of the villages

According to the field observation, almost the only half part of village *Addikelebes* is plain area from the entire land of *Kebelle Saesie.* To the eastern direction it is named as *Enda tsebeleity* which is conserved and protected area and to the western side *Meshal* conserved but not protected side. The interviewees conveyed that both sides were degraded before the time of soil and water conservation.

Table 13: Number of different plant species per unit area (10m× 10m = 100m$^{2)}$ and their average in four demarcated plots of each plain area

Villages name	Landscape name	Land Scape	Plots				Average
			A	B	C	D	
Addikelebes	Enda tsebeleity	Plain	4	13	7	9	8
Addikelebes	Meshal	Plain	3	1	2	2	2

The result in the above table shows that, still now there is inordinate variation between the two areas concerning to their plant species. According to the field observation, because of soil and water conservation and protection, sheet erosion and fragile soil structures were reduced in the *Enda tsebeleity* plain area. The trees planted between and inside the trenches receive the water they need from the trenches where they collect. As a result the land has good aspects of plant species diversity. As an evidence, inside of the four 100m^2 measured lands, the maximum and minimum number of species are thirteen and four respectively and averagely there are eight (8) plant species per 100m^2. Commonly, in addition to *Olea europaea* and *Juniperus procera* the area is covered with plants like *Withania somnifera, Bacium grandifolium, Argemone mexicana, Opuntiaficus indica, Rumex nervosus, Rhus retinorrhoea, Aloe megalacantha, Mytenus arbutifolia, Hypoestes farskaolii, Gomphocarpus purpurascence,* and *Sida schimperiana*. Generally the dry appearance of the area is already transformed to the forest land. However because of overgrazing, there is no good increment of plant species in *Meshal*. Most probably, there are only two (2) plant species in 100m^2 of the land. Those plants are *Bacium grandifolium, Aloe megalacantha* and small grasses and their coverage is small. Similarly other studies were assured that the overall impact of overgrazing is negative particularly in grasslands (Koukoura *etal,* 1998). This indicates us plant species diversity cannot improve unless the area is protected as soon as possible.

Enda tsebeleity *Meshal*

Figure 16: Conserved & protected and conserved but not protected plain areas of *Kebelle Saesie*

Source: field survey

To summarize the finding of the observation; in conserved and protected areas, conserved but not protected areas, and not conserved not protected areas the maximum and minimum average of plant species in $100m^2$ Space is 10&6, 6&2 and 3&2 respectively.

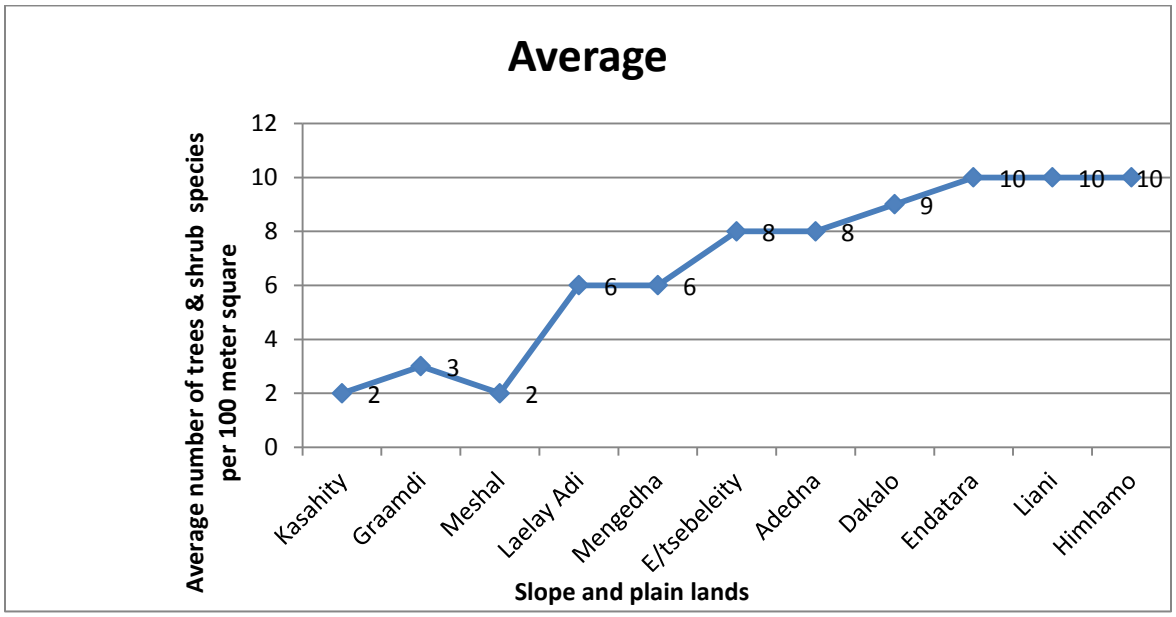

Figure 17: Average number of different plant species per unit area (10m × 10m = $100m^2$) of slope and plain lands

This needs an appreciation that in order to have advanced plant species in a given area, it is mandatory to conserve and protect the land.

