



**ADDIS ABABA UNIVERSITY
COLLEGE OF DEVELOPMENT STUDIES
CENTER FOR ENVIRONMENT AND SUSTAINABLE
DEVELOPMENT**

**ASSESSMENT OF SOIL EROSION AND ITS EFFECTS ON
AGRICULTURAL PRODUCTIVITY:
THE CASE OF MACHACKEL WOREDA, EAST GOJJAM ZONE,
ETHIOPIA**

**BY
MULUALEM MOLLA**

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Abstract

Soil Erosion has been a serious problem in Ethiopia and Its impediment on economic development persists more than three decades. This thesis studies to quantify the impact of soil erosion on crop yields using the results of a Machakel woreda, East Gojjam Zone Ketech watershed catchment. The research is to assess the extent of soil erosion and its effect on agricultural productivity, the perception and knowledge of people on soil erosion and gully. Both qualitative and quantitative data were collected. Quantitative data was collected from satellite images and household surveying and qualitative data collected from focus group discussion, key informant interview, and field observation. Descriptive, inferential, and econometric were employed for quantitative analysis while description, narration and content analysis were engaged for qualitative analysis. The findings of the study deal with the amount of average annual soil loss by using the RUSLE model used in Arc GIS images converted to quantitatively measurement of Ketech watershed $612,561.3 \text{ t. yr}^{-1}$. In the study of the gully erosion, AGERTIM (assessment of gully erosion rates through interview and measurement) has been developed. It comprises physical field measurement of the current volume and monitoring semi-structured interview techniques: womberet, Ketech, shembeqogelebet (a) and (b):Womberet, gully started around 1979, gradual change from cropland which started from fox digging small holes and grew into gully which increases rapidly and the average gully erosion rate in 33 years was found to be $168,921 \text{ m}^2/\text{yr}$, the amount of soil loss.,Ketech gully incision in 1984, small rill canals to grown gully through farming practice formulates in two adjacent croplands average gully volume erosion rates in 29 years was $9093 \text{ m}^2/\text{yr}$, the total soil loss estimated and the total soil loss of the other two-volume of gully erosion rate is estimated to be $3,500 \text{ m}^2/\text{yr}$. The perception of farmers to pertain the vulnerability of livelihood to consider food security faces to challenge soil erosion demarcates different reasons through the nature of demographic, level socio-economic, institutional and topographic factors significantly related with soil erosion was established determinants (sex, education, landholding size, experience, access to training, credit access, soil conservation, and extension service and family size) logit statistically significant association of analysis variables employed to determine for farmers' perception showed that landholding size, condition of education and farmers experience were significant factors of determining farmers' perception of soil erosion in the study area. To explain in the Agro-ecological zone, high land areas assure to field observation sever rill erosion, sheet and gully erosion comparatively aggravate in high land areas, high rainfall/high run-off and steep slope ($>0.5\%$) down-land based on the nature of soil type is luvisols of high possibility of eroded(0.35), its severity increase from time to time. so, community integrated participation soil conservation practice is the priority concern.

Key words: soil erosion, gully erosion, agricultural production, RUSLE, GIS, soil water conservation.

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Acronyms

ANRS	Amhara National Regional States
CRGE	Climate Resilience Green Economy
CSA	Central Statistics Agency
DA	Development Agents
DEM	Digital Elevation Model
DPSIR	Drive Pressure State Impact Response
DRR	Disaster Risk Reduction
FAO	Food and Agriculture Organization
FDRE	Federal Democratic Republic of Ethiopia
FGD	Focus Group Discussion
FSS	Food Security Strategy
GDP	Gross Domestic Product
GIS	Geographical Information System
GLASOD	Global Assessment of Soil Degradation
GPS	Geographical positioning system
GTP	Development and Transformation Plan
HH	House Hold
IFPRI	International Food Policy Research Institutes
ILM	International Land Management
IUSS	International Union of Soil Sciences
LDN	Land Degradation Neutrality
LULC	Land use and land cover
MoA	Ministry of Agriculture
MoFED	Ministry of Finance and Economic Development
MWAO	Machakel Woreda Agriculture office

MWRHH Machakel woreda rural households
NGOs Nongovernment Organizations
ONRS Oromo National Regional States
PASDEP Plan for Accelerated and Sustainable Development to end S poverty
PSNP Productive Safety Net Program
RDPS Rural Development Policy and Strategy
RS Remote Sensing
SLM Sustainable land management
SNNPRS Nation Nationality Peoples Regional States
SPSS Statistical package for social sciences
SWC Soil and Water Conservation
UN United Nations
UNCCD United Nations Convention to Combat Desertification
UNEP United Nations Environment Program
USLE: Universal soil loss equation and guess estimates
WEPP Water Erosion Prediction Project
WFP World Food Program
WMO World Meteorological Organization
WOCAT World Overview of conservation Approach and Technology

1. INTRODUCTION

1.1 Background of the study

Soil erosion is a main global problem for the 20th century and international agenda for the 21st century (IUSS, 1999). Ethiopia has provided a means of livelihoods for the majority of the population agricultural land; Soil erosion is greatest on cultivated land where average annual soil loss was 42 t/ha/yr.(Hurni, 1990). Soil erosion or in any other forms, to the soil is an indirect damage to agricultural production and ultimately food security. Crop emergence, growth and yield are directly affected through the loss of natural nutrients. In most developing countries, especially Sub-Saharan Africa 60-70% of the population in the rural areas depends on agriculture to earn a livelihood (Loulseged & McCartney, 2000).In Ethiopia 85% of the population lives in rural areas and they depend on agriculture to earn a livelihood (Düvel, Chiche & Steyn, 2003). The major causes of land degradation in Ethiopia are rapid population increase, deforestation, low vegetation cover and unbalanced crop and livestock production (Girma,2001).Topography, soil types and agro-ecological parameters are also additional factors playing significant role in the degradation processes influenced by man (Paulos 2001). The major driving forces for gully erosions are high population growth, lack of vegetation cover, overgrazing, intensive and short period rainfall, improper land use cultivation steep slopes, wrong diverting ditch, and soil characteristics (Jahantigh and Pessarakli 2011; Tamene and Vlek 2008).

Gully erosion is an environmental problem throughout the world. And its effect on soil, land functions and sediments (Ionita et al. 2015).Gully erosion is the most serious form of land degradation process and accounts for 56% of the degraded soils in the world (Sohan and Lal, Elirehema, 2001).its estimated 10 million ha of cropland worldwide is abandoned every year because of problems associated with soil erosion alone (Pimentel, 2000).Gully erosion is a highly visible form of soil erosion that affects soil productivity, restricts land use and can threaten roads, fences and buildings (Nyssen et al. 2004; Avni 2005; Carey 2006). It is the most prevalent type of water erosion in Ethiopia and it dissects the fields, impedes the tillage operations, damaging agriculture, residential area and restricts free movement of animals and human beings in different parts of the country (Daba et al. 2003; Woldeamlak and Sterk 2003; Awdenegest and Holden 2008). Gully erosion causes extensive socioeconomic and environmental impacts, and most of them are negative (Valentin et al. 2005; Marzolff et al. 2011). (Zgłobickiet al.2015) Gully erosion also decreases agricultural land, farm

productivity/crop yields and grazing land. Also gully-based valley sediment yield accounted for 10 to 94 % of the total watershed sediment yield (Poesen et al. 2003).

Rates of soil erosion are still very high on cropland, erosion rates have been significantly reduced in several areas of the world in recent decades. The reduction of erosion rates on cropland in the United States. Average water erosion rates on cropland were reduced from 10.8 to 7.4 t ha⁻¹ yr⁻¹ between 1982 and 2007. In a study conducted near the end of the 20th century (Pimentel et al.,1995) estimated that approximately one-third of the world's agricultural lands had been lost done to erosion in the previous 50 years, with about 1.0 × 10⁶ ha of additional agricultural land lost annually as a consequence of accelerated soil erosion. Soil losses to erosion were estimated as 17 Mg ha⁻¹ year⁻¹ in the United States and Europe and 35 Mg ha⁻¹ year⁻¹ in Asia, Africa, and South America (Pimentel et al., 1995).The fear of soil erosion, especially the associated removal of the most fertile soil layer as a prelude to mass starvation has been revised lately.

The 13% increase in production rates for the most common crops between 2001 and 2012, due to technological improvements, more rigorous land management and an increased use of fertilizer, might have masked the ongoing degradation of soils and their ecosystem service delivery capacity. Feeding Earth's growing population with increasing dietary preferences towards livestock products is undoubtedly enhancing the pressure on fertile soils thus exacerbating the erosion problem. Sustainable governance of soil has therefore become a topic of fundamental importance.

Soil erosion has been regarded as the most serious and wide-spread forms of land degradation, and itself a cause of fertility decline, through removal of organic matter and nutrients (Young, 1998). It extremely widespread in areas that have been under annual cropping and consequently opens the way for serious environmental deterioration (Young, 1998),vegetation becomes increasingly scarce, water resources dry up, thorny weeds predominate in rich pastures, footpaths grow into gullies, and soils become thin and stony. All of these manifestations have potentially severe impacts on the environment, for land users and for people who rely for their living on the products from a healthy landscape (Berry 2003).

Soil conservation is the preventing of soil loss from erosion in the appropriate land use and management practices that promotes the productive and sustainable use of soils and minimizes soil erosion. Slash and burn and other unsustainable methods of subsistence farming are practiced. Techniques for improved soil conservation include crop rotation, cover crops, conservation tillage and planted windbreaks and affect both erosion and fertility.

The degree of degradation is estimated in relation to changes in agricultural suitability, in relation to declined productivity and also in some cases in relation to biotic functions. The report also includes estimates of the percent of agricultural land impacted by different types of degradation.

1.2 Statement of the problem

According to the Ethiopian Highlands Reclamation Study (EHRS, 1984) soil erosion was estimated to cost the country 1.9 billion US\$ between 1985 and 2010. According to Mesfin (2004), Betru (2003), the annual loss in grain production due to erosion in 2000 was 170,000 tones and successively losses 2% of the annual grain production which is roughly equivalent to 120, 000 tons of cereal per year. This shows the loss of income in terms of lost agricultural production of US \$150 million. The Ethiopian highlands have been experiencing declining soil fertility and severe soil erosion due to intensive farming on steep and fragile land (Abegaz, 1995).

In the Ethiopian highlands case, the decline of soil fertility and severe soil erosion is due to water outflow on steep and fragile land that have been under intensive farming (Amsalu and Graaff, 2006). Soil erosion, with its associated loss of fertility and rooting depth, water resource degradation and loss of bio-diversity (Eyasu2003), erosion is particularly serious in the high and low potential cereal zones 50 % of the agricultural lands have soils with depths less than 10 cm, which make them unsuitable for farming (Eyasu2003; Kidane 2008).The key problem of research the additional expense of farming activities of soil erosion.

Assessment of soil erosion is expensive and time consuming in field measurement, the complexity of the soil erosion system, with its numerous interacting factors. Models will take into account many of the complex interactions that affect rates of erosion and can simulate

erosion process. Models can be used as a tool for understanding processes, interactions, to predict where and when erosion occurs and to estimate the amount of soil loss per year used as.

Gully form of soil erosion causes extensive socioeconomic and environmental impacts, and (Valentin et al. 2005; Marzloff et al. 2011). According (Zgłobicki et al, 2015) gully erosion decreases the agricultural land, farm productivity/crop yields and grazing land. Also gully-based valley sediment yield accounted for 10 to 94 % of the total watershed sediment yield (Poesen et al, 2003). According to the (Hurni, 1988) estimation the average erosion rate in infertile crop land are 70 tons / ha / year. Gully erosion is a highly visible form of soil erosion that affects soil productivity, restricts land use and can threaten roads, fences and buildings (Nyssen et al. 2004; Avni 2005; Carey 2006). It is the most prevalent type of water erosion in Ethiopia and its separate the fields, difficult plugging practices, damaging agriculture crops, residential area and restricts free movement of animals and human beings in different parts of the country (Daba et al. 2003; Woldeamlak and Sterk 2003; Awdenegeest and Holden 2008).The major driving forces for gully erosions are high population pressure, poor rangeland, clearing of vegetation cover, overgrazing, improper land use (cultivation on steep slopes), improper irrigation design, and soil characteristics (Jahantigh and Pessarakli 2011; Tamene and Vle2008).Therefore, due the existence of gully how much impacts on considering person.

Assessment of gully erosion uses different sources; aerial photo and satellite image analysis, unpublished documents, archives, statistical abstracts and reports from different offices were used as secondary sources. Using different technique ;object orientated image analysis (OBIA), extracted shoulder line of gullies from high spatial resolution digital orthophoto map (DOM) aerial photographs classified by remote sensing and points measured by RTK-GPS along the shoulder line of gullies lacking historical documents and also aerial photographs are not reliable in considerable gully, this paper consider as using AGERTIM (assessment of gully erosion rate through interview and measurement) technique to quantify the amount of soil loss.

Understanding of Farmers the problem and causes of soil erosion and its consequences will help to motivate farmers to use soil conservation practices (Amsalu & Graaff, 2006). Different site specific research confirmed the majority of the farmer aware about soil erosion and its impact on productivity (Teshome et al., 2016; Tadesse & Belay, 2004; Jaleta M. et al., 2016; Tefera&Sterk, 2010; Adugna, 2015) but they did not invest much in SWC measures because they do not

perceive a significant advantage to their use and lack of short term economic benefit (Mekuriaw et al, 2018). Additionally to this, farmers perception about the technologies be able to shelter for pests, difficult to tillage , and rats, need much labor, need incentives to implement, difficult to implement and reduce farm size are the factors affecting the adoption of SWC technologies (Mushir & Kedru, 2012).

Soil erosion has a detrimental effect on soil quality for agricultural production because erosion degrades soil functions for crop growth such as the supply of water, nutrients and rooting space soil erosion can be covering of productivity in other soils. Soil erosion by water is the dominant degradation process and occurs particularly on cropland, with annual soil loss rates on average of 42 tons/ha for croplands, and up to 300 tons/ha in extreme cases (Hurni 1993). Other degradation processes include intensified runoff from grasslands and related gullying, as well as high soil erosion rates from badlands (heavily degraded lands).The problem is due to the severity, extents and duration of impacts; farmers has taken prevention measures of loss of productivity address.

Therefore, this research identify quantify total soil loss the severity of soil and gully erosion and area coverage and also evaluate real perception of farmers problem and causes soil degradation and gully erosion and impacts on yield production and rephrase more implement of conservation practice and its profitable of conservation measures, as the case of Machakel woreda.

1.3 Objectives of the Study

1.3.1 General objective

The general objective of this research is to assess the extent of soil erosion and its effect on agricultural productivity in Machakel Woreda, East Gojjam Zone, Ethiopia.

1.3.2 The specific objectives

- Assess and Map the magnitude of soil erosion by RUSLE.
- To examine the extents Gully erosion of different in periods in the study area.
- To assess the perception of people on soil erosion and gully and its determinants.
- Assess to the impact of soil erosion and gully on the reduction of crop production on households.

1.4 Research question

This study will answer the following question.

- What are the extent and magnitude of soil degradation (sheet and gully erosion) in the study area?
- How do farmers understand the extent, causes and effects of land degradation?
- How much does land degradation affect farmer's crop production?

1.5 Significance of the study

The impact of soil erosion on the productivity of farmers is manifested through its removal of soil nutrient contents, making this land unsuitable for crops. So, this creates a reduction in crop yield. This study identifies the yield reduction in Machakel Wereda, and specifies the determinant of soil erosion, diverging consequences in crop land, and direct and indirect impacts of crop production and perception of farmers to understand causes and consequences of soil erosion. In addition to the extents and trends of the gully, the prevention measures of land degradation, land use management, and value added in the direction of government to SWC practices.

1.6 Scope of the Study

The thesis focuses on the effects of soil erosion on crop production. Farmers were understood to understand causes and consequences of soil erosion on the farm land and estimate the amount of annual soil loss by water erosion and quantify the history of gully and amount of soil loss and to understand perception of farmers on sheet, rill erosion and gully erosion, analysis of data, discussion, conclusion and recommendation to layout direction considerable person and institution based on the findings of research.

1.7 Limitation of the study

On the time of the study, many challenges were experienced but the time of data collection is more difficult. First, COVID-19 blocked transport for a few days to the study area and made it difficult to interview participants. The problem of funds to inadequate large number samples used. In addition, the study area was highland, not accessible to transport, making data collection difficult. Small samples relate to results that do not represent the population and the respondents of key informant interviews and focus group discussion members want to be allowed and unwanted to participate through

discussion cannot give enough time and enough respond.so this condition were influences to the finding of the results.

1.8 Organization of the study

The thesis is organized into five sections. the first section the Introduction part which consists of the study's background, statement of the problem, objectives, significance, scope, limitations and of the study. The second part is the Literature Review which revises around the same as the study literature is reviewed. Theoretical, empirical and analytical frameworks of the study are also combined in this part. The third section of the thesis describes the Research Methodology of the study. It combines description of the study area, research design, sampling technique, sample size determination, data type and data source, methods of data collection and methods of data analysis. The fourth section data analysis and data interpretation; and also, the fifth and last section contain Conclusions and Recommendations from the findings of the study.

CHAPTER TWO: LITERATURE REVIEW

2.1 Conceptual Definition Soil Erosion

Soils have played important roles in the earth's life support system through the provision of a multitude of essential ecosystem services (i.e. provisioning, regulating, cultural and supporting services) to humans and the environment (Keesstra et al., 2016b; Schwilch et al., 2016). Soil erosion refers to the wearing away of a field's topsoil by the natural physical forces of water and wind. It can be a slow process. It is relatively unnoticed or can occur at an alarming rate, causing serious loss of topsoil. Soil compaction, low organic matter, loss of soil structure, poor internal drainage, salinization and soil acidity problems are other serious soil degradation conditions that can accelerate the soil erosion process. Soil Erosion, whether it is by water, wind or tillage, involves three distinct actions soil detachment, movement and deposition. Accelerated erosion is largely the consequence of human activity. The primary causes are tillage, grazing, and cutting of timber. The rate of erosion can be increased by activities other than those of humans. Fire that destroys vegetation and triggers erosion has the same effect (Wikipedia).

Soil erosion is the displacement of the upper layer of soil; it is a form of soil degradation. This natural process is caused by the dynamic activity of erosive agents, that is, water, ice (glaciers), snow, air (wind), plants, animals, and humans. In accordance with these agents, erosion is sometimes divided into water erosion, glacial erosion, snow erosion, wind erosion, zoogenic erosion and anthropogenic erosion. Soil erosion may be a slow process that continues relatively unnoticed, or it may occur at an alarming rate causing a serious loss of topsoil. The loss of soil from farmland may be reflected in reduced crop production potential, lower surface water quality and damaged drainage networks. Soil erosion could also cause sinkholes. Human activities have increased by 10–50 times the rate at which erosion is occurring globally. Excessive accelerated erosion causes both "on-site" and "off-site" problems. On-site impacts include decreases in agricultural productivity and on natural landscapes ecological collapse, because of loss of the nutrient-rich upper soil layers. In some cases, the eventual end result is desertification. Off-site effects include sedimentation of waterways and eutrophication of water bodies, as well as sediment-related damage to roads and houses. Water and wind erosion are the two primary causes of land degradation; combined, they are responsible for about 84% of the global extent of degraded land, making excessive erosion one of the most significant environmental problems

worldwide. Intensive agriculture, deforestation, roads, anthropogenic climate change and urban sprawl are amongst the most significant human activities in regard to their effect on stimulating erosion. When a raindrop hits soil that is not protected by a cover of vegetation and where there are no roots to bind the soil, it has the impact of a bullet. Soils particles are loosened washed down the slope of the land and either end up in the valley or are washed away out to sea by streams and rivers. Erosion removes the topsoil first. Once this nutrient-rich layer is gone, few plants will grow in the soil again. Without soil and plants the land becomes desert like and unable to support life (Wikipedia).

The condition of the soil is one of the best indicators of land degradation. The soil integrates a variety of important processes involving vegetation growth, overland flow of water, infiltration, land use and land management. Soil degradation is, in itself, an indicator of land degradation.

Global Concept of Soil Erosion

Livelihood of human kind is closely linked to soil and soil contributes food, clean water, clean air, and are a major carrier for biodiversity (Katsuyuki, 2009; Keesstra et al., 2016). Most of the people in the world remain heavily dependent on soil resources as their main livelihood source that lead to high soil erosion. The high erosion rates are affecting mainly the developing countries due to intensive cultivation, deforestation, plugging of marginal lands and extreme climate hazards (Biswas et al., 2015; Colazo and Buschiazzo, 2015; Ligonja and Shrestha, 2015). Soil erosion is worldwide environmental problem that threatens the lives of most smallholder farmers (Dai et al., 2015; Erkossa et al., 2015; Gessesse et al., 2015; Ochoa Cueva et al., 2015; Taguas et al., 2015; Prosdociumiet al., 2016). Soil erosion rates beyond the tolerable limit changes in the hydrological, biological, erosional and geochemical cycles, which result lack of the services that the soil offers to the human beings (Berendse et al., 2015; Brevik et al., 2015; Decock et al., 2015; Smith et al., 2015). On cultivated lands, appropriate soil conservation mechanisms supported with Vegetation are efficient strategies to control soil losses (Cerdà et al., 2016; Zhao et al., 2015). About 80% of the current agricultural land degradation is caused by soil erosion globally (Angima et al., 2003; Rodrigo et al., 2015). Sustainable agricultural practice is challenged by severe soil erosion, as it reduces on-farm soil productivity and causes food insecurity (Sonneveld, 2003; Moges and Holden, 2006; Bewket, 2007). In most developing countries, including Ethiopia, anthropogenic activities trigger soil erosion (Belyaev et al., 2004;

Hurni et al., 2005). Land degradation may be defined as the loss of productive and ecosystem services provided by land resources. It is defined by the United Nations Convention to Combat Desertification (UNCCD) as the reduction or loss of the biological or economic productivity and complexity of pastoral, agricultural and wooded land due to soil erosion, soil impoverishment (such as nutrient depletion) and/or the loss of natural vegetation. Much of the world's land surface area is degraded, particularly in sub-Saharan Africa where it is critical to the livelihoods of poor farmers.

Soil erosion includes all process that diminishes the capacity of land resources to perform essential functions and services in ecosystems (Hurni *et al.*, 2010) are caused by two interlocking complex systems: the natural ecosystem and the human social system. Interactions between the two systems determine the success or failure of resource management (Berry, 2003). Principal processes of soil erosion by water and wind, chemical degradation (comprising acidification, salinization, fertility depletion, and decrease in cation retention capacity), physical degradation (comprising crusting, compaction, hard-setting, etc.) and biological degradation (reduction in total and biomass carbon, and decline in land biodiversity) (WMO, 2005). It is a continuous process and has become, however, an important concern affecting food security and the wealth of nations, and has an impact on the livelihood of almost every person on this earth (Bezuayehuet *al.* 2002).

Soil erosion and land degradation in Ethiopia and their connections with agriculture are a prominent environmental concern, as this is one of the most important causes of low and declining agricultural productivity, ongoing food insecurity and rural poverty in the country. Around 85 per cent of Ethiopia's population relies heavily on subsistence agriculture for their livelihoods, and their activities contribute to the increasing degradation and vulnerability of soil resources. Soil erosion occurs naturally due to processes of erosion by water and wind in the landscape, but it is increased by several orders of magnitude above background rates by human actions

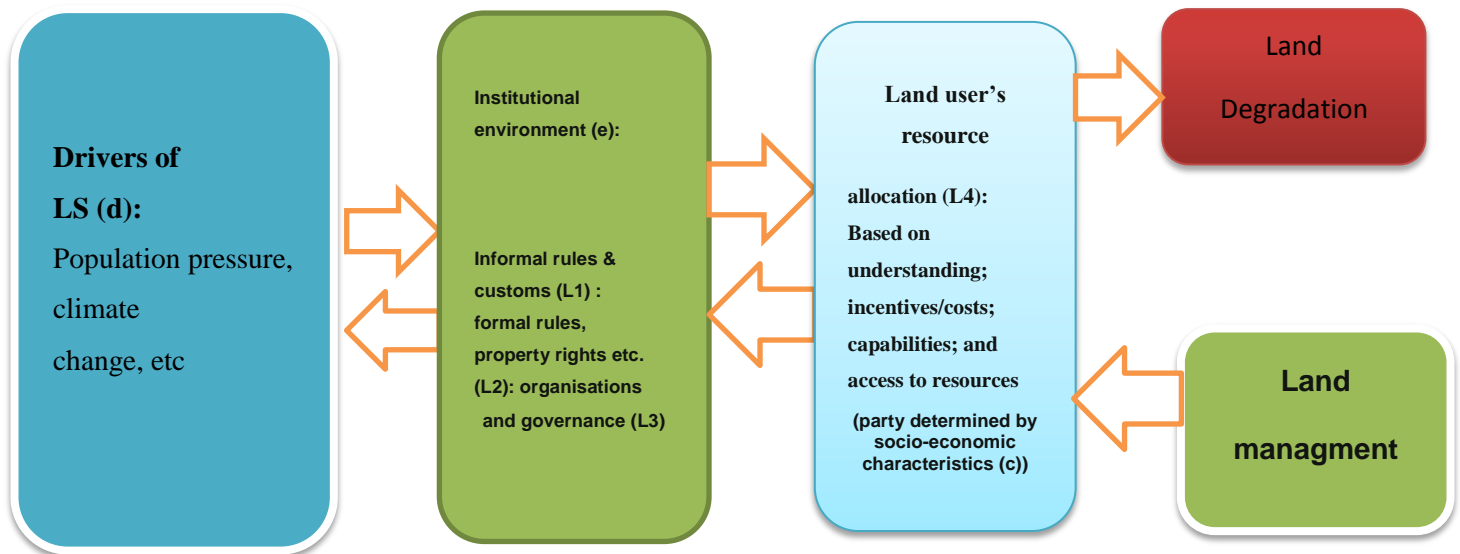


Fig.1: Conceptual framework the mediating role of institutions in land degradation and land management (Nkonya et al. ,2011)

Definition of Crop production

Crop is plants of the same kind are grown and cultivated at one place on a large scale, Crop Production is the art and science of the genetic improvement of crops to produce new varieties with increased productivity and quality .The advanced genetic and molecular techniques have resulted in new varieties of crop plants, medicinal plants and ornamentals.

Crop production is sustainable if the productivity as well as the ability to function (among other things the regenerative power and the buffering capacity) of the open system within which plants are cultivated, are permanently maintained to the full extent. Neither the agricultural ecosystem as a whole, nor its components (principally water, soil, air climate, flora, and fauna), nor other ecosystems which are directly or indirectly affected by crop production, nor the interactions among these ecosystems and their components are altered irreversibly over the long run.

2.2. Types of Soil Erosion

For this purpose there are different sources of soil erosion in various processes:

Soil erosion by water: the removal of soil particles by the action of water. Usually sheet erosion (more or less uniform removal of a thin layer of topsoil), rill erosion (small channels in the field) or gully erosion (large channels, similar to incised rivers). One important feature of soil erosion by water is the selective removal of the finer and more fertile fraction of the soil.

Soil erosion by wind: the removal of soil particles by wind action. Usually this is sheet erosion, where soil is removed in thin layers, but sometimes the effect of the wind can carve out hollows and other features. Wind erosion most easily occurs with fine to medium size sand particles. Erosion is the detachment of earth material from the surface. Once detached, agents like water or wind transport the material to a new location where it is deposited. The most ubiquitous form of erosion is that done by water.

Splash erosion is the detachment and airborne movement of small soil particles caused by the impact of raindrops on soil. Rain splash erosion is caused by the impact of water striking the surface. Rain splash erosion generally takes place in two steps. As precipitation is absorbed by the surface it fills the pore spaces, loosening soil particles and driving them apart. The impact of subsequent rain drops hitting the surface splash the particle away from the point of impact. The effect is to give the surface a dimpled-like appearance.

Sheet erosion is the detachment of soil particles by raindrop impact and their removal down slope by water flowing overland as a sheet instead of in definite channels or rills. When the surface pores are filled with sand, silt or clay, overland surface flow of water begins due to the lowering of infiltration rates. Once the rate of falling rain is faster than infiltration, runoff takes place. There are two stages of sheet erosion. The first is rain splash while the second stage is movement of the loose particles down slope by broad sheets of rapidly flowing water filled with sediment known as sheet floods.

Rill erosion is a shallow linear depression or channel in soil that carries water after a recent rainfall (Stocking and Murnagham, 2001). Rill erosion are especially common on bare land, whether newly planted or in fallow. Rills are channels small enough to be smoothed by normal tillage, but the drainage is already done and the soil is lost. In addition, tillage loosens the soil

making it more susceptible to rill erosion and every time they are destroyed the rills can reform, resulting in much more soil loss. Rill erosion is the most visible, most common and serious form of soil erosion. It is the intermediate process between sheet and gully erosion. If detachment of soil particles continues, or flow increases; rills will become wider and deeper.

Causes and magnitude of Soil Erosion

The causes of soil erosion were classified into biophysical factors such as unsuitable land use (land use for the purpose for which environmentally unsuited for sustainable use), socioeconomic factors such as poor land management practices, land tenure, marketing, institutional support, income and human health, and political factors such as lack of incentives and political instability (World Metrological Organization, 2005). Similarly, the major causes include rapid population increase, severe soil loss, deforestation, low vegetative cover and unbalanced crop and livestock production. In addition, topography, soil types and agro-ecological parameters were contributing factors in the degradation processes influenced by man (Temesgen et al., 2014). Socioeconomic and institutional factors were the underlying causes that affect land degradation through their impacts on farmers' decisions with respect to land use and land management practices (Mohammed and Teshome, 2015) Moreover, land degradation had caused economic and environmental impacts in different country. These impacts can also have a significant adverse effect on the population and can harm national, regional and global development. The immediate impact of land degradation is on soil productivity leading to impacts on people's welfare. Soil degradation through erosion, nutrient loss results in undesirable physico-chemical soil properties and there by considerably depresses crop yield. The most important factors reducing soil productivity by soil degradation are reduced soil depth and soil water storage capacity and losses of nutrient (Mohammed and Teshome, 2015) The strategies practiced prior by government to tackle the problem was the soil and water conservation measure to some extent but not fully practiced due to the fact that people have not full knowledge about it, the extension agents do not continually follow them due to the area lacks roads, even though the people not engaged to another activity outside of agriculture they sale wood and charcoal for surviving themselves and their family (Feyera and Tsetadirgachew, 2015) need to increase farmers' perception of soil erosion problem through the provisionof knowledge on demonstration of gains and risk reduction characteristics of soil conservation practices. This was important because, the extent to which farmers understand and feel the need for controlling

soil erosion affects adoption of soil conservation measures positively. Therefore, Machakel woreda were saw the nature of land scape steep slope and aggravated human induced causes .So, we will expected exist land degradation.

Gully erosion

Gullies are relatively permanent steep-sided water courses which experience ephemeral flows during rainstorms. They are almost always associated with accelerated erosion and therefore with landscape instability. The main cause of gully formation is too much water, a condition which may be brought about by either climatic change or alterations in land use. In the first case, increased runoff may occur through higher rainfall or if less rainfall produces a reduction in vegetation cover. In the second case, deforestation, burning of vegetation and overgrazing can all result in greater runoff. If the velocity of the runoff exceeds a critical or threshold value, gully will occur (Lal, 1988; Morgan, 1995).

Land degradation caused by gully erosion is a serious problem in many areas around the world (Poesen et al. 2006). The formation and development of gullies results in a whole range of phenomena that are unfavorable, from the human perspective; i.e. reduced acreage of cropland, increased risk of flash floods, covering of crops, farms and roads with silt, and intensive terrain and road network fragmentation (Poesen et al. 2003; Valentinet al. 2005).

The major driving forces for gully erosions are high population pressure, poor rangeland, clearing of vegetation cover, overgrazing, improper land use (cultivation on steep slopes), improper irrigation design, and soil characteristics (Jahantigh and Pessarakli 2011; Tamene and Vlek 2008). Gully form of soil erosion causes extensive socioeconomic and environmental impacts, and most of them are negative (Valentin et al. 2005; Marzloff et al. 2011). According (Zgłobicki et al., 2015) gully erosion decreases the agricultural land, crop yields and grazing land. Also gully-based valley sediment yield accounted for 10 to 94 % of the total watershed sediment yield (Poesen et al. 2003).

In Ethiopia dense gully erosion is typical parts of the landscape (Gebrehiwet 2004; Frankl et al. 2010). According to the (Hurni, 1988) estimation the average erosion rate in infertile crop land are 70 tons / ha / year. Yet the (CRSPT, U. 2000) report has indicated that, the average annual

rate of soil loss in Ethiopia is estimated to be 12 tons/ ha /year and it can be greater than 300 tons/ha/year on steep slopes where vegetation coverage is little.

Soil Erosion in Ethiopia

The most common form of soil erosion in Ethiopia is soil erosion by water. Soil erosion is indeed considered the most significant environmental challenge to the food security of the population and future development prospects of the country (Wagayehu 2003). A considerable volume of information has been produced since the mid-1980s regarding soil erosion in Ethiopia (Barbier 1989, 2000; FAO 1986; Hurni 1993 among others, all cited Eyasu 2003). But there is a lack of reliable and consistent data on the extent and rate of soil loss (tones/ha/year). Different data sources report different estimates on the amount of soil loss from arable land. As shown below in Table 1, the current rates of soil erosion in Ethiopia are estimated to vary between 42 and 300 tones/ha/year.

Table 2.1 Estimates of rates of soil loss on croplands in Ethiopia

Author Estimates of annual soil loss	Author Estimates of annual soil loss	Author Estimates of annual soil loss
FAO/EHRS 1986	130	USLE: universal soil loss equation and guess estimates
Hurni 1988: soil conservation research project	42	Measurement from runoff plots from eight stations across the country
Belay Tegene 1992	75	Measurement from runoff plots
AzeneBekele 1997	100	Guess estimate
TamireHawndo 1996	300	Secondary data and estimates

Source (Eyasu (2003)

The wide range of estimates in soil erosion rate is indicative of the complex patterns of spatial and temporal variations and conceptual and methodological difficulties inherent in making such estimates. Obviously there is considerable variability of erosion rates over time and place depending on agro-ecological zone and soil type. Soil erosion occurs at varying rates and with varying degrees in different parts of the country. Deforestation, forest burning and expansion of cultivated lands to marginal lands have also contributed to the widespread problem of land degradation in the country. ‘About 70 % of Ethiopia’s highland population and an area of over

40 million ha are affected by land degradation' (Melaku 2013), indicating the scale and extent of the problem confronting the country.

2.4 Effects/consequences of soil erosion

There were a number of shocks and stresses that trigger livelihood diversifications among the farmers in communities though farmland shortage was the top most important of all as access to it could have positive effect on others. Factors like soil degradation, population pressure, deforestation, low level of rural economy diversifications have complicated and, directly or indirectly, contributed to land scarcity as result land degradation (Feyera and Tsetadirgachew, 2015). Being land degradation was the common environmental problem in Ethiopia; land degradation puts disastrous impact on the socio cultural environment and ecological setting of the country (Temesgen et al., 2014) Land degradation had also an effect on climate change by reducing carbon sequestration and increasing accumulation of greenhouse gases in the atmosphere through deforestation and soil erosion. It also can cause loss of bio diversity, ecosystem services which are difficult to measure as they are not normally given monetary value or bought or sold and thus are poorly reflected in estimate of losses (Mohammed and Teshome, 2015). Land degradation reduces agricultural value to 7%. In monetary terms, this decline is equivalent to \$7.63 per hectare. If all of the agricultural lands are degraded, the loss for the country as a whole is \$267 Million where 85% of the population depends on agriculture, this loss is substantial. Type of energy used in cooking stoves and bequest variables are good instruments for land degradation. The significance of type of energy used in cooking stoves suggests a two-pronged policy to stem deforestation and to disseminate more efficient stove technologies (Maria et al, 2012).

Land degradation was a complex phenomenon influenced by natural, social and economic factors. It generally refers to the loss of the land's biological and or economic productivity. Land degradation remains an important global priority issue for the 21st century requiring renewed attention by individuals, communities, and governments because of its adverse impact on agricultural productivity and the environment, and its effect on food security and quality of life. The land degradation process appears particularly severe in developing countries, which has significant implications for climate change mitigation and adaptation. This was because the loss

of biomass and soil organic matter releases carbon into the atmosphere and affects the quality of soil and its ability to hold water and nutrients (Mohammed and Teshome, 2015).

Degradation included yield losses may become more significant in relation to yield growth in the future, as yield growth rates are projected to fall below 1% per year over the next few decades. Land degradation's effects on more severe in some regions and local areas due to a combination of resource factors (soils and precipitation) and economic factors (poverty, insecurity and lack of infrastructure) (WiebeK. 2003). Among main factors that affecting the crop production in Ethiopia was land degradation, which including soil erosion, deforestation, reduction of productivity, reduction of pasture land which affect the crop production and economy of the country. Other related factors like farm land size, education level, sex of household heads, experience of farmers, family size and quintals of fertilizer are also used the most issues underlined to contribute for crop production (Feyera and Tsetadargachew, 2015). Continues land fragmentation and degradation disturb the balance between crop, livestock, and forest production (Assume and Shigedaf, 2014).

2.5. Soil degradation effects on crop production and yields

Land degradation affected more than 3 billion hectare of the world land (Lal, 2014). As a result more than 3 billion people suffered to this problem (Nkonya, Mirzabaev, & Braun, 2016). This notably challenges influencing agricultural productivity and affected livelihoods of more than 1 billion people (ELD Initiative, UNEP, 2015). African agriculture remains most threatened by land degradation and more than 60% of its cropland is affected at various scales (Muchena et al., 2005). In sub-Saharan Africa (SSA), 75% of the population derives their livelihoods from subsistence agriculture Soil degradation induced by water erosion and its consequences are the main concern (Tully et.al, 2015). Soil degradation is any process that reduces the current and future productivity of soil. (Abrol and Oman ,2002) defined soil erosion physical removal and transportation of top soil from one place and its deposition to another by various agents such as striking and moving water, blowing winds, strong waves, snow and the forces of gravity.

Factors affecting crop productivity

This is further aggravated by high population pressure, climatic variability, top-down planning systems, lack of appropriate and/or poor implementation of policies and strategies, limited use of sustainable land management practices, limited capacity of planners, land users as well as frequent organizational restructuring (Tesfayeet *al.*, 2013; Kassieet *al.*, 2009; Tiwariet *al.*, 2008;

Bewket, 2007; Shiferaw and Holden 1998). The considerable diversity of Ethiopia's highland areas means that many factors influencing the adoption of land management inputs and investments are highly sensitive to the local biophysical and socioeconomic context. The settlement pattern of the population is influenced by environmental factors such as altitude, climate, soil fertility and by the economic activities which altogether skewed the population distribution towards the highlands. The highlands of the country are densely populated, resulting in over-grazing and severe degradation of the vegetation, while the lowlands, being affected by insufficient rainfall and high temperature are sparsely populated. Human population distribution is one of the important factors that have impacts on the productivity of agricultural lands and the conservation and management of biological resources.

Causes of crop Reduction

Environmental degradation and loss of ecosystem components, there would be reduced yield of food crops. Unsustainable practices in irrigation and production may lead to increased salinization of soil, depletion of soil nutrients, and erosion. This, in turn, will cause lower yields. The productivity of some lands has declined by 50 per cent due to soil erosion and desertification. Water scarcity is expected to affect over 1.8 billion people by 2025 according to the World Health Organization. This could cause not only health problems but also impact farm productivity. Watersheds have been damaged.

Water may be considered as one of the most limiting factors in increasing food production. Over-extraction of water resources from aquifers and rivers has led to much loss of this resource. River discharge has decreased in many areas mainly as a result of human action and use. This water scarcity is likely to reduce yields of food grains, as 40 per cent of world's crop yields is based on irrigation. Invasive alien species pests and diseases are another threat to food production. Pests and pathogens have had particularly severe effects on crop yields in the world's poorest and most food insecure region of sub-Saharan Africa. Grazing land in dry areas is considered degraded mostly because of overgrazing, compaction and erosion attributable to livestock. Increased demand for meat also results in an accelerated demand for water, and feed crops such as maize and soybean. In addition, large-scale industrial production of livestock products tends to be located close to urban centers and could lead to environmental and public health risks.

Effect of soil Erosion on Crop Production in Ethiopia

Soil Erosion and Improvement in Ethiopia unsustainable land management practices cost the country (via loss of soil and essential nutrients) about 3% of its agricultural Gross Domestic Product (GDP) or \$106 million. (Bojö and Cassells, 1995) also estimate that Ethiopia loses about 3 % of the agricultural gross domestic production due to soil erosion and nutrient loss. While modeling the impact of water erosion on food production in Ethiopia, (Sonneveld ,2002) reported a range of potential reduction in production of 10–30 % by 2030. The most critical and urgent onsite impact of soil erosion to the farmers decline in both the current and potential crop and livestock yields which translate into income losses. The consequences of soil erosion may also be viewed in the need to use more inputs to maintain soil productivity so as to attain the same level of yield (Wagayehu 2003). The impact of land degradation on agricultural productivity represents an on-site cost. However, soil erosion from agricultural fields has also serious external or off-site effects, which indirectly affect the rest of society.

Soil erosion has a negative implication to household food security status and contributes directly to the reduction in livelihoods among the rural communities in Ethiopia. The immediate consequence of land degradation is lower crop yields, leading to higher poverty rates among agricultural households. Based on experts' opinion, (Dregne1991) recounted an irreversible soil productivity loss in about 20 % of Ethiopia agricultural land due to water erosion. Ethiopia loses an estimated 1 billion tons of topsoil annually as a result of soil erosion alone (Berry 2003. A study by (Teketay 2001), for instance, estimates that “reduced soil depth caused by erosion resulted in a grain production loss of 57,000 (at 3.5 mm soil loss) to 128,000 tons (at 8 mm soil depth) in 1990 alone. It has been estimated that the grain production lost due to land degradation in 1990 would have been sufficient to feed more than four million people” (Teketay 2001).

2.6 Causes of soil erosion

Soil degradation may occur naturally, it has been highly exacerbated by anthropogenic activities. Besides, climate change combined with human activities continues to worsen soil degradation. With the objective of understanding the distinct nature of soil quality decline, here are the various causes, effects, and solutions of soil degradation.

Deforestation

Deforestation causes soil erosion on the account of exposing soil minerals by removing trees and crop cover, which support the availability of humus and litter layers on the surface of the soil. Vegetation cover primarily promotes the binding of the soil together and soil formation, hence when it is removed it considerably affects the capabilities of the soil such as aeration, water holding capacity, and biological activity. When trees are removed by logging, infiltration rates become elevated and the soil remains bare and exposed to erosion and the buildup of toxicities. Some of the contributing activities include logging and slash and burn techniques used by individuals who invade forest areas for farming, rendering the soils unproductive and less fertile in the end.

Overgrazing

The rates of soil erosion and the loss of soil nutrients, as well as the topsoil, are highly contributed by overgrazing. Overgrazing destroys surface crop cover and breaks down soil particles, increasing the rates of soil erosion. As a result, soil quality and agricultural productivity are greatly affected.

Improper cultivation practices

There are certain agricultural practices that are environmentally unsustainable and at the same time, they are the single biggest contributor to the worldwide increase in soil quality decline. The tillage on agricultural lands is one of the main factors since it breaks up the soil into finer particles, which increase erosion rates. The soil quality decline is exuberated more and more as a result of the mechanization of agriculture that gives room for deep plowing, reduction of plant cover, and the formation of the hardpan. Other improper cultivation activities such as farming on steep slope and mono-cropping, row-cropping, and surface irrigation wear away the natural composition of the soil and its fertility and prevent soil from regenerating.