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Generally, from the research conducted, it was concluded that soil and water conservation have a positive impact on plant species diversity increment. At present, almost the whole area of *Kebelle Saesie* is conserved using different conservation methods. The well-known mechanisms of conservation in the area are permeable rock dams and small-scale dams implemented in river lands, hillside terraces and terraces with trenches in slope area, hand dung trenches in plain area and contour plough in farmlands. In addition to these, people use controlled grazing, afforestation and reforestation mechanisms.

The result of this study showed that before soil and water conservations were practiced, the landscapes of *Kebelle Saesie* were highly degraded and worsened due to soil erosion. This promoted the government, NGOs and peoples of the locality to start working on soil and water conservation using different approaches and this has resulted in tangible recovery of natural vegetation and improvements of soil conditions. Specially, the plant species was enriched in both quantity and structural complexity. This in turn has created habitat for wildlife such as apes, monkeys, fox, and wild cat. Even more so the improved natural resource conditions of the conserved area helped in improving the livelihoods of the local community through expansion of irrigation, honey production and improved crop yield.

On the other hand, in this study there is another finding that assures the lack of soil and water conservation coverage in some areas. In *KebelleSaesie*, still now the areas like *Graamdi* and *Kasahity* do not get the chance to be conserved and there are areas like *Meshal* and *Laelay Adi* conserved but not protected. The actual images of those areas reflect severe erosion and degradation instead of rehabilitation. This outcome indicates that development of plant species diversity is unthinkable without conservation and protection of the entire land.

To summarize, preponderantly the implementation of soil and water conservation in *Saesie kebelle* enhance the capacity of the land to provide key ecosystem services in a way of reducing

nutrient deterioration of the soil and successively recuperate the growth of different plant species needed for food, medicine, shelter and shelter construction for human and animals.

5.2 Recommendations

- ✓ Based on the result of this study, highly degraded areas were identified in non-conserved and conserved but not protected areas. In these areas, increment of plant species diversity is very poor. For this, I recommend that these areas should be prioritized in the implementation of soil and water conservation measures. Besides, residents of the locality should tackle against the environment destructive phenomena like deforestation, overgrazing, farmland expansion and excessive selling of wood and charcoal. Those interrelated activities would reduce soil erosion and accumulate essential nutrients for the growth of various species of plants.
- ✓ From the informal discussion, key informants said concerned organizations and governmental bodies involved in soil and water conservation should shift emphasis to give greater attention in conserving water and soils before the land lost all the fertile soil rather than targeting land that has been already exhausted and degraded.
- ✓ The present study clearly discussed that, SWC structures should be implemented and maintained on less fertile and steep slope areas by giving primary focus rather than fertile lands. Because those areas are most likely exposed to severe degradation and highly affect the rest landscapes.
- ✓ Finally, I recommend that further study should be conducted to improve the development of plant species through SWC practices. The research should also identify new conservation techniques of soil and water that can go with the topography of the area and could be implemented by the capacity of the society.

CHAPTER SIX

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Appendices

Index 1

ADDIS ABABA UNIVERSITY

Collage of natural and computational science

Department of Zoological sciences

Questionnaire to be filled by peasants of kebelle Saesie

The main purpose of this questionnaire is to collect valid and reliable data on the impact of soil and water conservation on plant species diversity at the selected villages of kebelle Saesie eastern zone of Tigray region. Thus your genuine response will help the researcher to provide reliable and valuable suggestions and recommendations. Your response will be used only for academic purpose. I would like to express my appreciation in advance for your time and consideration

General directions

1. No need of writing your name

2. Mark (✓) in the box of your alternative answer(s)

3. Please give answers to each close ended item as appropriate as possible

4. Please give your short and precise responses to the open ended questions

5. Your participation is voluntary based

Section one: Back ground information

1. Name of the kebelle:_____ village:_____

2. Sex: Male ☐ Female

3. Age: ≤18 ☐ 19-55 ☐ ≥56 ☐

4. Educational level: -Below certificate ☐

-Certificate ☐

-Diploma ☐

-Degree ☐

Section two: Questions related to the impact of soil and water conservation on plant species diversity