Misuse or excess use of fertilizers

The excessive use and the misuse of pesticides and chemical fertilizers kill organisms that assist in binding the soil together. Most agricultural practices involving the use of fertilizers and pesticides often entail misuse or excessive application, thereby contributing to the killing of soil's beneficial bacteria and other micro-organisms that help in soil formation. The complex

forms of the fertilizer's chemicals are also responsible for denaturing essential soil minerals, giving rise to nutrient losses from the soil. Therefore, the misuse or excessive use of fertilizers increases the rate of soil degradation by destroying the soil's biological activity and builds up of toxicities through incorrect fertilizer use.

Urbanization

Urbanization has major implications on the soil degradation process. Foremost of all, it clears the soil's vegetation cover, compacts soil during construction, and alters the drainage pattern. It covers the soil in an impermeable layer of concrete that amplifies the amount of surface runoff which results in more erosion of the topsoil. Again, most of the runoff and sediments from urban areas are extremely polluted with oil, fuel, and other chemicals. Increased runoff from urban areas also causes a huge disturbance to adjacent watersheds by changing the rate and volume of water that flows through them and impoverishing them with chemically polluted sediment deposits.

Industrial and Mining activities

Soil is chiefly polluted by industrial and mining activities. As an example, mining destroys crop cover and releases a number of toxic chemicals such as mercury into the soil thereby poisoning it and rendering it unproductive for any other purpose. Industrial activities, on the other hand, release toxic effluents and material wastes into the atmosphere, land, rivers, and groundwater that eventually pollute the soil and as such, it impacts on soil quality. Altogether, industrial and mining activities degrade the soil's physical, chemical, and biological properties.

2.7 Perception and Knowledge of people on soil erosion and gully and its determinants

Farmers' perception of soil erosion refers to individual farmer's evaluation or awareness of soil erosion which is caused by socio-economic, demographic as well as others like topographic factors (Alemayehu, 2007). Although soil degradation is often acknowledged as an insidious and slow process (Ervin & Ervin, 1982; Odendoet al, 2010), farmers need to perceive severity of the problem and associated yield losses before they can consider investing in soil fertility enhancing technologies. In particular, if farmers underestimate soil fertility status, they may fail to replenish soil nutrients because they erroneously view such investments as unnecessary, unprofitable or both (Odendoet al, 2010).

Farmers` perception of soil erosion refers to individual farmer`s evaluation or awareness of soil erosion which is caused by socio-economic, demographic as well as others like topographic factors (Alemayehu, 2007) Although soil degradation is often acknowledged as an insidious and slow process (Ervin & Ervin, 1982; Odendoet al, 2010), farmers need to perceive severity of the problem and associated yield losses before they can consider investing in soil fertility enhancing technologies. In particular, if farmers underestimate soil fertility status, they may fail to replenish soil nutrients because they wrongly view such investments as unnecessary, unprofitable or both (Odendoet al, 2010).

Soil erosion and fertility of crop land indicators that farmers are able to Know as being linked with the problem of soil degradation have been identified by studies accompanied in Tanzania (Vigiak et al., 2005), Kenya (Murage et al., 2000; Okoba and Graaff, 2005), Rwanda (Steiner, 1998), Ethiopia (Corbeels et al., 2000), Latin America (Barrios and Trejo, 2003), India (Kerr and Pender, 2005) and Nepal (Desbiez et al., 2004). Farmers` occurrence of soil erosion can be classified based on the frequency of observation by the farmers challenging. Classes such as `most frequent`, `frequent`, `occasional` or `sparsely occurring` can be defined (Vigiak et al., 2005).

Effective protection and conservation of SWC can be realized only when farmers accept and decide on the benefits of SWC technologies and actively involved in the implementation and maintenance processes. The decisions of farmers to use and manage natural resources highly depend on their perception of the landscape (Assefa& Bork, 2015). Indeed, farmers can modify the technologies to their own real situations (Teshome et al., 2016). Their perception and participation also varies from place to place and from household to household due to different interactive factors. Thus, a better understanding of factors that influence farmers` perception and willingness towards SWC is very important for designing and implementation of efficient, effective and people friendly technologies (Derajew, Bekabil, &Wagayehu, 2013).

2.8 Review of methods of assessment of soil erosion (such as RUSLE)

Review of Soil loss assessment

Estimating soil loss is significantly more difficult than estimating runoff because there are so many variables, both occurring naturally such as soil and rainfall, and chosen management practices. As a result, models, whether empirical or process-based, are necessarily complex if they are to include the effect of all the variables.

For some purposes, meaningful and useful estimates can be obtained from models, and the best example is the estimation of long-term average annual soil loss using by the Universal Soil Loss Equation (USLE). On the other hand, estimates of regional or national erosion are of very little significance or value, and the classic example of this is the three different estimates of suspended sediment yields within Africa compared by (Stocking, 1987).

Constructing a model based on physical processes is possible for small components of the erosion process; for example splash erosion involves only the energy of the rainfall, the extent to which the soil is covered and exposed by vegetation, and the soil type. Similarly, sediment transport requires only an understanding of the effects of particle size and velocity of flow. But a model of erosion in a field situation would require equations for both of these, and also equations to predict deposition and delivery ratio, none of which are presently available. If the boundary conditions are limited, for example to soil loss from arable land of moderate slopes, it may be possible to set up an empirical black box model, and this has in fact been done successfully with the USLE. But there are other difficulties. The effect of extreme rainfall events may dominate the total amount of soil loss, particularly in the tropics and subtropics. In that case, the prediction of soil loss is heavily dependent upon rainfall probability studies.

The equation is presented in the form

$$A = R \times K \times L \times S \times C \times P$$

Where:

A is the average annual soil loss in tons per hectare

R is a measure of the erosive forces of rainfall and runoff

K is the soil erodibility factor - a number which reflects the susceptibility of a soil type to erosion, i.e., it is the reciprocal of soil resistance to erosion

L is the length factor, a ratio which compares the soil loss with that from a field of specified length of 22.6 meters

S is the slope factor, a ratio which compares the soil loss with that from a field of specified slope of 9%

C is a crop management factor a ratio which compares the soil loss with that from a field under a standard treatment of cultivated bare fallow.

P is the conservation practice factor a ratio which compares the soil loss with that from a field with no conservation practice, plugging up and down the slope.

The units require some explanation, particularly as they were originally derived in imperial units, and the conversion into metric or SI units is the source of much error and confusion, compounded by the fact that the official USDA SCS reference on the subject (USDA, 1978) contained errors which had to be corrected in a supplement of 1981.

The factors L, S, C and P are each dimensionless ratios which allow comparison of the site being estimated with the standard conditions of the database, the erosivity factor, is computed by the erosion index (EI₃₀) method which is the summation for each rainstorm of the kinetic energy (expressed in MJ/ha when using metric units in the USA or in J/m² in Europe), multiplied by the greatest amount of rain in any 30 minute period expressed in cm/h in USA or in mm/h in Europe.

K, the erodibility factor, is the average soil loss in tons per hectare for each unit of the metric R as calculated by the EI₃₀ method. In effect, the units of K are arbitrarily chosen so that when multiplied by R in its unconventional units the product is in tons per hectare.

Review of RUSLE model in Ethiopia

The RUSLE was specifically developed for conditions in the USA. Therefore use of RUSLE in other areas requires adaptation to local condition. Thus, Hurni (1985), made a first attempt to adapt the RUSLE to the Ethiopian-Eritrean Highland conditions using the data available at that time. Other researchers like (Helden, 1987) and (Nyssen *et al.* 2006) examined and adapted the different factors of the RUSLE after Hurni (1985) to the Ethiopian Highlands.

2.9 Analytical frame work

The framework categorizes the causes of land degradation into proximate and underlying, which interact with each other to result in different levels of land degradation. Proximate causes of land degradation are those that have a direct effect on the terrestrial ecosystem. The proximate causes are further divided into biophysical proximate causes (natural) and unsustainable land management practices (anthropogenic). The underlying causes of land degradation are those that indirectly affect the proximate causes of land degradation, such as institutional, socio-economic and policy factors. For example, poverty could lead to the failure of land users to invest in sustainable land management practices leading to land. Generally, all theories are advocates Ethiopia in the causes of Land Degradation because Externality is over Exploitation of Natural Resources it is non-excludable ,it cannot pay for service provide, neither government nor society can exclude to common goods like grazing area, forests water bodies (river, lakes, ponds)and local roads. But as study area Machakel Woreda were rural farmers their title or tenure crop land areas.so, farmers directly and indirectly affect environment. The study area will direct impact of farmer their crop land the consequence of reduction of crop productivity

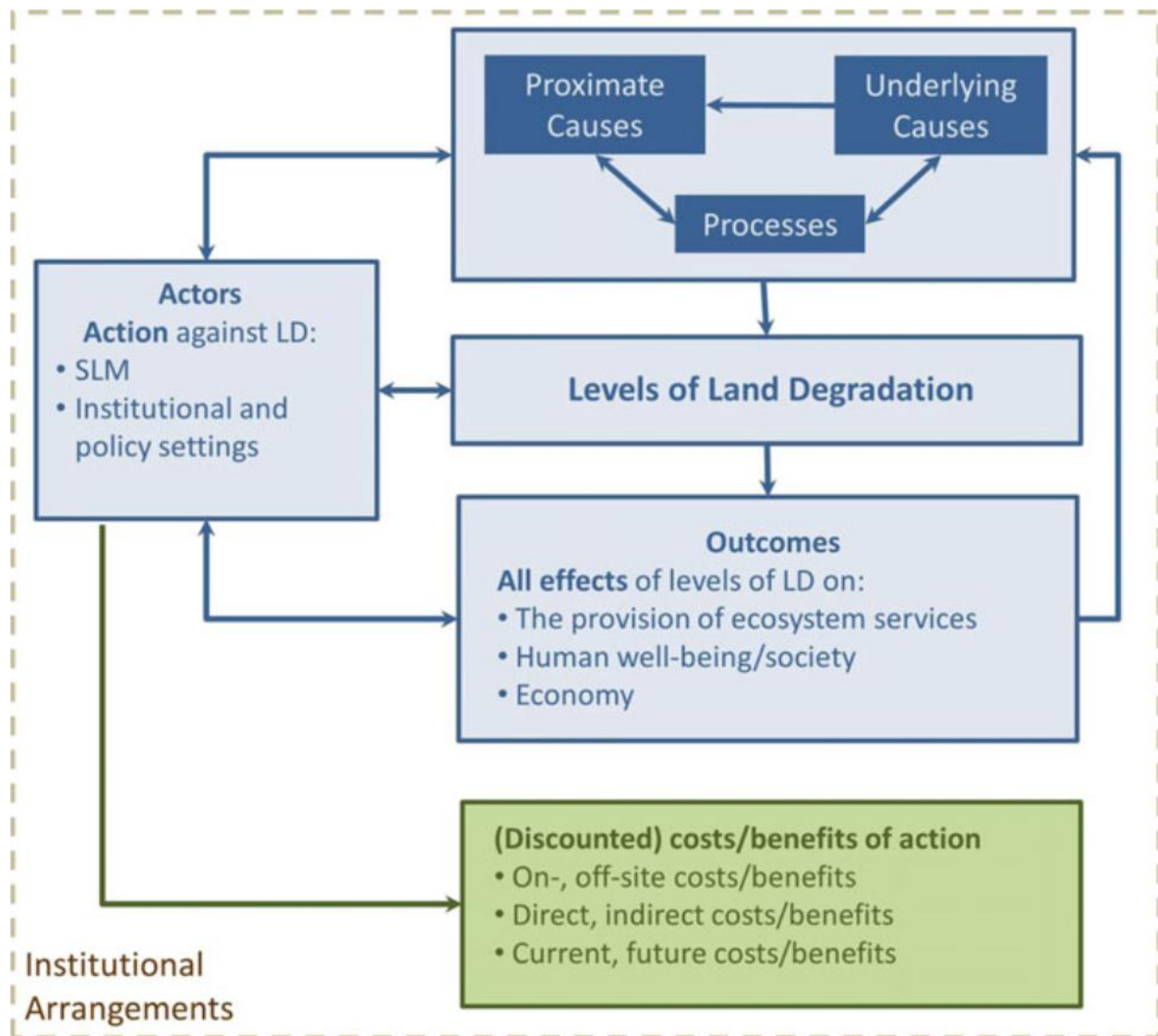


Figure.2 Analytical frame work of Land Degradation (Nkonya et al. ,2011)

CHAPTER THREE: DISCRIPTION THE STUDY AREA AND RESEARCH METHODOLOGY

3.1. Description of the Study area

3.1.1 Location of the Study area

Machakel Wereda is found in East Gojjam Administrative Zone of Amhara National Regional State, Ethiopia. Geographically located at 100 19" 75" to 10041" 00" N latitude and 370 16" 46" to 370 45" 42"E longitude. It is 330 km from Addis Ababa.

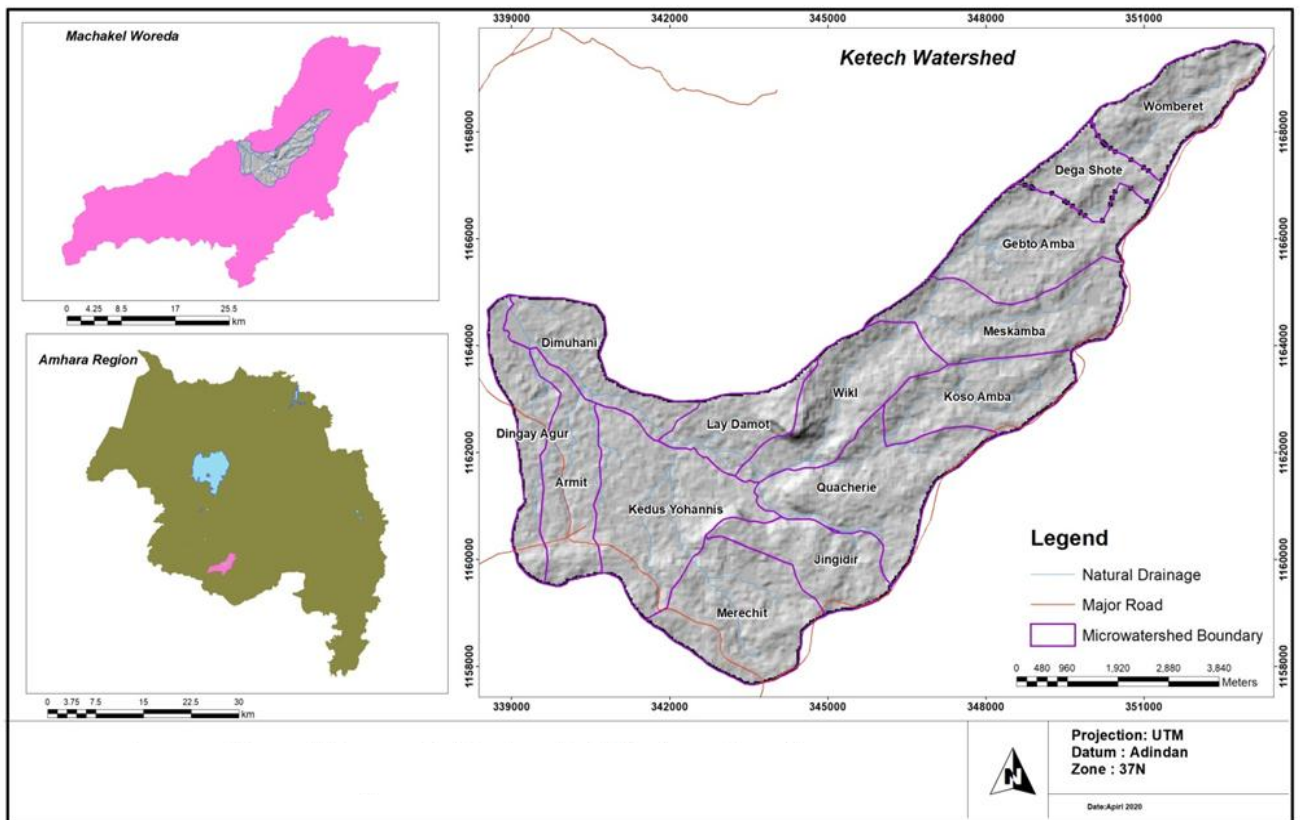


Figure 3: The location of study area (GIS Images)

3.1.2. Climates of the study area

The average annual rainfall 1200-1800 mm and average annual temperature are 27°C. Main rainy summer season has duration of from June to September and have different agro-ecological zone, Worchi 2% (The northern part of worada), dega 58.76% (The northern and central part of the Worada), woinadega39.1% (the central and Southern part of the worada), and kola 0.092% (Southern part of the Worada) (MWAO,2012).

3.1.3. Drainage and Topography of study area

Altitude of the study area has between 1800 and 3300 m.a.s.l. ranges, with undulating topography. Its slope ranges from > 1% (Arc GIS). There are also seasonal and intermittent streams, with steep slopes. Have different rivers that can be used for irrigation purpose (Jedeb, kulech), spring water shade catchment (ketech, partial Temcha) and have micro water shade. Most of the rivers and springs flow down from north to south influence of the undulating topography towards north (GIS, MWAO, 2012).

3.1.4. Geology and Soils of study area

The study area has different topography including mountain, forest, grazing area, crop land, settlement areas. Due to these different topography of the land, there exists a number of plant and animal species, Livestock(cattle, sheep and horse), Cereals (barley, wheat, teff, maize,), Fruits (apple, peach), Vegetables (potato, carrot), Wild Mammals(hyena, baboon, fox, monkey, wart hog, rabbit),Reptiles(snakes, lizards), Amphibians (frog), Birds (francolin, guinea fowl, falcon), Insects(termites, ants, grasshopper, butterfly), Tree species(eucalyptus, Acacia sp.), grass species (Bermuda grass, Mech, Adyo, Asendabo, Sinar, Engcha, Gortebe).have different water shade catchment (ketech, Jedeb, kulech and partial Temcha) and micro water shade and also have four major soil type, leptosols, luvisols, nitisols and vertisols different agro-ecological zone ,Worchi 2%, dega 58.76%, woinadega39.1%, and kola 0.092% .

3.1.5. Socio - Economic characteristics

Machakel Wereda is divided into 25 rural Kebeles with a total population of 141,290 in 2011 E.C. 70,041 are male and 71,249 female, and also have 2,339 women headed household and 17,864 are man headed households, people are highly dependent on agriculture subsistence mixed-farming socio-economic activity, mainly produce cereal crop products wheat, maize, teff, barely and potato in uses staple food of the crop was produced. Cattle, sheep, donkey and horses are taken as source of labor (MWAO,2012)

3.2. Research Methodology

Descriptive research design survey was status of various groups at a given point of time. Data collects both qualitative and quantitative uses mixed research design collecting both kinds of data in order to address the stated objectives of the study needs the collection of statistical numerical data for the quantitative approach and to describe existing conditions of qualitative data.

3.2.1 Qualitative Method

Data would gain GIS map and a deep understand Machakel woreda Authors and public servant : Land use management, soil and water conservation work, crop type and crop productivity, Land degradation and causes of land degradation, opinion and limitations with Semi-structured interviews, focus group discussions and observation will collects the qualitative data.

3.2.2. Quantitative methods

Quantitative data was collected from GIS satellite images, from field measurement of gully and farmer's household surveying demographic and socio-economic data, secondary data in Machakel Woreda Agriculture office total area coverage amount of annual yield production (GIS, MWAO, WORHH)

3.3 Data types and Sources

Both qualitative and quantitative types of data were gathered the research used primary as well as secondary data. Primary data were collected from farmers through structured questionnaires, semi-structured interviews, direct field observations and focus group discussions. Secondary data (Satellite image, aerial photo, topographic map, meteorological data and others) were

collected from different governmental and non-governmental organizations. In addition, Global Positioning System (GPS) data collection was carried out to generate primary information regarding the ground truth for image classification and soil loss vulnerability verification.

Secondary data sources were collected from Machakel Wereda Agriculture office, socio-economic data and published documents, researches, articles and books.

3.4 Sampling frame and Size

Sample Size Determination

Three Kebeles, namely Degasegne, Debrekelomo and EmbullyYewubesh on different agro-ecological zone of Machakel Wereda (high, medium and low altitudes) respectively selected. About 100 households from all selected Kebeles were selected.

So to get important information, the sample households were proportionally selected with related to the number of total households of each Keble used as the following formula:

$$n = \frac{N(S)}{\Sigma N}$$

Where, n= the number of required samples of each kebele

N= Total households of each kebele

S= Total sample households

ΣN = Total households of the three sample kebeles

S is determined to be 5% of the total households of all sample kebeles (ΣN) =130.

- Degasegne = 680 = N1
- Deberekelemo = 780 = N2
- Amariyewebesh = 800 =N3

$$\text{Total} = \underline{\underline{2260}}$$

Then, based to the above formula, sample respondents were proportionated as from Degasegne 30 households, from deberekelemo 35 households and from Amarie yewebesh 35 households. In addition, three focus group discussion which was composed of farmer's development group members living around gully areas and selected aged farmers were conducted.

Sampling techniques

The sample study area was to select Purposive sampling methods Wereda and Kebeles, whereas three Kebeles were selected based on agro-ecological classification. A sample size of 100

household farmers studied. The sample for the design areas uses a probability multistage sampling technique, both probability and non-probability sampling.

Table 3.1 sampling techniques

Select Zone	Selection Woredas	Selection Kebele
East Gojjam Zones	Machakel Woreda	Degasegne Debrekelemo &Amarieywebesh

First, non-probability sampling will select East Gojjam Zone, Machakel Wereda, and three Kebeles using purposive sampling technique methods. East Gojjam has Agricultural suitable land and agricultural base livelihoods' used mixed farming, crop production, and animal rearing. It is a large number of survivors and highly affects eroded cropland areas causing summer high rainfall to formulate soil erosion and have different water shade catchments. Secondly, Degasegne, Deberekelemo, Amarie yewebesh selected three kebeles Sample sizes determined 100 households for all selected Kebeles. So, from Degasegne 30 households, from deberekelemo 35 households and from Amarieyewebesh 35 households have titled certified land tenure.