1. In which part of your locality was the soil and water conservation taking place repeatedly?

A. Plain area C. Mountains and slopes

B. River

Please, justify your response

_____

_____

2. What is the overall goal of soil and water conservation?_____

_____

3. Is there any difference in your area before and after the soil and water conservation is implemented?

A. Yes ☐ B. No ☐

4.If your answer is" yes" in what aspect is the change?_____

_____

5. The Soil and water conservation role in the plant species diversity increment is

A. High ☐ B. Medium ☐ C. Low ☐ D. Undecided ☐

6. If your answer is high or medium what type of plants did the area has after soil and water conservation?

_____

_____

7. What mechanisms do you use to increase plant species diversity in addition to soil and water conservation?

_____

_____

8. Do you think soil and water conservation has a role beside to the plant species diversity increment?

A. Yes ☐ B. No ☐

9.If your answer is" yes" explain it_____

_____

10. The farmers of your locality are beneficiary from soil and water conservation practices economically.

A. strongly agree ☐ B. Agree ☐ C. Disagree ☐ D. strongly disagree ☐

11. If your answer is" strongly agree" or" agree" explain the values of soil and water conservation._____

_____

12. Does soil and water conservation has importance on keeping health of both human and animals of an area?

A. Strongly agree ☐ B. Agree ☐ C. Undecided ☐ D. Disagree ☐

13. If your answer strongly agree or agree how?

_____

_____

ኣዲስ ኣበባ ዩኒቨርሲቲ

ኮሌጅ ተፈጥሮ ሳይንስ

ዲፓትመንት ዙኦሎጂካል ሳይንስ

ብሓረስቶት ጣብያ ሳዕሲዕ ዝምላእ ናይ ፅሑፍ መሕተት

ቀንዲ ዕላማ ናይዚ ናይ ፅሑፍ መሕተት ኣብ ጣብያ ሳዕሲዕ ቁሸት ዓድቀለበስን ብዔራን ዝካየድ ማይን ሓመድን ዕቀባ ኣብ ናይ ተኽልታት ዓሌት ምውሳኽ ዘለዎ ኣስተዋፅኦ ዝገልፅ ሓቃዊ መረዳእታ ንምእካብ እዩ ስለዚ ነዚ ተረዲእኩም ንትህብዎ ትክክለኛ ምላሽ ኣቀዲመ እናመስገንኩ ንዑኡ መሰረት ተገይሩ ዘተኣማምንን ጠቃምን ሓሳብን ምክርን ንምውሃብ ክክኣል እዩ ስለዚ እትህብዎ ናይ ፅሑፍ ሓሳብ ንትምህርቲ ጥራሕ ኮይኑ ንምትሕብባርኩም ደጊመ ከመስግነኩም እደሊ

<u>ሓፈሻዊ መምርሒታት</u>

1 ሽም ምፅሓፍ ኣየድልን
2 ኣብ መልሲ መውሃቢ ሳንዱቅ (✓) ምልክት ተጠቂምካ መልስ
3 ንሕድሕድ መብራህርሂ ዝደሊ ሕቶ ክንድዝከኣል ግቡእ መልሲ ሃብ/ቢ
4 መልስካኻ ሓፂርን ንፁርን ክኸውን ኣለዎ

መልሲ እንትትህብ ብነፃነት ክኸውን ኣለዎ

ክፍሊ ሓደ; ሓበሬታ ደሕረባይታ

1 ሽም ጣብያ:_____ ሽም ቁሸት:_____

2 ፆታ: ተባ [ ] ,ኣ [ ]

3 ዕድመ; ≤18 [ ] 19-55 [ ] ≥56 [ ]

4 ደረጃ: ትምህርቲ ትሕቲ ሰርቲፊኬት [ ]

ሰርቲፊኬት [ ]

ዲፕሎማ [ ]

ዲግሪ [ ]

ክፈሊ ክልተ; ሓመድን ማይን ዕቀባ ኣብ ናይ ተኽልታት ዓሌት ምዕባይ ንዘለዎ ኣስተዋፅኦ ዘድሃቡ ሕቶታት

1. ማይን ሓመድን ዕቀባ ብተደጋጋሚ ዝስራሕ ኣበየናይ ቦታ እዩ?

ሀ/ ሜዳ [ ] ሩባ ሐ/ [ ]ን ቁልቁለት ዝበዝሑ ቦታን መ/ ኣብ ከ[ ] [ ]

መልስኹም ኣብራህርህዎ

_____

_____

2. ሓፈሻዊ ዕላማ ናይዚ ማይን ሓመድን ዕቀባ እንታይ እዩ?