3.5. Methods of Data Collection

We were applying both quantitative and qualitative data collection methods.

Household Survey: data were quantitatively managed by respondent's open and closed-ended survey questions. This questions simply understand, un biases for farmers and translate to Amharic language to provide Information requiring the socio-economic and demographic information of households, and also address how you understand Farmers on soil erosion and gully in the reduction of a crop by removal of the fertility of the soil and when to happen gully, the extents, and the trends of the gully and they would take protective practical measures were collect by survey questioner.

Key Informant Interview (KII)

KII were conducted the different volume of the question type forewarned in different persons, interviewees from Machakel Wereda agriculture office in crop development team leader, natural resource management team leader and extension service team leader were deep understand semi-structured interviews the demographic, landholding type, geographic, socio-economic status, and erosion type due to the study area. The severity of soil erosion areas and type of cropland government follow up on farmers to growth productivity and prevention of cropland (identify flood vulnerable areas and the major causes of Land degradation and decline of crop yield in addition to how many farmers training per year and the content, the style of training how to address extension services, and prevention of Environment.

Focus Group Discussions

Data were collected in FGD structured and semi-structured questionnaire supplemented with interviews. The survey was adequate with its locational characteristics, size, and population. To understand gully erosion formation and problem, its consequences, and measures for the reduction of crop production. Farmers perceive to have the causes of how do create the gully and the impact of ecology and reduction of productivity and how do you use prevention measures to protect removal of soil loss were addressed different groups of elder farmers to form four age intervals. Direct Field Observation I would be observed the condition of eroded cropland and sustainable land management practices on the ground. To analyses, the level of eroded cropland, and the major causes of soil erosion estimates the soil's physical behavior, the moisture content residual crop. Identify the slope of land estimates the runoff flash floods. In addition, farmers land management, a measure of conservation soil erosion and measure the length, the width, and the deepest of the gully and to estimate the trend of the gully.

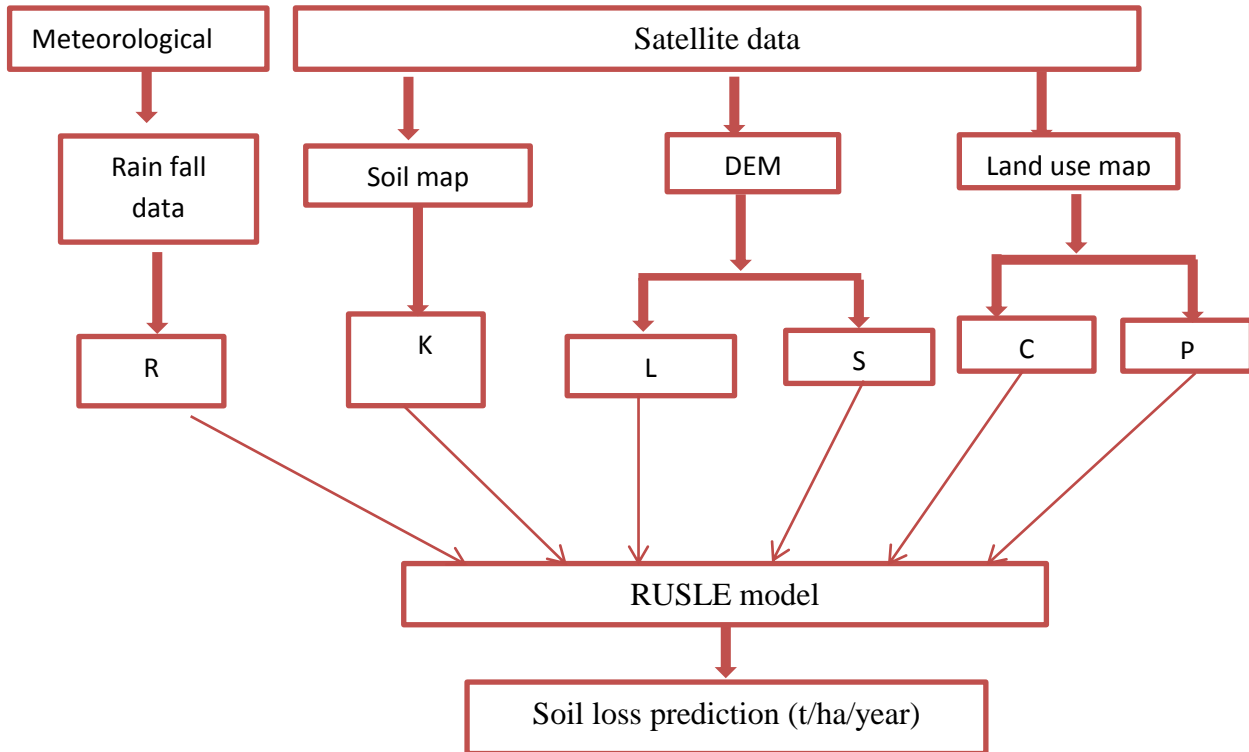
3.6 Methods of Data analysis

Data analyzed by using the Statistical Package for Social Scientists (SPSS vers.20) software interpreted by descriptive statistics mean, standard deviation, frequency distribution, percentage and used the as chi-square test. And, the qualitative data obtained through key informant interview, field observation and focus group discussions were analyzed by narrative analysis, it makes to sort-out and revised shape and triangulate with the quantitative data. GIS Spatial data visualize and explore geographic information and analytical results that pertain to the question.

3.7. GIS Data sources, methods of Analysis

Data analysis and processing was made by digitizing, calculating, and classifying the necessary information of each thematic layers using Arc GIS 10.2.2 software. Additionally, some simple statistical methods, such as percentage, average, and graphic tabulation was also employed for the analysis and interpretations. The basic methodological the approach followed in RUSLE has been detailed in the following simplified flow chart (Fig 4)

Figure 4: Schematic diagram of RUSEL modified Saha model



3.8. Method study of gully

Gully erosion with sever high land of Ethiopia ,Machakel woreda is a part of central Ethiopia which is located at 10°35'26 N /37°41'22.88 E, has different agro-ecological zone dega 58.76% woindega 39.1% , kola 0.019% and wurchi 2% . Total area coverage 79,556 hectar and the average cultivated land is 41,584 hr. and average crop yield produce in the woreda :wheat teff, maize, barely and potato womberet ,Ketech, shembeqogelebet (a) and (b) gully is source in woino streams and Mekalem spring respectively center of Degasegn, Amariyewebesh Kebeles its elevation 2760 ,2245m.a.s.l and annual rain fall is 1200-1800 mm. steep slope of land scape is >0.03/3% soil type is luvisols and nitisols high possibility of erosion, the community were mixed farming livelihoods animal rearing and tillages.

Monitoring

Monitoring of gully erosion comprehended four parts. Two are treatment (womberet in degasegne Kebele and gelebet in yewebesh embuly Kebele) and the other two are non-treatment gullies (Keteche in Degasegne non treatment, at the back of shembeko gelebet gully in amarie yewebesh kebele). Measurement of gully in the history of gully and physical measure of depth, width and length of each treatment and non-treatment gully and calculate total area coverage and total volume of loss of soil and the interviewer told absolute / relative age of the gully calculate the total loss of soil relative to their age and it helps to evaluate in agro-ecological zone ,dega segne is high land and Amarie Yewe besh is low land zone, it to examine to high and low land basic differences in slop factor, soil erodibility and erosibility factor and land use land cover determinants and identify severity and extents of gully ralative to change conservation practices done or not being to saw the differences. This founds wonberet treatment gully and non-treatment ketech new gully its creates perpendicular to katech stream/springs forms to create Amanuel to Degasegn transport road bounds forms collecting summer floods to make diverting road construction flow floods. Ketech gully ,was aggravate highly steep down slop exposure to cutting land ,it begins the beds of the gully joint Woino stream banks flow North to South direction and the ketech gully flow floods East to West direction ,It co-joint and collapse in the mouth of flood endings the medium of woino stream banks.

Table 3.2: shows Measuring of gully area coverage

Name of gully	Area coverage gully (hr)	Starting of gully E.C
Womberet	411	1979
Ketech	11	1984
Shembeko gelebet (a)	4.2	1974
Shembeko gelebet (b)	2.5	2008

Source : author 2012

Womberet , Ketech were located in the high land areas and Shembeko,Gelebet were located in low land areas in this physical measurement results ,high land area more severe than low land area ,evolution of gully were diversified age the effect of age not influence in this gully but there aggravate causes and community implement of conservation practices.

Interview technique

Gully erosion is determine specifically selected in different climatic zone ,high land moderate and low land climate .In this area primary join Kebeles trained development agent collect necessary documents and discussion formulates high impacts of community around the villages and long years revolution history and short term dangerous to life and difficult mange conservation practices characteristics selected in two Kebeles .Second to determine the sample to selected different age farmers in the village and personal affected by gully erosion farmers in Key informant interview to discuss the history of gully ,age of gully. in addition to, the behavior of gully disturb ecology and environment in this case affects human beings and animals in working and walking of disable and elders the participates community survivor in focus group discussion age category. To understand the age of gully not expected to absolute calendar time, it is useful to consider seasonal happening related events and changed to normal calendar time.

Community reference calendar for interview

1989	partial land reform
1983	down fall of Derege
1978	community resettlement
1975	land reform
1970	Qeyshiber
1966	revolution

CHAPTER FOUR: RESULT AND DISSCUSION

4.1. Description of respondent

The plan of researcher has 100 household participants in the tree Kebeles. Succeed to 100 % sure collected all addressed questioner. In the study area were community culture unaccepted woman works, so from to achieve the objective of researcher were more of the respondents has male so to achieve target. From the total the respondent 29% female and 71% male were selected participants. So to achieve our objective majority of male participants are focused in agricultural practice.

Table 4.1 Age distribution of respondents

Age	Frequency	Percent
18-30	18	18
31-40	20	20
41-50	24	24
> 51	38	38
Total	100	100

From the instance of table 4.1 38% respondents has >51 age, 24% respondents has 41-50 age intervals, 20% respondents has 31-40 age interval and 18% respondents has 18-30 age intervals. So maximum age of the farmers has more experienced in the work area the respondents more advantage accuracy of research results.

Table4.2 Show educational back ground of respondents.

Education	Frequency	Percent
unable to read and write	61	61
able to read and write	34	34
attend to grade 10 certificate	4	4
above attend to grade 10 certificate	1	1
Total	100	100

According to table 4.2 61% respondents has un able to reads and write, 34% respondents has were able to reads and write, 4% respondents were attends to grade 10 certificates and 1% respondents were above attend to grade 10 certificates .To show the results of above table more of the respondents has unable to read and write so its impacts understand new agricultural technology simply it affects productivity of farmers.

Table 4.3: Experience distribution of respondents

Experience	Frequency	Percent
0-3	7	7
4-6	13	13
7-9	11	11
>10	69	69
Total	100	100

Show table 4.3. 69 % of respondents farmers were experience were greater than 10 years,13% respondents have 4-6 years experienced to farming practice ,11% respondents were 7-9 years' experience to farming activity and 7% were 0-3years experience to work agriculture . as we show the result of the above table more respondents were express >10 years' experience of farming practice and experience is real to profitable of livelihood So, it assures advantages to improve productivity of farmers though practical experiences guarantee to food security of Machakel woreda farmers.

Table 4.4 Credit distribution of respondent

credit access	Frequency	Percent	Valid Percent	Cumulative Percent
No	24	24	24	24
Yes	76	76	76	100
Total	100	100	100	

From the total respondents, 76 % respondents favored to credit access, while 24% respondents could not access to credit. From the above table, most of the community members were having

credit access by government available on kebele administration to improve productivity of land and improve crop yield. Farmers challenge was to pay birr in cash for special seed .But available credit access solved this problem.

Table 4.5: Extension service distribution of respondent

Extension service	Frequency	Percent
good Extension service	91	91
poor Extension service	9	9
Total	100	100

From the three Kebeles interviewers 91% respondents were get good extension service from Kebeles DA and 9% respondents were unable gets good extension service to DA. As I have been told from Machakel woreda Agriculture office, Every Kebeles has good extension service and It was assured from survey respondent’s advice for the productivity of farmers.

Table 4.6: Training access distribution of respondent

Traing access	Frequency	Percent
Have to training access	64	64
no access	36	36
Total	100	100

According to the above table, 64 % respondents took training by DA while 36% respondents were with no training access in the woreda. So it indicates more of the respondent access in the Kebeles development agents and additional assure in focus group discussion to any community participation works selective villages development committee members trained by NGOs or government organization. This team leader was given in the team members in community work in practical.

Table 4.7 No. of livestock distribution of respondents

No of livestock	Frequency	Percent
<2	42	42
>2	58	58
Total	100	100

According to the above table, 58 % of respondents have greater than two oxen, while 42% respondents have not own two oxen. It indicates majority of respondents are poor because the first property of farming activity is oxen. Those who have no minimum two oxen farmers have difficulties to farming activity which in turn affects productivity of crop yields.

Table 4.8: Land holding distribution of respondent

land holding	Frequency	Percent
<1hr	50	50
1-3hr	30	30
3-5hr	12	12
>5	8	8
Total	100	100

From the above table, 50% of the respondent has less than 1 hectare of their own land, 30% respondents has six “gemedé” 1.5 hectare of their own land, 12% respondents have 3-5 hectare of their own land. As a result, half of the respondents’ access of land holding is less than one hectare. This amount of land is very small own land tenure which is the basic land holding property of agriculture. There is no land means, there is no crop productivity.

Table4.9. Distribution of family member respondents

no of family	Frequency	Percent
< 3	21	21
4-6 families	47	47
7-9 families	27	27
>10 families	5	5
Total	100	100

According to table 4.9, 47 % of respondents have 4-6 family members, 27 % of respondents have 7-9 family members and 5% of respondents have greater than 10 members of family. This result indicates that more of the respondents have greater than 4 numbers of family members to advocate productivity of their family and prevention of soil erosion.

The result of this research assures that the socio-economic analysis of the respondents express minimum amount of land holding access, medium members of family, average property is low access on pair oxen and average group of age is in medium level age >45 and more households man managed family but special to government qualification (credit access and training access .from full of government employment right positions to logistics artificial manure). Then to improve productivity of farmers more focus has to be given to determine the interest of farmers in labor intensive SWC practice.

4.2 Asses and Map the magnitude of soil Erosion by RUSLE.

4.2.1. Input Data for RUSEL

Quantitative Analysis from GIS data satellites images capture data. Soil loss is most identifying by USLE (Universal Soil Loss Equation) for satellite images uses of GIS and RS (Geographic Information System) technology for quantitatively evaluating soil loss by erosion. Satellite data were analyzes soil type and land use land cover (LULC) maps and slope length/steepness in digital Elevation (DEM) model of the study area and additional secondary soil data and annual rainfall data are the primary inputs use in USLE for formulation of how much amount of soil loss.

4.2.2. Methods and estimates of RUSLE parameter

Average annual soil loss rate was determined by a cell-by-cell analysis of the soil loss surface by superimposing and multiplying the respective RUSLE factor values (R, K, LS, C, and P) interactively by using “Spatial Analyst Tool- Map Algebra -Raster Calculator” in Arc GIS 10.2.2 environment as shown equation (Hurni ,1985).

$$A= R* K* LS* C* P$$

Where, A is the average annual potential soil loss (t ha⁻¹yr⁻¹); R is the rainfall-runoff erosivity factor (MJ mmha⁻¹ h⁻¹ yr⁻¹); K is the soil erodibility factor; LS is the slope length and degree; C is the land cover management factor; P is the conservation practice factor then we computed to each micro water shade of Ketch watershed.

Rain fall erosivity (R) factor

Daily rainfall records from the watershed rain gauge stations covering the period 1995-2019 were used to calculate the rainfall erosivity Factor (R-value). The mean annual rain fall was first generated for getting continuous rain fall data for each grid cell. Then, the R-value corresponds to the mean annual rain fall of the watershed was calculated the R-formula established by (Hurni,1985) to Ethiopia condition:

$$R = -8.12 + 0.562 * P$$

Where R is the rainfall erosivity factor and P is the mean annual precipitation (mm).

R-factor was computed using conversion tool (above equation) in raster surface using spline (Isohytal) interpolation methods in Arc GIS software. As shown in the map below the maximum R-value is High: 1007.27 whereas the minimum R-value is 956.188.

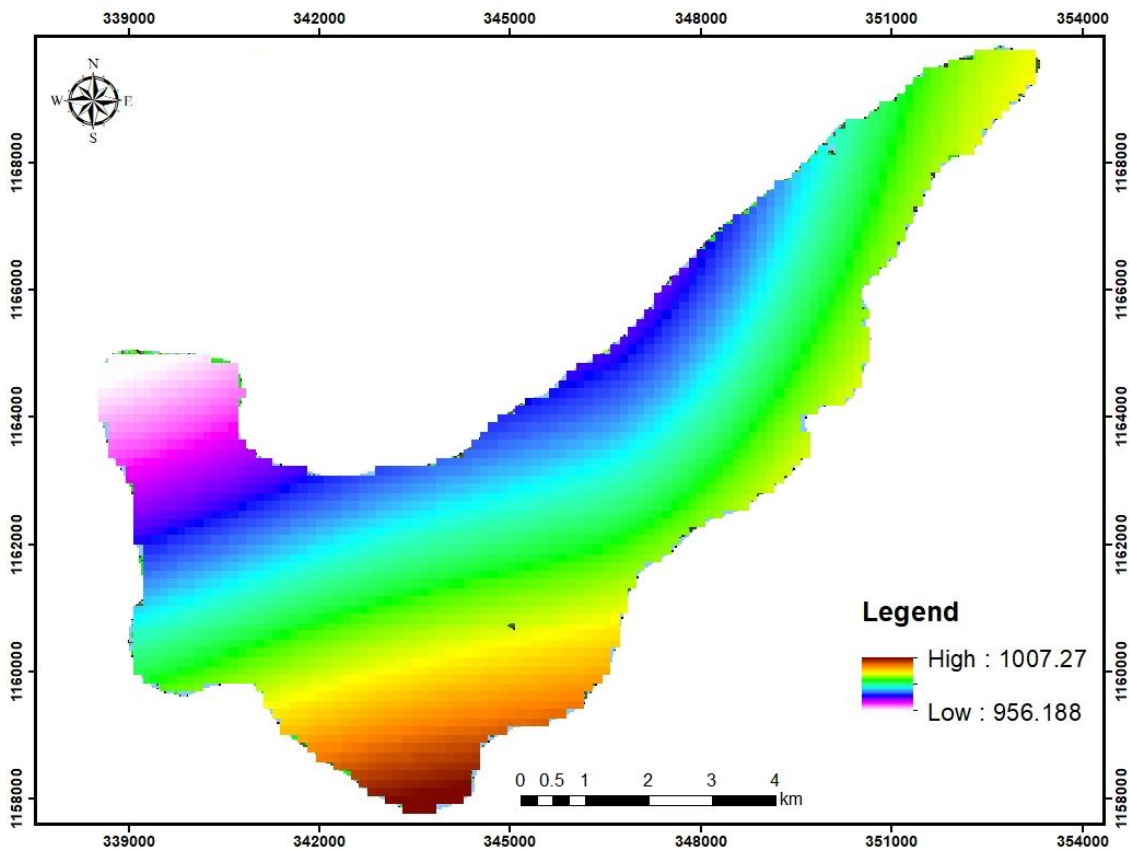


Figure 5: map of Rain fall erosivity factor (R-value) Ketech watershed

Soil Erodibility (K) factor

The soil erodibility (K) factor for the watershed was estimated based on the vulnerability of soil washing rain fall and resistivity of run-off soil unit types referred from soil database adapted to Ethiopia by (Hurni,1985) and (Hellden,1987). Finally, the shape file results were changed to a raster with a cell size of 30x30m. The raster map was re-classified based on their erodibility value as shown below.

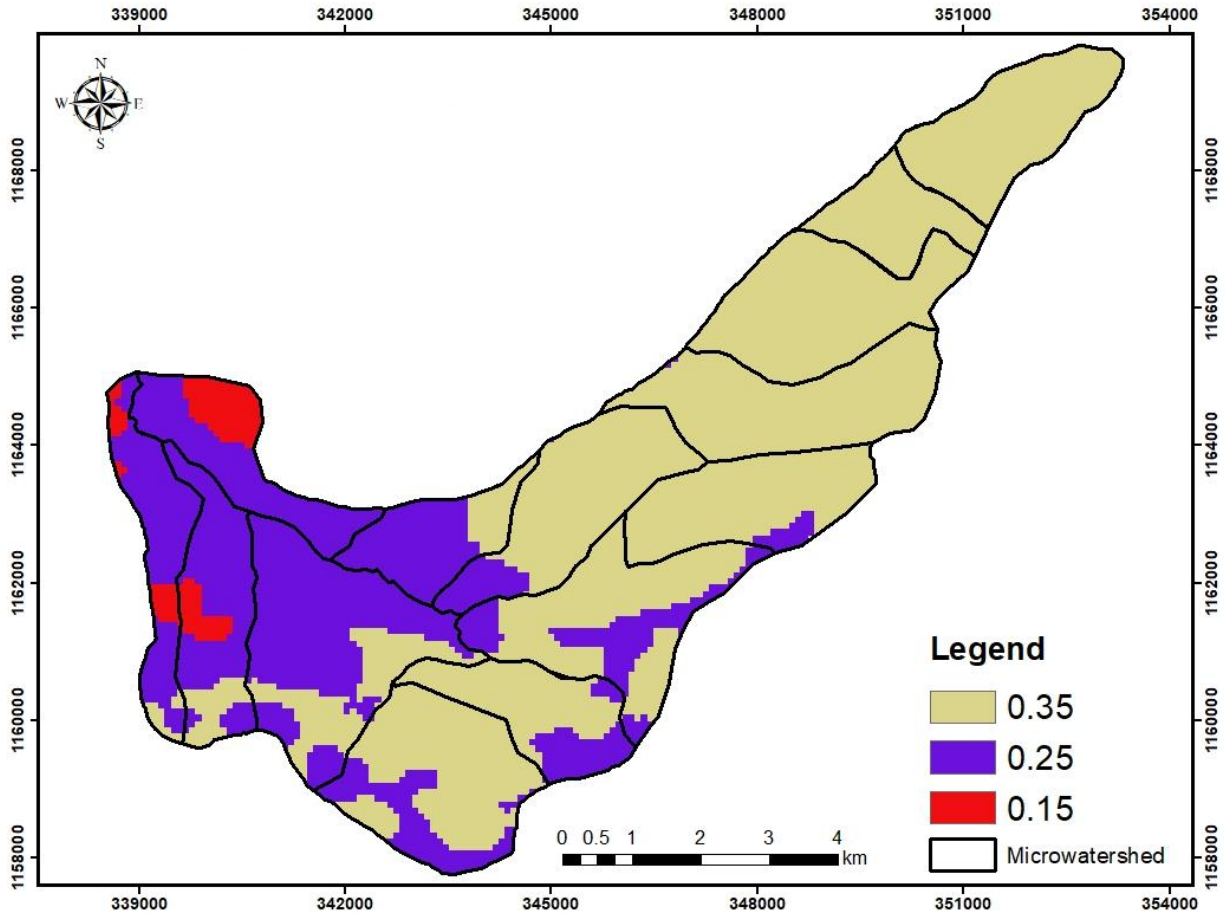


Figure 6: Soil Erodibility factor of Ketch watershed

Slope length and slope steepness (LS) factor

The 30m spatial resolution DEM was employed to map the flow accumulation and slope gradient the study watershed from Nile basin DEM data by using Arc GIS 10.2.2 software. Then by using spatial analyst tool map algebra- raster calculator in Arc GIS 10.2.2 we could calculate and map the slope length and steepness (LS) factor based on equation (01) as defined in (Griffin ,1988).

$$LS = \text{pow}[(\text{flow accumulation}) * \text{cell size}/22.1, 0.6] * \text{pow}[\sin(\text{slope}) * 0.01745/0.09, 1.3] \cdot (01)$$

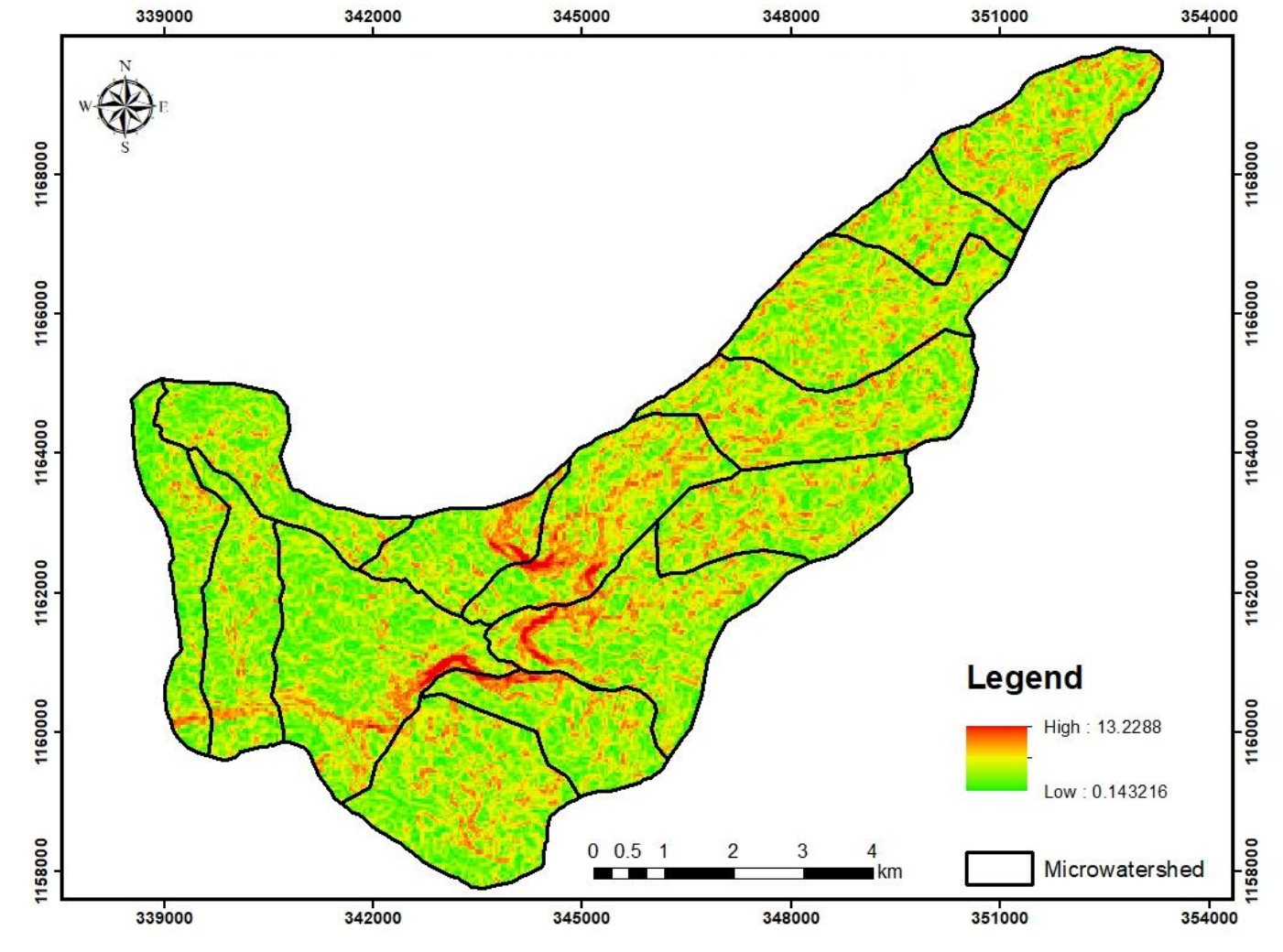


Figure 7: Slop Length and Steepness factor (LS) map of Keteche watershed

Cover management (C) factor

A land use and land cover map of watershed was prepared from Landsat 8 through supervised digital image classification technique using Erdas Image 2014 software. A field checking effort was also made in order to collect ground truth information. In supervised image classification technique, land use and land cover types were classified so as to use the classified image as an input for generating cover management (C) factor and support practice (P) factor. Based on the land cover classification map the corresponding C-values obtained from (Hurni,1985) for all land use types were assigned in a GIS environment

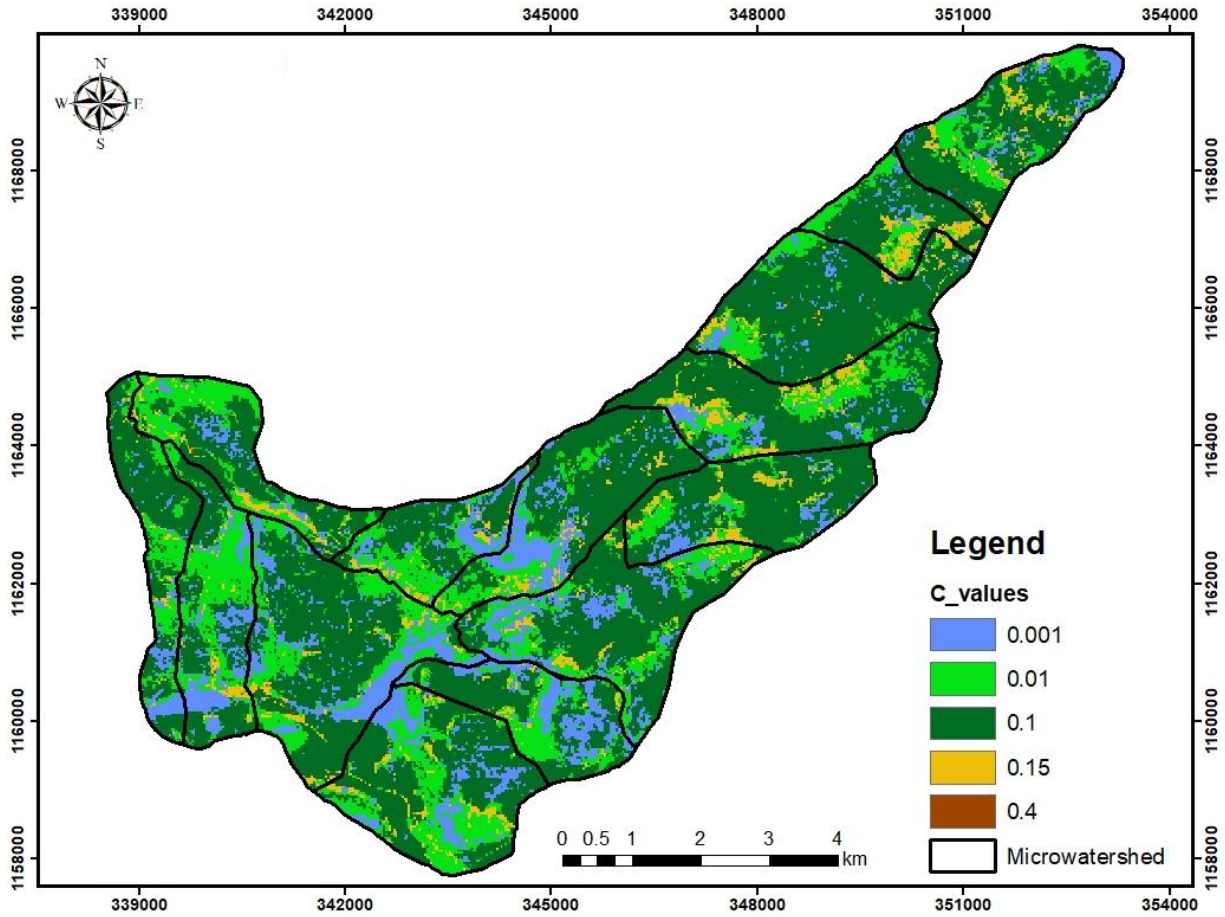


Figure 8: Cover Management Factor (C) Ketech watershed

Table 4.10: The LU LC class and their corresponding C-values

LULC	C-values	Area	%ofarea coverage
Forest	0.001	820.08	13.65012
Woodland	0.01	31.95	0.531803
Shrub/bush	0.01	101.07	1.682296
Crop Land	0.1	3521.34	58.61222
Grass Land	0.01	1180.71	19.65275
Barren Land	0.15	348.48	5.800401
Settlements	0.4	4.23	0.070408

Erosion management practice factor (P-value)

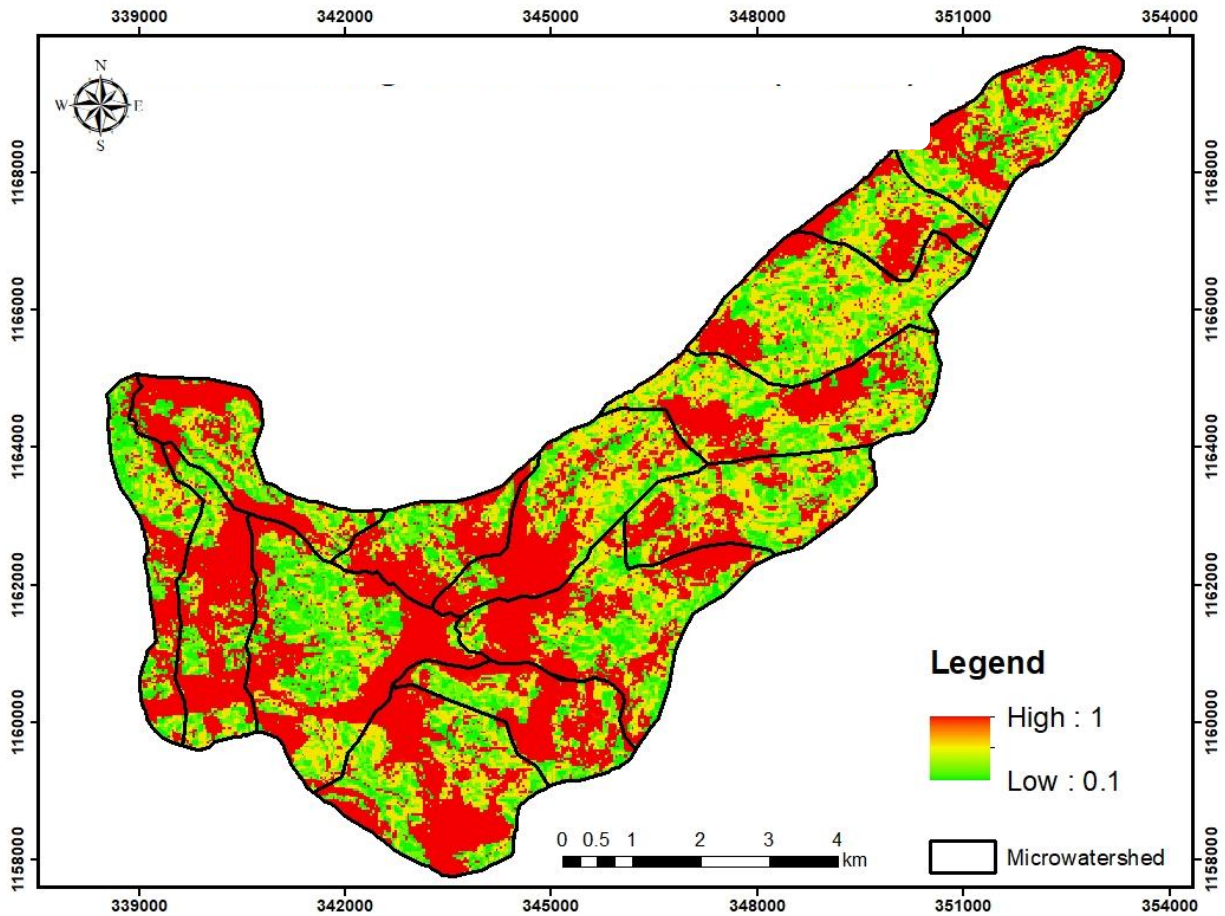


Figure 9: Erosion Management Practice Factor (p-value) ketch watershed

The P-factor was assessed using major land cover and slope interaction adopted by (Wieschmeier and Smith, 1978) for Ethiopia condition. The corresponding P-values were assigned to each land use land cover and slope classes. The P-factor map then was produced through analyst tool, extract and the intersection of land use and slope class map in Arc GIS environment.

4.2.3. Validating the model

RUSLE model parameters process occurring in Ketech water shade represents in annual mean soil loss responses various out puts. Mean annual rain fall around water shade district meteorological station in Dembecha, Rebugebia, Dingaybere, yechereka & Amanuel. The distribution of input rain fall record data station, Amanuel has high annual rain fall records this display more closer to Ketech water shade area, the dependent annual soil loss highly induced in rain fall availability. But to calculate model in average rain fall in region based results its affect the result in output soil loss. In addition, during the field observation all sample Kebeles crop land areas, high depth gully forms in short distance coverage in high steep slope nature, moderate slop and slight slope of area (eg. Amarie Yewebesh) of different land scape soil type, so our result RUSLE of not cover soil severity class because depend elevation based classification of severity classification is limitation of this model.

Using RUSLE model to R-factor using Daily rainfall records from the watershed rain gauge stations covering the period 1995-2019 were used to calculate the rainfall erosivity Factor (R-value) using (Isohytal) interpolation methods in Arc GIS software. The soil erodibility (K) factor soil data base adapted to Ethiopia by (Hurni,1985) and (Hellden,1987) werechangedtoarasterwithacellsizeof30x30m.The raster map was re-classified based on their erodibility value .The 30m spatial resolution DEM was employed to map the flow accumulation and slope gradient the study watershed from Nile basin DEM data by using Arc GIS 10.2.2 software. Then by using spatial analyst tool map algebra- raster calculator the slope length and steepness (LS) factor based on equation-factor of watershed was prepared from Landsat 8 through supervised digital image classification technique using Erdas Image 2014 software field checking collect ground truth information, corresponding each land use land cover and slope classes.

4.2.4. Soil Erosion Estimates and Vulnerability Analysis

4.2.4.1. Estimation of soil loss parameters

It is classified into five rates of erosion severity classes ($t\ ha^{-1}yr^{-1}$): very slight (0–5), slight (5–15), moderate (15–30), sever (30–50), very severe (> 50). This parameter indicates to risk prone areas and to respond priority areas to soil conservation practices (Hurni, 1985).

4.2.4.2. Estimation of mean annual soil loss

Average annual soil loss rate was determined by a cell-by-cell analysis of the soil loss surface by superimposing and multiplying the respective RUSLE factor values (R, K, LS, C, and P) interactively by using Spatial Analyst Tool- Map Algebra -Raster Calculator in Arc GIS 10.2.2 environment as shown in equation (02) adopted by (Hurni ,1985).

$$A = R * K * LS * C * P \quad (02)$$

Where, A is the average annual potential soil loss in $t.ha^{-1}yr^{-1}$; R is the rainfall-runoff erosivity factor; K is the soil erodibility factor; LS is the slope length and degree; C is the land cover management factor; P is the conservation practice factor then we computed all micro watershed of Ketech watershed = **101.97ton.ha⁻¹yr⁻¹ or 612, 561.3 t. yr⁻¹.**

Table 4.11: Soil types and their corresponding K-value and total area coverage

Soil type	K-value	Area -Ha	%age of area	Color of the soil
Leptosols	0.35	278.144	4.6	Gray
Luvisols	0.35	3592.62	59.7	Gray
Nitisols	0.25	1971.48	32.8	Reddish
Vertisols	0.15	166.122	2.7	Black

Source GIS image data interpretation

According to table 4.11, Vulnerability of soil erosion is associated to the nature of soil type and becomes decisive; Ketech watershed has leptosols, luvisols, nitisols and vertisols. These soil types are highly erodible in simple rain. Due to Machakel woreda agriculture office documents, Machakel woreda have 79,556 hr. total area coverage, and 41,584 hr. cultivated land, Ketech watershed 6007 hr. total area coverage based on GIS images map information. 64.4% and 32.8 % of this area (leptosols, luvisols), nitisols soil, its erodibility factor was 0.35 and 0.25 respectively.

It is high possibility of washing by simple rain drizzle rain (0.5/0.02) mm diameter of rain droplet.

More of the water shade catchment is crop land 3521 (see table 3.2) total hectare cover and 12.85 ton.ha⁻¹yr⁻¹ average soil loss in the result of amount of soil loss assume crop land per hectare vulnerable to crop productivity of farmers under risk of food security of community.

LULC of Ketech water shade catchment, 59.7 % was crop land area and large area coverage, it is highly vulnerable human and animal induced soil erosion, improper farming and improper diverted ditch , more means of livelihood of farmers soil erosion affects crop land reduce quality of soil ,reduce moisture content, disturb organic matter of soils ,its result of difficult to plough activity ,reduction of crop growth it results reduction of crop productivity and affects livelihood of farmers consequences of Environmental changes.

4.2.4.3. Vulnerability and prioritization

Annual soil loss of area Vulnerability to soil erosion is concentrated to the nature of soil type is decisive; Ketech has leptosols, luvisols, nitisols and vertisols. These soil types are highly erodible in simple rain. Due to Machakel woreda agriculture office documents Machakel woreda have 79,556 hr. total area coverage, and 41,584 hr. cultivated land, Ketech water shad 6007 hr. total area coverage GIS images map information. 64.4% and 32.8 % of this area (leptosols, luvisols), nitisols soil its erodibility factor was 0.35 and 0.25 respectively it is of high possibility of washing by simple rain /drizzle rain soil large coverage and also have 3,521.34 hr. area cultivated /crop land, their slop were 0-50%, of area is erodibility factor if it also more probability to wash simple rain about (0.5/0.02mm)diameter.

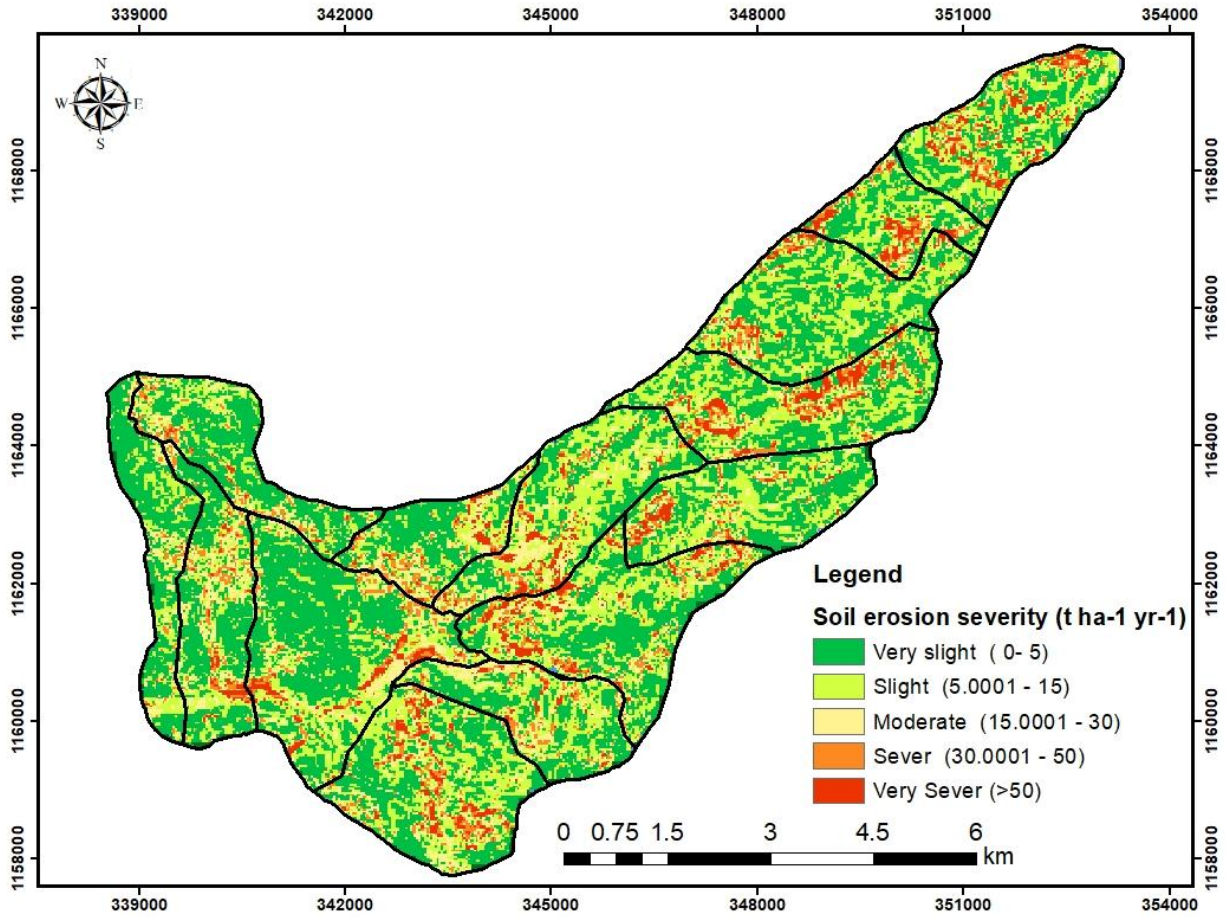


Figure 10: Soil Erosion severity map of Ketch watershed.