_____
_____
_____

3. ኣብዚ ቦታ እዚ ቅድመን ድሕረን ማይን ሓመድን ዕቀባ ምስራሑ ዝርአ ኣፈላላይ ኣሎ ዶ?

ሀ/ እወ ☐ ለ/ የለን ☐

4. መልስኹም እወ እንተኾይኑ እቲ ኣፈላላይ ብመዳይ እንታይ እዩ?

_____
_____
_____

5.ማይን ሓመድን ዕቀባ ናይ ተኽልታት ቁፅሪ ዓሌት ኣብ ምውሳኽ ዘለዎ ግደ

ሀ/ ልዑል ☐ ለ/ ማእኸላይ ☐ ትሑት ☐ መ/ ኣይውሰንን ☐

6. መልስኹም ልዑል ወይ ማእኸላይ እንተኾይኑ ድሕሪ ማይን ሓመድን ዕቀባ ኣብቲ ቦታ እነታይ ዓይነት ተኽልታት ኣለዉ?

_____
_____
_____

7. ካብ ማይን ሓመድን ዕቀባ ብተወሳኺ ናይ ተኽልታት ዓሌት ንምውሳኽ እንታይ ሜላ ትጥቀሙ?

_____
_____
_____

8.ማይን ሓመድን ዕቀባ ካብ ናይ ተኽልታት ዓሌት ምውሳኽ ብተወሳኺ ካልእ ረብሓ ኣለዎ ዶ ትብሉ?

ሀ/ እወ ☐ / የብሉን ☐

9. መልስኹም እወ እንተኾይኑ ኣብራህርህዎ

_____
_____
_____

10. ናይ ከባቢኹም ሕብረተሰብ ብናይ ማይን ሓመድን ዕቀባ ተጠቃሚ እዩ

ሀ/ ብጣዕሚ እስማዕማዕ ☐ ለ/ እስማዕማዕ ☐ ሐ/ ኣይስማዕማዕን ☐ / ብጣዕሚ ኣይስማዕማዕን ☐

11. መልስኹም ብጣዕሚ እስማዕማዕ ወይ እስማዕማዕ እንተኾይኑ እቶም ረብሓታት ግለፅዎም

_____
_____
_____

12. ማይን ሓመድን ዕቀባ ኣብ ጥዕና ደቂ ሰባትን እንስሳትን ምሕላውረብሓ ኣለዎ ዶ ?

ሀ/ ብጣዕሚ እስማዕማዕ ☐ እስማዕማዕ ሐ/ ☐ ዮስንን መ/ ኣይ☐ማዕን ☐

13. መልስኹም ብ/ እስማዕማዕ ወይ እስማዕማዕ እንተኾይኑ ብኸመይ?

_____
_____
_____

Index 2

Interview questions

Table 1: slope areas of the villages

No	Name of the slop area	Year of SWC	Feature of the land before SWC
1	Himhamo		
2	Dakalo		
3	Liani		
4	Adedna		
5	Endatara		
6	Mengedha		
7	Kasahity		
8	Graamdi		
9	Laelay Adi		

Table 2: The river area of the villages

No	Name of the river	Year of SWC	Feature of the land before SWC
1	Liani		
2	Enda Mariam		
3	Mai messanu		
4	Laelay golgol		
5	Elamadaro		

Table 3: the plain areas of the villages

No	Name of the plain land	Year of SWC	Feature of the land before SWC
1	Enda tsebeleity		
2	Meshal		

Index 3

Data from Observation

Number of plant species per unit area (100 m^2) and their average in four demarcated Plots (slope and plain areas only)

Land	Landscape	Plots				Average
		A	B	C	D	
Himhamo	Slope	9	12	6	13	10
Dakalo	Slope	8	11	7	9	9
Liani	Slope	6	9	10	13	10
Adedna	Slope	9	8	5	11	8
Endatara	Slope	15	4	9	11	10
Mengedha	Slope	8	3	7	6	6
Enda tsebeleity	Plain	4	13	7	9	8
Laelay Adi	Slope	5	4	8	6	6
Meshal	Plain	3	1	2	2	2
Kasahity	Slope	2	1	1	3	2
Graamdi	Slope	4	3	2	3	3

Index 4 (Photographs of Kebelle Saesie lands)

Grazing controlled area in Kebelle Saesie

Holes prepared for tree planting during this rainy season

Hand-dug trenches Method of SWC in Kebelle Saesie

Hillside terracing Method of SWC in Kebelle Saesie

Maimessanu River in Kebelle Saesie

Liani River in Kebelle Saesie

Laelay Adi (Conserved but not protected slope land of Kebelle Saesie)