Table 4.12: severity classification and annual soil loss ($t \cdot ha^{-1} \cdot hr^{-1}$) percentage and priority

Soil erosion severity	Severity class	Total annual soil loss ($t \cdot ha^{-1} \cdot hr^{-1}$)	Percentage of soil loss (%)	Conservation priority
0-5	Very slight	32.34431	1	Fourth
5-15	Slight	144.39	6	Second
15-30	Moderate	48.1	2	Third
30-50	Sever	0	0	
>50	Very sever	2185	90.6	First

Vulnerability risk classification of the RUSEL model classified in to five categories in terms of annual soil loss: Very slight (0-5), slight (5-15), moderate (15-30), sever (30-50) and > 50 very sever ,so in this category classification of severity (90.6 %) of water shade was very sever covered areas it is highly vulnerable and priority to conservation practices .

Table 4.13: Annual soil loss of each micro water sheds within the Ketech Major watershed

Micro watershed	Area in ha	Min	Max	Mean	Rank
DegaShote	227.728	2.97	111.65	16.57	1
Womberet	410.377	2.48	120.72	16.24	2
Meskamba	527.162	2.14	114	15.37	3
Lay Damot	261.966	1.76	265.59	14.83	4
Quacherie	576.923	2.49	159.31	14.74	5
Wikl	479.833	1.76	208.6	14.52	6
Merechit	564.169	3.02	105.03	14.11	7
Jingidir	323.672	1.67	113.88	12.41	9
Armit	374.521	2.09	159.29	12.2	10
KedusYohannis	692.443	2.11	158.63	11.1	11
KosoAmba	415.59	1.78	106.15	11.07	12
GebtoAmba	522.701	2.93	129.68	9.95	13
Dimuhani	330.949	1.74431	87.078	9.23	14
DingayAgur	299.237	1.73	80.43	7.38	15
Total	6007.27	1.67	265.59	12.85	

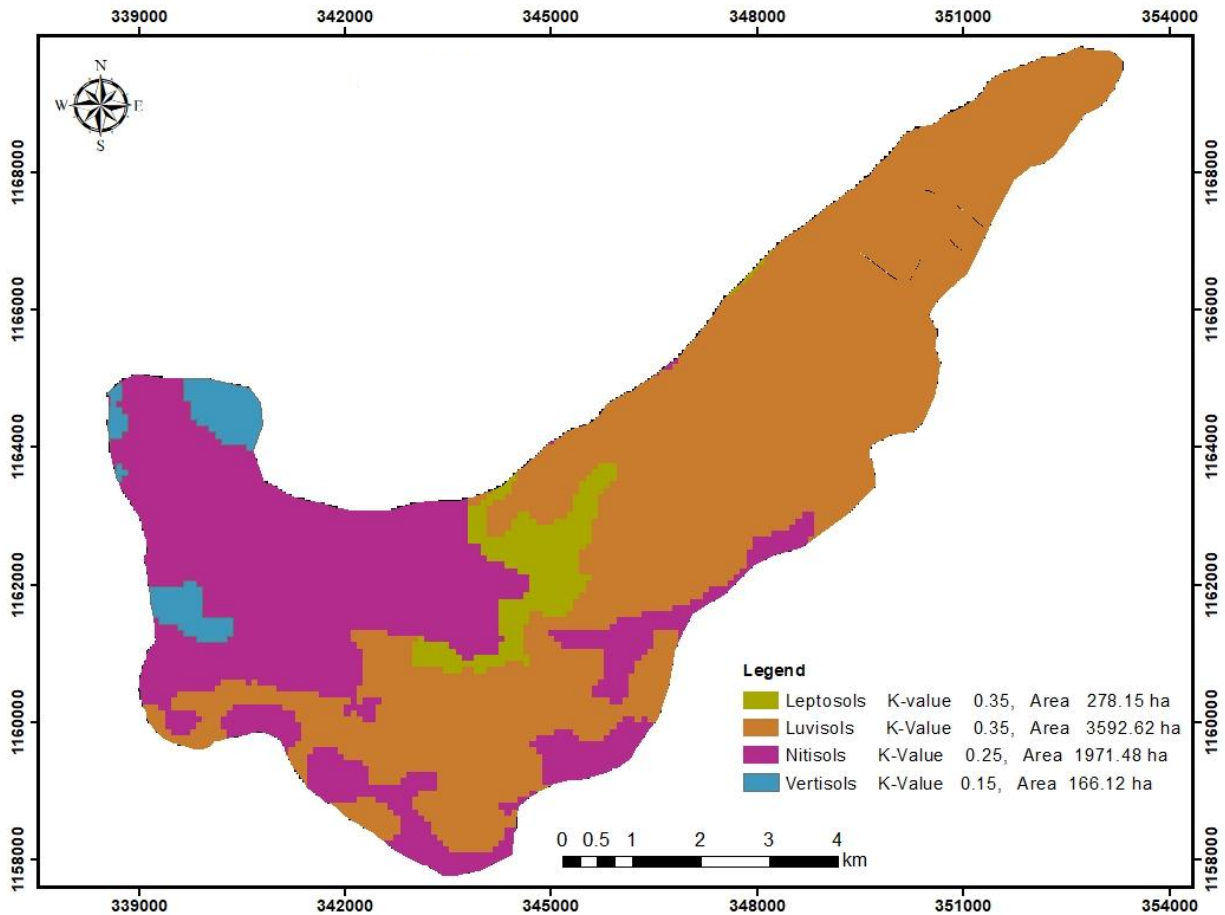


Figure 11: Soil map of Ketch watershed

According to soil map, soil type classification was leptosols, Luvisols, Nitisols and Vertisols, The total area water shade catchment 64 % (3870 ha) land coverage of land erodibility factor is very high (0.35) it aggravate to erosion. So, sever vulnerability to erosion prone area and high area coverage and 1971 ha of land is erodibility factor is 0.25, it is also with high vulnerability and affects crop yields and productivity of farmers to priority to conservation practices.

4.2.4.4. The major Causes of Soil Erosion in study area

According to RUSSEL model results, the causes of study area soil erosion with high vulnerability of soil type are Leptosols, Luvisols, Nitosols and Vertisols with high erodible factor (0.15-0.35). The basic thing to aggravate the causes of soil erosion and the topography of land is those with high steep slope area classification included area >3% it is sever vulnerable areas and erosion management p-factor is (0.1 -0.33) very less to soil prevention management practices to control soil erosion and land use land cover management C- factor (0.001-0.4) almost none of cover management more of land cover is in the catchment crop land (3521 ha.) cover poor management conservation practices its aggravates of soil erosion .

4.2.4.5. Perception of people on the causes of soil erosion

To identify the main causes of soil erosion in the perception of farmers prepared eight common causes of soil erosion and addition to select more than one option and open end to add exclude this option.

Tables 4.14: causes of soil erosion distribution of respondent.

causes of soil erosion	Frequency	Percent (%)
Deforestation	16	16.0
Deforestation , improper plough, over grazing	1	1.0
deforestation, over grazing	2	2.0
deforestation, steepness of land	2	2.0
high rain fall ,high runoff, deforestation, improper plough	1	1.0
high rain fall/ high run off	30	30.0
high rain fall/high run off, over grazing	1	1.0
high rain fall/high runoff, deforestation	3	3.0
high rain fall/high runoff, deforestation ,over grazing	1	1.0
high rain fall/run off, steepness of the land	1	1.0
high rain, steepness of the land	1	1.0

improper plough	5	5.0
improper plough, deforestation, over grazing	1	1.0
over grazing	6	6.0
over grazing, steepness of land, soil being erodible	1	1.0
soil being to erodible	3	3.0
steepness of land	20	20.0
Total	95	95.0

The occurrence of erosion by respondents assured to be 90 % and the indicator perceive different understanding of community and we asked the main causes of this erosion and 30 % of responds replied the main causes of this area high rain fall and high run-off summer season (June-September) the annual rain fall of this region 1200-1800 ml is caused, 20 % respondents thought about are the main causes of this area erosion is the topography of the land naturally steepness of the land is aggravate to high run off flash flood ,16 % respondents the main cause of the erosion deforestation the clearance of forests it cannot reduce/prevent the run-off water ,6 % of responds the main cause of erosion is over grazing unbalanced livestock and grazing grass land .To conclude result triangulates to three focus group discussion participants express the main cause of soil erosion was focus high rainfall and the steep slope of land and the behavior of soil type is erodible to aggravate non-conservation practice land which risks to future life dangerous to survive to food security.

4.3. To Examine the Extents of Gully erosion of different time periods in the study area.

Gully erosion has high challenges of Ethiopian high lands areas. In the reasons of land use land cover problem the nature of land scape the behavior of soil type aggravates of improper utilization of resource so to understand the gully history, extent, trends and patterns of gully its impacts of community, the managements of gully cause and treatment, perception of quensiquence uses AGERTIM (assessment of gully erosion rates trough interview and measurement). The analysis will apply on analyzing data through descriptive and inferential statistic method were be used for data that will be gathered from interview, and personal

observation and physical measurement. Gully will identify areas damages to know their current area, these gully will measure by on the two sides and length of the gully using by field measures and. Both observers on the sides also estimate maximum depths of each gully visually at similar points and average values were field measure for each point. Following this, the maximum depth of each gully was summarized.

Identify the loss of gully Erosion

In the AGERTIM (assessment of gully erosion rates through interview and measurements) methods collecting information in focus group discussion and key informant interview disturb information was given by informant groups found other survivor and cross-checked given information's and it creates time variation ranking uses boring matrix identify to reliable time.

This method, allows assessment of long term gully extension. It combines with current measurements of gully, the evolution of estimated gully dimensions rates could be calculated using:

$$V = \sum LiAi \quad (1)$$

According to the equation the total current volume of four gullies is, **181,514 (m³)**

So, in the long term,

$$RL = V Bd/T C \quad (2)$$

$$RS = (V - V0)Bd/T C \quad (3)$$

where RL =area specific long term gully erosion rate ($t \text{ ha}^{-1} \text{ a}^{-1}$), RS =area specific short-term gully erosion rate ($t \text{ ha}^{-1} \text{ a}^{-1}$), V =total gully volume (m^3), $V0$ = initial gully volume, at the beginning of the considered time span (m^3) T =time span considered (years), Bd =soil bulk density, 1.2 t m^3 (Nyssen *et al.*, 2000b) and C =catchment area (ha).

4.3.1. Womberet gully

To study Womberet gully selected adjacent owner crop land, W/ro Adiss Zewdu 45 years old, and Ato Mekuriaw Minwagawe 55 years old and Sefer Esekemech 28 years old was participants of Key informant interview and 8 member's focus group discussion, were selected in social participation of gully treatment. In this discussion, tri-sect walks to treatment gully to beds of the gully and the head of the gully above the gully, the North side of the gully is hill, the East side of

the gully is Ketech streams very small flow of water almost null in the observation time, and in the south side the mouth of gully the flow of stream banks and in the West side of the gully is good wheat sowing crop residual land in the edges narrow roads. Before the re-settlement of community, seven households were surviving, after settlement the residence of this area were that of “seferatabia ” places with no erosion and gully formation , in addition, this area is covered with sowing , teff, wheat, barely without artificial fertilizers. Ato Mekuriaw said, Woino gully starts in Zemene Derege around in 1979 E.C. fox digging in small hole make small line in streams edge leading to high flood in the summer and the Zemene Dereg this is area is crop land change to Amaga / grazing land in the Kebeles administer and in summer season being livestock home in the night aggravate soil erosion cutting the land / making land slide and intensification of in the width and in the heads of streams and then in the short time creates of high social impact and the cattle was loss of grazing land the owner of land tenure is substitute is far distance and difficult to walk on San Gberel Orthodox Church’s they were not every walked Sunday (is dedicated in the resurrection of Lord).

Table 4.15: Summarize of interview and construct the base map

Seasonal Events	Land use during the event
2000-2012	Forest land treatment
1983-2000	Full of gully
1975	Grazing land and livestock home in summer night
1975	Change crop land to grazing la in land reform
Before 1965	cropland, Home land

Wonberet was long age gully in a few all direction of the head and the side were wider and wider at this time the residence of the villege discuss in “idir” and tradational association agreement to Sunday on church they are ask rerepresentative of governements ,so government give responses to join SLM project supports gabion wire proffesional advice and the community collect stone make treach and gabion and planting trees . So, at this time the gully of womberet is treated and give ecological advancement to community.



Figure 12: Images of Womberet gully in different time extent

4.3.2. Ketch gully

The age of the key informant interviewer, a 28 years old, said he knew the gully when he was going to school from elementary to high school as it was difficult for him to walk especially in the summer seasons and rain with high floods. We estimate age around 22 years old in the references of Sefer Stemch happen the gully. In addition to this, based on the information from documents ,the owner of adjacent two crop lands non surviving to this woreda ,the land was

managed by another person in rent of yields, this case highly affects to aggravate soil erosion and also land slide and gully formation. Because they cannot feel ownership/privatize and monitoring and conservation to soil erosions.

In the other key informant interviewer to manage the land temporarily in rent to yields, he said the awareness of Ketech gully the owner of the land tenure and family member and the beginning of the gully started before 1983, the owner went to Addis, sowing the farm. During beginning the plough between the two adjacent boundary of width 80 cm at the center small canal compared as ox-drawn tillage line/fer-like canals. After two years this canal changed to small gully which is difficult for a child to walk or pass but high adolescent walks. But now a days forms high gorges with the total area coverage of 11 ha. and volume of Ketech gully is $9093\text{m}^3/\text{yr}$.



Figure 13: Partial picture of untreated Ketech gully

4.3.3. Shembeko gelebet

Embulie yewebesh have different gully in the nature of soil type and the nature of landscape. Ketech water shade catchments were the last tail mouth to tributary to Temcha river many cubic meters floods flow in the many direction creating canals steep slopy topography covered long distance. Shembeko gelebet gully have around this area different gully happen in different time. This research were selected Shembeko gelebet (a) and Shembeko gelebet (b) ewre respectively.

To understand these gullies we would selected impacted person affected farm land tenure two person in type (a) and type (b) key informant interview and one five members focus group discussion deployed data so we will discuss detail:

4.3.4. Shembeqogelebet

Embulie yewebesh have different gully in the nature of soil type and the nature of land scape Ketech water shade catchments were the last tail mouth to tributary to Temcha river many cubic meter floods flow in the many direction creating canals steep sloppy topography covered long distance. Shembeko gelebet gully have around this area different gully happen in different time. This research was selected Shembeko gelebet (a) and Shembeko gelebet (b) were respectively. To understand these gullies we would selected impacted person affected farm land tenure two person in type (a) and type (b) key informant interview and one five member's focus group discussion deployed data so we will discuss detail:

4.3.4.1. Shembekogelebet (a)

Forms East to west flow of Mekelan shite small tributary spring . Based on data process I was join in the key informant tri sect walks collect information this gully begins 1974 in crop farm lands tenure (Ato Ademe) in the causes of Mekalem shite floods .during the beginning of erosion the canal of tributary approximately 60 cm width and 80 cm depth to saw sample canal to living around observation time starts .the owner of farm during show landslides saw ignorance because the bed is the foot of grazing land used as being control of cattle/like a fence. after a year cutting two dimensions made huge gully soluble move many segments like circle in the north and south sides .The home of the land tenure in this area in the north /left side a fare from 100 m .Then he is very exited it crack sign to slide part of surface .so this person apply to government of offices in the Woreda and kebele administration high risk .At this time RCC project join support community in2002 E.C. farmers in conservation of natural resource and prepare planting plants. During this time the owner is former planting trees and made gabion .the gully were relief through treatment .this practice appreciation and learnable .The gully total area covered 2.5 ha. of land was damaged in erosion .

4.3.4.2 Shembekogelebet (b)

Shembeko gelebet (b) located the back of type (a) 200 meter length and average width 12 meter and depth 4 meter depth total area coverage 2.4 ha to understand the history and behavior of this gully selected personal impacted farmers uses in the key informant interview join and trisect walks around the gully to discuss begins before 2008 E.C. edges Ato Meselu Birhanu 's land the causes human induced action of conservation practices to relief type (a) diverting floods made a ditches above the type a gully hills collected round catchment floods ,land scape normally steep slope and around crop land farmers made canals one direction. Left and right side tillage's canal collects in center cone shape flow make rill erosion in adjacent farm lands. In the focus group discussion the participant's information there is no different from key informant farmers but gully before two years were relief but aggravate the gully in short time to impacted Ato Amare Tilahun's land. And the whole Shelel –Sedeye ' travel roads were damaged the village elders and animals very difficult to walk high impacts to society movements to market, jobs any social interaction.



Figure 14: Partial Images of shembeko gelebet (b)

This gully unlike to different others, created fast high impact untill now. But to the next summer to avoid huge area coverage to save two adjucent lands it is required to apply integrated community participation coservation practics and above the gully implement conservation practice terracing mainly diverting canals. It can be concluded from key informant interview and

consecutive focus group discussion that conservation practice was not done in common good resources roads, after relief was restarted and happened it is important to implement gabion and trench stop simple unavoidable resource and labour.

4.3.5. Result of the research

The total gully assessment of four gully Womberet is AGERTIM (assessment of gully erosion rate through interview and measurement methods told in the key informant information is 33 age the evolution of width depth proportion is 3:2 and total area coverage is 411 ha. ,and Ketech gully was in the key informant obtaining information 29 age and in the field measuring on the observation time 11.16 ha .and proportion of width depth in the quensiquence 2:1 the evolution is very delay with in age .Shembeko gelebet with in the key informant information is 28 years now in the measurement time the gully is stopped with in years conservation practice in 2002 E.C and total area drainage in current measuring time is 4.2 ha in addition to focus group discussion the quensiquence of gully width depth dimensions ratio 3:2 the fourth gully Shembko gelebet (b) this gully due to key informant obtaining information and focus group discussion 4 years age and total area coverage dimensions of quensiquence is width to depth ratio 3:2 .it is very young and high impact .

Table 16: Total area coverage and total volume of sample gully

Location	Total area coverage (hectar)	Total losse of (m ²)per year	Years of begins
Womberet	411	168921	1979
Ketech	11.16	9093	1984
Shembeko gelebet (a)	4.2	2500	1974
Shembeko gelebet (b)	2.5	1000	2008

4.4. Perception and knowledge of people on Soil Erosion and Gully and its Determinants

4.4.1. Perception on the extent, magnitude, coverage and impacts

In the Machakel woreda has different agro-ecological zone from 2000-3300 altitude, 58.7% of area are dega, 39.1 % of land is woinadega and 0.092 % of land is partial kola areas .From this

different classification take three sample Kebeles, Degasegne has high altitude, Debrekelemona middle altitude and Amariyewobesh low altitude areas .This three Kebeles represent Machakel woreda whole agro-ecological Zone to understand the perception and knowledge of farmers indicates. So to identify the perception and methods of symptom of occurrence on soil erosion crop land prepare four close and open ended survey questions to ask 100 households.

Table 4.17: Farmers perception of soil Erosion distribution of respondent

Farmers perception of soil erosion	Frequency	Percent
No	9	9
Yes	91	91
Total	100	100

According to table above, 91 % of respondents understand to happen soil erosion their farm while 9 % of respondents do not know soil erosion to happen in their farm, the majority of households assure soil erosion exists in their own crop land. But it not conclude only this result, then triangulation qualitative data “explain” Or add depth to quantitative findings , (Dzurec And Abraham ,1993).Focus group discussion and field observation on around crop land , majority of focus group participants told us more of crop farm lands have sever soil erosion in the summer season laying the reason the nature of woreda topography is steep down and there in no land cover (deforestation, the nature of soil is red color mererie / leptosols it is less resistivity droplet of rain.in addition to average rain fall is 1200-1800 ml/year .it creates high aggravate to soil erosion .due to the field observation time .we observe in three Kebeles around crop farm land there is difficult to walk different size gully ,and I will digging to in small depth ,the soil was dry and stiff stony soil and understand soil was washed deeply make rill erosion exposure to floods we assure in the summer season have highly run-off flash flood. As a result the researchers conclude that in the sample Kebeles exist soil erosion selected Kebeles was different agro-ecological zone, all of zones have seen soil erosion all over woreda has assure soil erosion.

Table 4.18: The occurrence of /indicators of symptom of soil erosion of respondents

The occurrence of /indicators of symptom of soil erosion	Frequency	Percent
All	6	6
crop yield reduce annually	39	39
deposit soil on level land after rainfall	2	2
fertile soil seen down slop in furrow	9	9
rill observed on farm land after rain	13	13
sandy soil occur on top of farmland	14	14
the color top soil is changed	7	7
the color top soil is change, crop yield reduce annually	1	1
Total	91	91

The respondent of the interviewer are assure soil erosion exist in their farm, how to identify soil erosion the indicator of soil erosion seen in the farm listed simple 8 choose the option. So the symptom 39 %of respondents are to occur the reduction of crop yields, 14 % of respondents are sandy occur on top of farm land ,13 % are rill observed on the farm land after rain remove of top soil to form a canal like line seen,6 percent of respondents indicates the whole symptom occur on the crop land. The topography of Machakel woreda is steep the slop of land is in the Ketch water shad 0-50 percent and the formation of soil is highly erodible less resistivity of rain droplets 01-.33. This is highly affected to summer floods and less land use land cover practice in the woreda.

Table 4.19: respondents think Problem of soil erosion on farm land

Results of respondent	Frequency	Percent
Yes	90	90.0
No	5	5.0
Total	95	95.0

According to table 4.19, 90 % respondents replied soil erosion being problem to farming activity while 5% respondents replied as there is no problem with soil erosion consequences. Majority of the respondent's soil erosion creates problem in the farming activity. We conclude that based on the above results and the evidences of during field observation time high problem plowing activity of farmers to create high gully and forms landslide between adjacent lands.

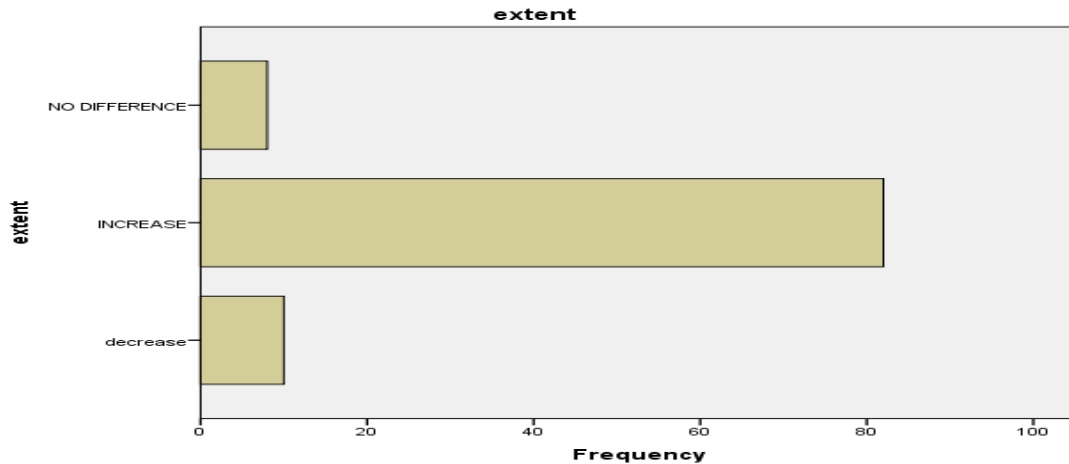


Figure 15: The extent of erosion distribution graph

The extents of soil erosion increases from time to time as 82 % respondents expressed, 10 % respondents expressed the decrease of the extent of erosion, 3 % of respondents replied as there is no differences now and before. Due to the GIS images results indicate the slope of the land is very high to susceptible to erosion and the nature of the soil (Leptosols, Luvisols, Nitisols and Vertisols) is also high erodible access to simple rain fall and the result of arc GIS information to support the house hold survey evidences and to assure in the field observation time the extents of Machakele woreda erosion is increased time to time, it is of high risk around the community of Ketch watershed.

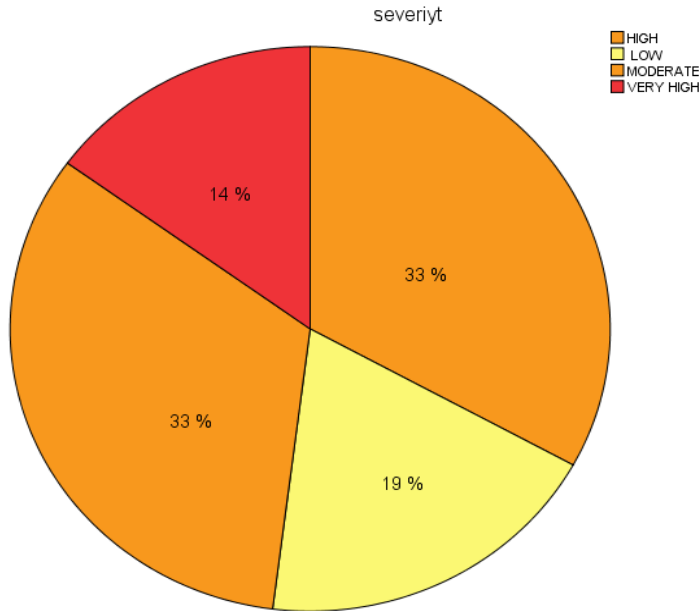


Fig 16: The severity of soil erosion in study area

According to fig 10, 33 % of respondents the severity of the erosion is high & moderate impact to the crop land and productivity of farmers, 20 % of respondents the severity of erosion in their crop land low impact of land and 14 % of respondents express very high severity of erosion on farm and average severity of study area 60% degree of severity risks and field observation and the result of focus group discussion and indicates, evidences the severity of soil erosion of farm land very dangerous condition and high risk to productivity of farmers diversified different size of gully the consequence of livelihood and Environment its priority SWC practice.

4.4.2. Reasons for perception variation among the People

Perception of farmers to pertain the vulnerability of livelihood to consider food security faces to challenge soil erosion demarcates different reasons through the nature of demographic, level socio-economic, institutional and topographic factors significantly related with farmers' perception of soil erosion. So, this determinants is depend on the perception of farmers different reasons, economic viable, Knowledge of local environment, taking formal and informal learning, day to day experience to face soil erosion problem depend to demographic determinants (sex, age, educational back ground and family size), economic factor (land holding, livestock) and institutional determinants (training access, extension service and credit access) would be

impacted. To analyses this determinants use logit Econometrics statistical methods after adapting them to the problems of economic life and personal aspect.

In the econometrics literature, logit and probit models may be used to analyze discrete dichotomous variables that influence farmers’ perceptions of soil erosion (Verbeek, 2003). These models use a binary choice variable as the dependent variable. As (Baidu, 1999) point out; there is possible loss of information if a binary variable is used as the dependent variable. This is because knowledge of whether a farmer perceives or does not perceive soil erosion may not provide sufficient information about the farmer’s behavior as farmers have various extent of perception on soil erosion. The use of ordered dependent variable is very informative because severity of the problem such as soil erosion is likely to determine actions taken to alleviate it. Following (Verbeek, 2003), the general ordered logit model can be specified as;

$$Y_i^* = \beta' X_i + i_i \dots \dots \dots \text{Equation 1}$$

Where;

- Y_i is the underlying unobserved (latent) variable that indexes the level of perception of soil erosion,
- X_i is a vector of explanatory variables describing farm, household and institutional characteristics,

β 'are parameters to be estimated and

- ϵ_i is the error term, assumed to follow standard normal distribution.

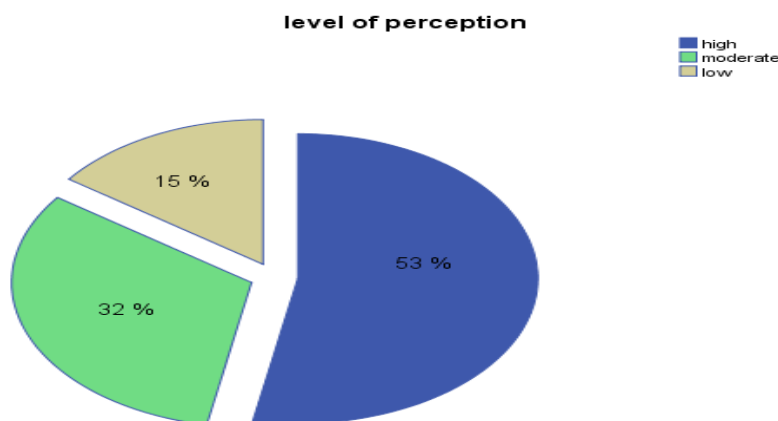


Figure 17: Farmers level of perception on soil erosion chart

According to the above graph to know the level of perception of people 53 % of respondent's high perception of soil erosion, 32 % of respondents the level of perception is moderate and 15 % of respondents has the level of perception is low being assure to the results. To indicate the results more of the knowledge of people is high, so farmers to understand the causes and the occurrence of erosion to solve the problem and the consequences of erosion and conservation practices.

In addition to the reason of different of perception of people is the determinant of perception

Table 4.20: Determinants of Farmers' Perception on Soil Erosion in Logit Estimation model in Study Area.

VAREBLES	ESTIMATION (B)	STA.ER.	WALD	DF	Sig.	Exp(B)
[perception=1]	-353	2.729	0.17	1	.879	
[perception=2]	1.135	3.155	0.129	1	.719	
SEX	.077	.122	.072	.635	.528	1.205
AGE	-.012	.042	-.031	-.283	.778	1.127
EDUCATION	-.120	.059	-.224	-2.036	.045**	1.131
EXPERIENCE	.078	.037	.233	2.124	.037**	1.127
CREDIT ACCESS	.140	.783	.032	1	.858	1.150
EXTENTION	.296	.166	.251	1.786	.078	1.842
TRAIING	-.301	.172	-.230	-1.748	.085	1.619
LIVESTOCK	-.126	.101	-.138	-1.243	.218	1.152
LAND	.149	.048	.330	3.072	.003***	1.075
FAMILY	-.008	.053	-.016	-.145	.885	1.076
Chi-square $\chi^2 = 45.09$		p –value = 0.000				
-2 Log likelihood = 130.138^aN=100						
Nagelkerke R² = .195						

**Significant at <5%

***Significant at <1%

The perception of farmers assures in the parameter of likelihood ratio, goodness of fit test shows a good fit for the model. The confidence of interval (χ^2) statistics testing that the coefficients of the model excluding the constant term, are highly significant (at $P < 0.001$) supporting the specification. The signs of five (50%) explanatory variable show non-significant ($p > 0.10$), two explanatory variables (extension service and training access) indicate marginal significant to perception of farmers on soil erosion and also two of them (Education and Experience) indicates significant evidences ($0.01 < 0.05$) estimation parameter. Land is highly significant explanatory variable to this research estimation parameter. Half of explanatory variables have estimated parameters assure expectations. As the result one value of odds ratio add in significant explanatory variable change on dependent variable on perception, positive sign indicates positive effects of perception and negative sign indicate influences of dependent variables. To conclude soil erosion of farmers perception to increase in the values of positive independent variable and negative effects have suggest reduction.

4.5. Impact of Soil Erosion and gully on the reduction of crop production on households.

The degree of soil erosion is expressed in all erosion subtypes in qualitative and quantitative terms as an impact on productivity (negligible, light, moderate, strong, extreme impact). Classification is based on estimation of the changes in quantity of yield productivity and also takes the level of management into consideration. Changes in productivity are expressed in relative to current crop average productivity status of farmer's survey compared to the average productivity in the secondary data of Machakel Wereda agriculture administration office.

The data analysis of this research depends on both quantitative and qualitative approach. The primary data collected from sampled household were be processed and analyzed by using the Statistical Package for Social Scientists (SPSS). The survey data will be analyzed and interpreted by using descriptive statistics such as mean, standard deviation, frequency distribution, percentage and will use chi-square test. And, the qualitative data obtained through key informant interview, field observation and focus group discussions will analyses by narrative analysis, it makes to sort-out and reflect up on them, enhance them and present in a revised shape and

triangulate with the quantitative data to analyze effect of the reduction of crop productivity in the cause of land degradation on household.

4.5.1. Erosion impacts on agriculture practices and yields

Soil erosion assure in the above table 4.17, results exist in the Machakel woreda, due to in the Machakel woreda agriculture office have 20,465 households live agricultural depend livelihoods, so soil erosion highly affected To evaluate impacts of soil erosion on physical activity /farming activity and its quensiquence.

Table 4.21: thought of soil erosion impact on the farming activity respondent

Do you think soil erosion impact on the farm land	Frequency	Percent
Yes	92	92
No	2	2
Total	94	94

Then to evaluate the perception / awareness of farmers, I ask related to the above question to invite 100 households from three Kebeles the result of descriptive statistics summarized in below table.92 % of the responds of participants are there is impact in or disturb in farming activity ,2 % respondents are there is no problem creates in the farming activity . But not this result only enough to conclude to assure seem like in other discussion this question is one parts of focus group discussion title on the discussion time speaks difficult to farming activity ,in addition to this we express in the above field observation trisect walk in the three Kebeles farm land areas .as time of this observation seen many places too difficult to plowing huge gullies.so, as a result I conclude soil erosion is in the study area are highly impact of farming activity.

Table 4.22: Soil erosion impact of farming activity distribution of respondent

Soil erosion impact of farming activity express	Frequency	Percent
plowing activity	71	71
All	8	8
harvesting activity	3	3
plowing activity, sowing activity	2	2
sowing activity	2	2
weeding activity	2	2
labor loss , reduction of crop	2	2
plowing activity, weeding activity	1	1
plowing, harvesting activity	1	1
Total	92	92

According to table 4.22 Soil erosion conclusion, the impact of farming activity, farming activity takes place from preparation of farming /plowing to harvesting of yields which activity is more difficult to work to assure this activity prepared open and closed ended question invite in households , Between of 100 households 71 % participants respond difficult to work /farming activity is plowing activity is difficult to work, 8 % responds plowing, sowing weeding activities are difficult to farming activities, in the open ended questions participants express impacts in labor loss and reduction of crop ; in addition to this results of statistics in the group discussion between the group members for example , one of the participants Ato Mekuriaw Minwagawe said; it is too difficult to the activity of plowing , during plowing oxen afraid off the gully to close end of a side and back to the center it is time taken .the other 13 % responds sowing, weeding and harvesting activities are impacts in farming activities. We concluded that soil erosion impacts of farming activities and tillage are labor intensive.

Table 4.23: Time Duration soil erosion tables distribution of respondents

Time Duration soil erosion tables	Frequency	Percent
In the last 20 years	28	28
In the last 15 years	16	16
In the last 10 years	29	29
In the last 5 years	20	20
Total	93	93

According to table 4.23 Soil erosion impacts of farming activity in the above results, impact influences in tillage activity. When to start effects of disturbance activity to know duration of impacts in agriculture prepared four option questionnaires and collect data from 100 households. Then the statistical results of these data displays 29 % respondents impact of soil erosion happens in the farm land the last 10 years said 28% participants of household respond in this questioner impacts of soil erosion happen the last 20 years would answer, 20% respondents has express soil erosion impacts happen in the last 5 years and 16 % of respondents.

Table 4.24: Impact of soil erosion on crop yield distribution of respondents

Do you think soil erosion impact on the farm land tables	Frequency	Percent (%)
Yes	92	92
No	8	8
Total	100	94

As shown in table 4.24, soil erosion also impacts on directly and indirectly crop yields. Productivity of crop in their farm it gets fertile soil suitable moisture and suitable whether condition in this research to assure soil erosion direct affects farm land in loss of nutrient. Decline of nutrient's land it can affect quantity and quality of crop .according to table below show results indicates 91 % of respondents agree to soil erosion impacts on crop yields but 2% respondents soil erosion cannot affect crop yields , we conclude this result from the above results of this paper in the study area soil erosion is exist in the three focus group discussion and household survey results and arc GIS results of Ketech water shade catchment area as show this

result soil erosion is exist and affects Machakel woreda farm land, we conclude that it can exist soil erosion it also decline nutrient happen so exist crop yields impacts on quality and quantity.

Table 4.25: Soil erosion seriously impacted crop type show table

Soil erosion seriously impacted crop type show	Frequency	Percent
Teff	54	51
Wheat	20	20
Barely	13	12
Potato	4	3
teff , wheat	3	2
All	2	1
Maize	2	1
teff, barely	2	1
Total	100	91
Missing	9	9
Total	100	100

In the above results, it is shown that soil erosion impacts on crop yields .In Machakel woreda the main produce crop are wheat, barely, teff, potato and maize, widely suitable for agro-ecological zone. In this crop type which is seriously impact by this soil erosion. identify to this affected crop ask you 100 households as an shows above table 4.25 and cross sectional to focus group discussion, 54 % household respond seriously impacted crop is teff,12% household respond highly impacted crop is wheat. Less impacted crop type maize 1% respondents express. As indicates teff highly affected in soil erosion and highly susceptible to climate change its found fertile soil and depth, favorable condition but very necessary to community stable food suitable to health.

Table 4.26: Trends of impact soil erosion on crop yields distribution show table

Trends of impact soil erosion on crop yields	Frequency	Percent
Increase	90	90
Decrease	3	3
no difference	1	1
Total	94	94
Missing	6	6
Total	100	100

According to the above table result of erosion impact on productivity of land serious products of local of crops, in duration of soil erosion happen results above maximum one decade and half years. so this impact were sequences year to year to know the trend of this change were understand to this research ready to this close ended questions to surveying in sample households .respondents are given 90% household responds the trend of soil erosion impact were increase time to time, 3% household respond are the trend of soil erosion impact was decrease time to time .1% household respond no differences impact of soil erosion in crop productivity. As a result of this table the trend of erosion increases year to year and relatively the impacts also increases. Soil erosion always exist a decline of soil fertility, no proper plant growth and we cannot get good result of crop.

Table 4.27: decline of yield/hr. respond distribution table

shows decline of yield decline /hr.	Frequency	Percent
1-3 q./hr.	51	51
4-6 q./ hr.	32	32
6-8 q./hr.	7	7
>10 q./hr.	1	1
no difference	3	3
Total	94	94

According to above results it can be concluded that soil erosion impacts on crop yield. The trend of the impact increase to year to year, this impact more seriously affected teff and wheat products ;So this decline amount of product quantity to know and understand the difference year

to year we prepare closed and open ended survey question to sample Kebele household and discuss focus group discussion. We ask household survey question invite 100 sample. From sample respondents 54% of respond 1-3 quintal per hectare reduces in one product seasons and 34% of respondents 4-6 quintal per hectare of product reduce in one product season 7% of respondents 7-8 quintal product of yield reduces per hectare per year and the other 3% respondents there is no differences year to year will respond.

As the result half of the respondent assures the 1-3 quintals per hectare of yield is reduces annually. This number is high impacts of food security in the community in addition to majority of respondents less than one hectare land tenure, 1 hectare by local measure instrument 3 'gemedes' from this plot of land 1-3 quintal product was reduce the livelihoods of community is dangerous to survive. In the community land holding capacity is less they cannot access to enough land tenure especially in adolescent managed household because land was reform and distributed in 1975 E.C. After this year there is no land reform, becoming this year born residences they cannot accesses enough land so in this amount of yield would be decline of products the community food security of this means of livelihood will be challenges. In addition to this this household survey result cross-section to Machakel woreda agriculture office documents average cultivated area 41,584 hectare and five years crop yield data collects in secondary data, 2007-2012 crop yield season, 2007-2008 as a base line data relative to becoming years, as show the table 6%, 3%, 13%, 18% reduce year to year respectively and the amount of yields reduction.

4.5.2. Direct Impacts of soil erosion

Table 4.28: Consequences soil erosion on farm land shows respondents

Consequences soil erosion on farm land shows	Frequency	Percent
All	11	11
reduction of crop growth	3	3
reduction of crop yield	49	49
reduction of soil fertility	22	22
reduction of soil fertility, reduction of crop yields	1	1
reduction of soil fertility, reduction of crop	1	1
reduction of soil fertility, reduction of crop growth	1	1
reduction of soil fertility, reduction of crop yield	1	1
Total	89	89

The consequence of soil erosion reduction of fertility ,loss of nutrient ,acidity of soil , reduction of yield, difficult to farm activity additional labor west and influences productivity of farm and farmers. Generally to prepared three common criteria to identify the consequence of the study area. the surveying respondents three clear closed options questioner and additionally specify inviting open criteria of consequences, from 100 sample households 89 % respond properly the other 11% is not answer given; then 49 % of respondents the consequence of their farm land is saw reduction of crop yields , 22 % house hold responses the consequence of this area reduction of soil fertility ;11 % response gives all criteria of consequence’s (Reduction of crop yield, reduction of soil fertility and reduction of crop growth) express this way,3 % of respondents reduction of crop growth and the other 4% respondents,1% for each grouped consequences ,(reduction of soil fertility& reduction of crop yields), (reduction of soil fertility& reduction of crop), (reduction of soil fertility and reduction of crop growth) and(reduction of soil fertility & reduction of crop yield) selected responses , so assured other researcher the consequences of soil erosion in the study area results reduction of crop soil fertility and reduction of crop growth all are the last result of land degradation is reduction of crop yields its indicator of loss of soil fertility and its affects the normal condition of crop not enough content /mineral and moisture retention depth of soil to deep rooted crops like maize and potato items highly affects its simply dry and strong soil cannot productive sowing of this area . we can understand this house hold survey and arc GIS documents of Ketch water shad high vulnerability of topography ,behavior of soil the LULC management of the woreda and SWC of farmers conclude that don’t doubt this result divisible to focus prevention methods .

4.5.3. Indirect Impacts of soil erosion

Table 4.29: annual crop production Machakel woreda

No	Production years in E.C	Production in quintal	Difference per year	Average relative to base line in%
1	2007-2008	2.25 million quintal	Base line	---
2	2008-2009	2.12 million quintals	0.13 million quintals reduce	6%
3	2009-2010	2.19million quintals	0.06 million quintals reduce	3%
4	2010-2011	1.97 million quintals	0.27 million quintals reduce	13%
5	2011-2012	1.86 million quintals	0.39 million quintals reduce	18%

Source: Machakel woreda agriculture office

Crop yields increase by half indicates decline soil fertility. Reduction of crop production different reasons have in this case I would ask professional crop development officer in Machakel woreda , he said the reason of this reduction of yields to be 'soil degradation, soil fertility decline, climate change, optimum rain fall, variety adaptation , lack of special variety , disease and pest invasion ' being gives technical suggestion. This concludes that relatively the focus group discussion, statistics, and office secondary data in the average productivity /hectare.

Table 4.30: measure taken to prevent the reduction of crop productivity respondent tables

Variables of indirect impact	Frequency	Percent
use in organic fertilizer	76	76
change crop type	12	12
use in organic fertilizer, use organic fertilizer	4	4
use inorganic fertilizer ,change crop type	2	2
Total	100	100

The reduction of crop yields assure uses the three data collection instruments, household survey, three focus group discussion each sample Kebeles, Machakel woreda agriculture office in the source of secondary data. Farmers' to improves crop productivity in the world use inorganic fertilizer, use special verity, special tilling equipment, done sustainable land management, and uses different technology. In our study area severity and trend of soil erosion very high and impacts to also show very high so, farmers as this condition they cannot simply saw/sitting admirely, temporarily or sustainably solve them ,therefore, to assure by research this solution prepare open and closed ended survey questioner ask sample household .As show in the above 4.30 table 76% respondents the reduction of crop yield solve to improve uses artificial fertilizer temporary solution, 12% of respondents would respond to prevent reduction of crop yield changes crop type would be a solution for example to sowing teff seed to substitute wheat, teff if not productive yield to relative to wheat and other cereals natural agro -ecological selective (1700-2200) but teff in Ethiopia staple/delicious food item source carbohydrate in the woreda enjera less productivity and fiber contents of grain important to prevent diabetes in assisting with blood sugar for this advantages it being produce yield . 4% of respondents said uses artificial and

organic fertilizers, artificial fertilizers almost appreciation more respondents, organic fertilizer more divisible to fertility of soil prevention of soil nutrients but it cannot satisfy quality because consume large quantity too prepare. As a result cross checks to focus group discussion in household survey result show more of farmers uses artificial fertilizers in the focus group discussion results the participants told long aged persons in time of adolescent stage none use of artificial fertilizer but land is fertile and many access of land alternative tillage land and then to improve crop yield land fallow and crop rotation. But now days it is not enough farm land .this owned plot of land to improve crop yield productivity the last option is artificial fertilizers it cannot use more labor. In addition to this once year sowing with artificial fertilizer in the next season without artificial fertilizer none of planted seed. So we conclude the temporary solution of loss of productivity measure by farmers is inorganic fertilizer.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1. Conclusion

Soil erosion was severing in the Machakel woreda with in source of different causes the result food insecurity and affect central part of Ethiopia in East Gojjam zone, living mixed farming practice (animal rearing and cultivating land) community. The socio-economic analysis of community were minimum land holding access, medium members of family, average property is low access on pair oxen and average medium level age >45 managed family and more households man dominated managed family but special to government expected logistic access (good credit access and training access, has trained DA officers right positions to logistics inorganic fertilizer) .

On the other hand the perception farmers on soil erosion to analyze the occurrence of symptoms to happen in farm land differentiate their understanding and experience exist soil erosion indicate in decline of yield productivity compare to last decades and assure farmers understand the main causes of soil erosion is known lay out in their understanding high rainfall and the steep slope of land and the behavior of soil type erodible was aggravates of non-conservation practice.

Land to measure the extent of soil erosion increase and increase time to time in the history information before three decades the extent of soil erosion and gully erosion is minimum because this time assure to field observation ,key informant interview and focus group discussion minimum population number non-degraded natural resource high forestation coverage less agriculture explanation, soil was absorb rain water in the ground flood reduced and flow distributed and farmers fallow farm intercropping and crop rotation conservation methods .

After three decades gully the extent of gully is increase the history of majority gully is begins back of three decades and evolution severity is very fast happen everywhere different level of impact.

To explain in the Agro-ecological zone high land areas assure to field observation sever rill erosion, sheet and gully erosion comparatively because aggravate in high areas high rain fall/high run-off and steep slope down land and the nature of soil type is (leptosols possibility of erosion is 0.35) and medium and low land areas has different topography combine to high

erosion risk to moderate erosion risks because its steep slope is (between $>0.5\%$) of farm land and also change severity increase time to time.

Assure the impact of soil erosion on crop productivity of farm land was changed 1-3 quintals per hectare of yield is reduces annual this number adds artificial fertilizers, so high impacts of food security in the community in addition to majority of respondents less than 1 hectare land tenure, 1hectare by local measurement instrument 3 '*gemede*' from this plot of land 1-3 quintal product was reduce the livelihoods of community is dangerous to survive. In the community land holding capacity is less they cannot access to enough land tenure especially in adolescent managed household because land was reform and distributed in 1975 E.C. After this year there is no land reform, becoming this year born residences they cannot accesses enough land so in this amount of yield would be decline of products the community food security of this means of livelihood will be challenges.

In addition to this this household survey result cross-section to Machakel woreda agriculture office documents average cultivated area 41,584 hectare and five years crop yield data collects in secondary data, 2007-2012 crop yield season, 2007-2008 as a base line data relative to becoming years, as show the table 6%, 3%, 13%, 18% reduce year to year respectively and the amount of yields reduction

More of the water shade catchment is crop land 3521 total hectare cover and $101.97\text{ton}\cdot\text{ha}^{-1}\cdot\text{yr}^{-1}$ or **612, 561.3 t. yr⁻¹** average soil loss in the result of amount of soil loss assume crop land per hectare vulnerable to crop productivity of farmers and under risk of food security of community of study area because high steep slope and high erosion management factor un available of land cover affected soil erosion on crop land and this area is more sever to erosion based on findings the above data .then priority to soil conservation practice terracing too because aggravate in improper farming practice rehabilitation of crop lands to improve yield productivity.

Soil erosion depends on slops of topography and land use land cover, in Arc GIS images in the catchment slop is $>0.5\%$ and their land use land cover factor is 0.1-0.33 value in crop land soil erosion is highly affected in rill and sheet erosion and also gully erosion, this indicates land cover management is poor so, farmers to prevent their land from soil erosion and degradation works Conservation of SWC practices because the Ketech water shade catchment arc GIS data

total annual maximum 265.59 t/ hr, minimum 1.67 t/hr and mean /average lose 12.85 t/hr in soil lose the four Kebeles of Machakel woreda

LULC of Ketech water shade catchment 59 % was crop land areas and it large area coverage, it is highly vulnerable human and animal induced soil erosion, improper farming practice and improper diverted ditch canals based on steep slope land, frequency of high rain fall and un able to conservation practice aggravated this condition the of crop land soil now sever by the erosion, land to improve crop productivity necessary for fertile soil, depth and moisture content. In Machakel woreda farmers livelihood affects by rill and sheet soil erosion because crop land reduce quality of soil, reduce moisture content ,disturb organic matter of soils ,its result of difficult to plough activity ,reduction of crop growth it results reduction of crop productivity and affects livelihood of farmers consequences of Environmental changes (I was saw in observation time) because reduce productivity of land farmers is planting Eucalyptus tree (absorb ground water soil is change acidic nature.

Gully are severe in the sample kebeles and also in the Machakel woreda ,in the nature of land s cape steep slope topography and the possibility of soil erosibility and erodibility factor aggravated human induced factor improper farming and uninteresting non cashed conservation practice it is very sensitive to rill, sheet and deep gully erosion and forms of land slide .according to in the key informant interview discussion sever land degradation were show in the farm land loss of nutrient, moisture and loss of soil decomposed matters. we would discuss the informant experience at the head of Shembeko gelebet (b) gully Eucalyptus tree was planted the owner sowing repetitively with artificial fertilizer to improve yield productivity after few years the land was not planting any crop type , during this time farmer's would advise Wereda agriculture office test soil ,soil was test show acidity it treatment to lime but not productive then he was plants this tree. So farmers knowing and understanding the behavior of land to private property but not worry communal lands/ common goods, grazing lands, roads. To assure that gully begins in common goods inter to private land uncontrollable power .So to change this attitudes devoted to minister of Agriculture to the head to the foot,

on the other the objective of the research is to measure the extent of different time : As I report to this findings before three decades the extent of soil erosion and gully erosion is minimum because this time assure to field observation ,key informant interview and focus group discussion minimum population no. , non-degraded natural resource high forestation coverage less

agriculture intensification ,soil was absorb rain water in the ground flood reduced and flow scattered and farmers fallow farm intercropping and crop rotation.

After three decades gully the extent of gully is increase I show in field observation time and assure in the participant discussion average age of interviewer >40 years old tell you the history of majority gully is begins back of three decades and evolution is very fast happen everywhere different level of impact .

To explain in the Agro-ecological zone high land areas assure to field observation sever rill erosion, sheet and gully erosion comparatively because aggravate in high areas high

5.2. Recommendation

This result indicate the findings focus stakeholders on soil erosion impacts of crop productivity recommended to focus direction.

1. Agro-ecological zone of the study area has different high steep slope topography high rain/high run-off floods it forms high gully, farmers are seriously integrated community participation of conservation practices soil erosion and gully rehabilitation.
2. Farmers has perceive productivity crop farming only uses increase artificial fertilizers.so focus on decompose / organic fertilizer expand manufacturer and creates market opportunity input for farmers .
3. In household survey findings farmers' implements conservation practice terracing, gabion, diversion ditch, planting trees and improper farming on their farming land but during the field observation time I cannot seen expected responses. Government representative or Development Agents thought and advocates monitoring of farmers.

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Appendix

Addis Ababa university college of Development studies center for Environment and sustainable development this questioner is prepared for the research partial fulfillment of the requirement for the degree of master, Environment and sustainable development on assessments of soil erosion and its effects on agricultural productivity in the case of Machakel Wereda, East Gojjam Zone.

So, please participate contribute given supportive data for me and give open discussion for advocate question!

I. PART ONE MEASURE OF SOIL EROSION IN (GIS) IMAGES DATA

1. How many hectare of land holding in the study area

2. Rainfall erosivity (R factor)

- a. Ten years mean annual rainfall data
- b. R factor of soil

3. Soil erodibility (K factor)

- a. Rain Fall of the study area
- b. Runoff of the study area
- c. Soil types of the study area
- d. Soil classification of K factor of the study area

4. Slope gradient factor (S factor)

- a. The digital elevation model (DEM) different sample 100 m grid cell size
- b. To Classify 8 different type slope.

5. Slope length factor, L

- a. The instance point of runoff water flow
- b. The point decrease slop steepness in Digital Elevation Model (DEM)

6. Cover and management factor, C

List of land coverage	Amount of size in hectare	Proportion/percentage	factor, C
Cropland			
Grazing land			
Living land			
Forest /wood land			
Wetlands			
open water			
Bush land			

7. Conservation practice factor, P

Land use/land cover	Amount of size in hectare	Proportion/percentage	P factor
cropland,			
Grazing land			
Living land			
Forest /wood land			
Wetlands			
open water			
Bush land			

Hints

- 1 Light: there are some indications of degradation, but the process is still in an initial phase. It can be easily stopped and damage repaired with minor efforts.
 - 2 Moderate: degradation is apparent, but its control and full rehabilitation of the land is still possible with considerable efforts.
 - 3 Strong: evident signs of degradation. Changes in land properties are significant and very difficult to restore within reasonable time limits.
 - 4 Extreme: degradation beyond restoration.
8. The degree of soil erosion of crop land
- a. Light

- b. Moderate
- c. Strong
- d. Extreme
- e. No difference
- 9. The rate of soil degradation of crop land /rate of areas
 - a. rapidly increasing degradation
 - b. moderately increasing degradation
 - c. slowly increasing degradation
 - d. no change in degradation
 - e. slowly decreasing degradation
 - f. moderately decreasing degradation
 - g. rapidly decreasing degradation
- 10. variation of soil erosion : spatial
 - high land
 - lowland
 - middle land
 - land use land cover in/(time variation)

II. PERCEPTION OF FARMERS ON SOIL AND GULLY EROSION AND ITS DETERMINANTES

1. Do you think that there is soil erosion in your farm land?

A. Yes

B.No

2. If your answer is yes for Q no 1 how do you know the occurrence soil erosion on farmland?

(more than one answer options possible)

A. The color top soil is change

B. Crop yield reduce annually

C. Sandy soil occur on top of farmland

D. Fertile soil seen down slop in furrow

E. Rills observed on farmland after rain

F. Deposited soil seen on tree root

G. Deposited soil on level land after rainfall

H. Specify differences -----

3. What do you think about the main causes of this soil erosion? (more than one response are possible)

A. Heavy rainfall/ high run-off

B. Deforestation

C. Improper plough

D. Overgrazing

E. Steepness of the land

F. Soil being too erodible

G. Improper construction of ditch

H. Others (specify) _____

4. What is the extent of soil erosion?

A. Increase

B. Decrease

C. No differences

5. What do you think the severity of soil erosion of your farm?

A. Low

B. Moderate

C. High

D. Extreme

6. Do you think that caused the problem soil erosion on your farm land ?

A. Yes

B. No

7. If the answer Q 6 is yes, what is the consequence of soil erosion in your land?

A. Reduction soil fertility

B. Reduction of crop yields

C. Reduction of crop growth

D. Other (specify)-----

8. Do you think use conservation methods to prevent soil erosion?

A. Yes

B. No

9. If the answer Q 8 is yes, do you implement conservation methods to prevent soil erosion?

A. Yes

B. No

10. If the answer Q 9 is yes, what the major soil erosion conservation methods is to apply?
(more than one answer are possible)

A. Terracing

B. Soil and stone bund

C. Check Dams

D. Diversion ditches

E. Contour plugging

F. Fallowing

G. Intercropping

H. Crop rotation

I. Planting Trees

J. Others, specify _____

11. Do you think about doing soil erosion conservation methods conservation measurements are profitable?

A. Yes

B. No

12. If the answer Q 10 is yes, how the result of profitability is expressed soil erosion conservation methods? (more than one answer are possible)

A. To prevents soil erosion

B. Improve land productivity

C. Improve soil fertility of farm

D. To increase moisture retention

E. Other, specify _____

13. If the answer Q 9 is No, what are the disadvantages of soil erosion conservation measures do not apply in your farm? (more than one response are possible)

A. Reduction of crop productivity

- B. Loss soil of crop land
- C. Difficult to cultivate simply
- D. Consume to more labor
- E. Other is specify_____

14. If the answer Q8 is No, what are the major constraints to implement conservation technologies? (more than one answer are possible)

- A. Do not understand of advantages conservation
- B. Difficult implement technologies
- C. Required too much labor to construct bund
- D. Decrease farm land /difficult to plow
- E. Poor agricultural extension services
- F. Not understand erosion impact on crop
- G. Others, specify_____

15. Do you think that there is gully erosion in your farm land?

- A. Yes
- B. No

What is the name of the gully_____

16. What is the main the causes of soil gully erosion?

- A. slope of the land
- B. deforestation
- C. improper farming practice
- D. high intensity of rainfall
- E. absence of appropriate soil conservation practice

17. Do you know when the gully starts?

- A. Yes
- B. No

18. If the answer Q12 is yes, when start the gully?

- A. 16-20 years
- B. 10-15 years
- C. 6-10 years

D. 0-5 years

E. Other specify _____

19. Do you think that affect the gully erosion in your farm land?

A. Yes

B. No

20. do you any practices soil conservation methods to protect gully erosion?

A. Yes

B. No

21. If the answer Q20 is yes, what the major gully conservation methods is implemented?
(more than one answer are possible)

A. Terracing

B. Soil and stone bund

C. Check Dams

D. Diversion ditches

E. Planting Trees

F. Others, specify _____

22. Is a difference before implementation and after implementation gully conservation methods in your farm?

A. Yes

B. No

23. If the answer Q16 is yes, what are the differences implement express gully conservation methods? (more than one answer are possible)

A. To relief gully

B. Increase crop productivity

C. Improve land productivity

D. Improve soil fertility of farm

E. To increase moisture retention

F. Other, specify _____

24. Determinants of perception and Knowledge of soil erosion and gully erosion?

24.1 Age :

- a) 18-30
- b) 31 -40,
- c) 41-50
- d) d) >50 years old

24.2 Sex

- a. female
- b. mail

24.3 Educational

- a. Unable to read and write
- b. Able to read and write
- c. Attend to grade 10 certificate
- d. Above attends grade 10 certificates

24.4 Experience

- A .0- 3 years
- B.4-6 years
- C.7-9 years
- D.>10 years

24.5 Credit access

- A.Yes
- B.No acess

24.6 Extension services

- A. good extension service
- B. poor extension service

24.7 Training

- A. has access
- B.no training

24.8 No of livestock

- A. have \geq two oxes
- B. under two oxes

24.9 Land holding capacity

- A. have <1r hr.

B.1-3 hr.

C.3-5hr.

D.>5 hr.

24.10 Family size

A.3 families

B.4-6 families

C.7-9 families

D.>10 families

25. How much the extent of perceptions on soil and gully erosion?

A. High

B. Moderate

C.Low

III. IMPACT OF SOIL EROSION ON CROP PRODUCTIVITY

1. Do you think that there is soil erosion in your farm land?

A. Yes

B. No

2. If your answer is Q1 is yes, do you think soil erosion impact on farm activity?

A. Yes

B. No

3. If your answer Q2 is yes, how do the express the impact on farm activity? (more than one answer options possible)

A. Plowing activity

B. Sowing activity

Weeding to activity

Harvesting activity

E. Others (specify)-----

4.If your answer Q1 is yes when soil erosion occurs in your farm land?

A. In the last five years

B. In the last ten years

C. In the last fifteen years

D. In the last twenty years

5. Do you think about there is impact soil erosion on crops yields?
- A. Yes
 - B. No
6. If the answer Q5 is yes, which type of crop is seriously impacted by soil erosion and gully?
- A. Teff
 - B. Wheat
 - C. Barely
 - D. Potato
 - E. Others specify-----
7. What is the trend of the impact soil erosion on crop yields?
- A. Increase
 - B. Decrease
 - C. No differences
8. If your answer Q5 is yes, how much quantity of crop product is reducing?
- A. 1-3 ql./hr.
 - B. 4-6 ql./hr.
 - C.6-8 ql./hr.
 - D.>10 ql./hr.
 - E. No differences
9. What measure taken to prevent the reduction of crop productivity?
- A. Use artificial fertilizer
 - B. Uses organic fertilizer
 - C. Change crop type
 - D. None of uses
 - E. Others (specify)-----
10. Do you think climate changes impacts decline of crop productivity?
- A. Drought
 - B. Flood
 - C. Pest invasion
 - D. Air pollution
 - E. Wetting

F. Other (specify)-----

11. Where did you come this climate change ?

A. Deforestation

B. Unable to work SWC practices

C. Increase population

D. Over grazing

E. Other (specify)-----

IV. Focus group discussion questions

1. Do you think there is soil erosion in your woreda ?

2. What do you express the occurrence /the indicator of soil erosion in your woreda?

3. What type of erosion is occurring?

A. Rill erosion

B. Sheet erosion

C. Gully erosion

D. Other (specify)

4. When did soil erosion start in your woreda

5. What do you think are the main causes of soil erosion in this woreda?

6. What do you think are the impacts /consequences of soil erosion in farm land

➤ In crop

➤ In plugging

➤ Crop growth

➤ Soil loss

7. Do you think soil erosion affects crop productivity of farm land?

➤ How much quantity /hectare

8. Which type of erosion is more occurring?

9. What do you express the extents of soil erosion on farm land

A. Increase

B. Decrease

C. No differences

10. What do you express the severity of soil erosion on crop production

A. Low

B. Moderate

C. High

D. Extreme

Please specify the reason-----

11. What type of crop is more affects by soil erosion?

12. Do you implement any conservation measures to reduce crop productivity?

13. Do you understand control by soil conservation technology?

14. What type of soil conservation technology was applied?

15. Do you profitable soil conservation technology?

V. SECONDARY DATA FROF MACHAKEL WOREDA AGRICULTURE OFFICE

A. DEMOGRAPHIC DATA

1. Population number the worda -----

2. Demography of people

No	Characteristics	Age				Education			
		0-18	19-35	36-45	>46	Unable to read and write	Able to read and write	grade1 0	>grade 10 certificates
1	Female								
2	Male								

3. House hold number-----

➤ Number of Woman managed household-----

➤ Number of Man managed households-----

4. Education of population?-----

B. LANDHOLD DATA

1. Land hold/household land tenure? ratio

➤ Number of Woman managed land owner/tenure-----

➤ Number of Man managed land owner/tenure -----

2. Land use and land cover of the woreda in percent?

3. SWC practices in the woreda?

4. Extension service

C. GEOGRAPHICAL DATA

1. Area coverage of woreda /hectare-----

2. Area coverage of cultivated land /hr.-----

3. Soil type -----

4. Crop type-----

5. Average annual rainfall of woreda-----

6. Elevation of the woreda in agro-climatic zone classification

A. Specify High land Kebeles and its elevation-----

B. Specify Middle land Kebeles and its elevation-----

C. Specify Low land Kebeles and tis elevation-----

D.SOCIO-ECONOMIC DATA

1. Family composition

No	Characteristics	Age				Total
		<18	18-35	36-65	>66	
1	Female					
2	Male					

2. Annual revenue of farmers /crop production /hr.?

3. Is there any differences crop productivity last 10 years yes/no

A. Increase

B. decrease

4. How much amount of quintal of crop reduces per hectar-----

5. Do you know the cause of reduction? Please discuss-----

6. Farmers training institute?

A. Yes

B. No

7. Credit access

A. Have access

B. No access

E.EROSION TYPE DATA

1. List of hazard vulnerable land in this woreda?-----

2. List of flood vulnerable farm lands in this woreda?-----

3. List of vulnerable gully in this woreda-----

4. List of selected vulnerable treatment gully in this woreda-----

5. Do you any suggestion on soil erosion and gully erosion-----

DECLARATION

I, the undersigned, declare that this thesis is my original work performed under the supervision of my research advisor Dr. Engdawork Assefa and has not been presented as a thesis for a degree in any other university, and that all sources of materials used for this thesis have also been duly acknowledged.

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