Addis Ababa University
አዲስ፡አበባ፡ዩኒቨርሲቲ
SEEK WISDOM, ELEVATE YOUR INTELLECT AND SERVE HUMANITY !

COLLEGE OF DEVELOPMENT STUDIES

CENTER FOR FOOD SECURITY STUDIES

ASSESSING THE IMPACT AND EFFECT OF WATERSHED MANAGEMENT TO RURAL HOUSEHOLD FOOD SECURITY: A CASE OF REBU WATERSHED, WALISO *WOREDA* ETHIOPIA

BY

ROZINA GETENET

OCTOBER2019

ADDIS ABABA, ETHIOPIA

ADDIS ABABA UNIVERSITY
COLLEGE OF DEVELOPMENT STUDIES
CENTER FOR FOOD SECURITY STUDIES

ASSESSING THE IMPACT AND EFFECT OF WATERSHED MANAGEMENT TO RURAL HOUSEHOLD FOOD SECURITY: A CASE OF REBU WATERSHED, WALISO *WOREDA* ETHIOPIA

BY:

ROZINA GETENET

ADVISER: DESALEGN YAYEH (PhD)

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF FOOD SECURITY AND DEVELOPMENT STUDIES, ADDIS ABEBA, ETHIOPIA.

DECEMBER2019

ADDIS ABABA, ETHIOPIA

DECLARATION

First, I declare that this thesis is my original work and all sources of material used for this thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements of Master of Science degree at Addis Ababa University and is deposited at the University Library to be made available to borrowers under rules of the library. I also declare that this thesis can be submitted to any other institution, if the university found it necessary. Brief quotations from this thesis are allowable without special permission provided that accurate acknowledgement of source is made.

Name: ________________ Signature______________

Place: Addis Ababa University, Addis Ababa

Date of Submission:__________________

THESISAPPROVAL

ADDISABABAUNIVERSITY

COLLEGEOFDEVELOPMENTSTUDIES

CENTERFORFOODSECURITYSTUDIES

This is to certify that the thesis prepared by RozinaGetenet, entitled:Contributionof watershed management to household food security in WalisoWoreda, OromiaRegionalstate,Ethiopia.To Submitted in fulfillment for the requirement for the Degree of Master of science (Food security and development studies)complies with the regulations of the Universityandmeetstheacceptedstandardswithrespecttooriginalityandquality.

Advisor__________________ Signature____________ Date____________

SignedbytheExaminingCommittee:

InternalExaminer__________________ Signature____________ Date____________

ExternalExaminer__________________ Signature____________ Date____________

Chairman________________ Signature____________ Date____________

Final approval and acceptance of this thesis is contingent upon the candidate’s submission of the final copy of the proposal, incorporatingall the comment by Examining Board, to the council of graduated studies (CGS) throughthecenteracademiccommittee(CAC) of the center.

____

Chairpersonofthecenterofgraduatedprogramcoordinator

ACKNOWLEDGEMENT

Above all, I want to thank the Almighty God and the Virgin Mary for giving me the strength and courage to accomplish this research work.

I would like to express my deepest - gratitude and appreciation to my advisor DesalegnYayeh (PhD) for his dedication, encouragement, support, valuable, provision and friendly guidance from title adjustment to thesis accomplishment.

I am grateful thanks to members of Food security staff in AAU for their assistance and encouragement during my study. My thanks also go to MoA, GIZ, and Waliso*Woreda* offices staff for their valuable comments and suggestions on the structure and the content of the thesis. I am also indebted to students and staff of Food Security. I really enjoyed a lovely working environment and nice social events with them, all of which I can never forget.

Lastly but not least, I would like to send my special gratitude to my family and relatives for their moral and technical support.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ACRONYMS

ATA	Agricultural Transformation Agency
CSA	Central Statistical Agency
FAO	Food and Agricultural Organization
FCS	Food Consumption Score
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GIZ	The German Development Cooperation
GPS	Global positioning system
HDDS	Household Dietary Diversity Score
HH	Household
HHFS	Household Food Security
ILRI	International Livestock research Institutions
KII	Key Informant Interview
LU/LC	Land use/land coverage
MOARD	Ministry of Agriculture and Rural Development
NDVI	Normalized Difference Vegetation Index
NGO	Non-Governmental Organization
OLI/TIRS	Operational Land Imager/Thermal Infrared Sensor
SLMP	Sustainable Land Management Programme
WFP	World Food Program
WSM	Watershed Management

ABSTRACT

The aim of this study was to assess the contribution of watershed management practices to household food security in Waliso Woreda, Oromia Regional State, Ethiopia. Household based cross-sectional mixed research design was employed in the study. Household survey was conducted on 341 sample households those selected using stratified random sampled method. Land use land cover change of the watershed were analyzed at the entire Rebu watershed and at 5 micro watersheds in which watershed management intervention was carried out using the GIS environment from 2000-2019.Household dietary diversity score model was used to assess household food security status. Descriptive statistics such as frequency and percentage was used to analyze quantitative data. The qualitative data obtained from interviews and FGD was analyzed by describing and interpreting deeply the situation of watershed management practices on rural household food security conditions and physical changes on the environments. The finding of the study indicated that land use/land cover change both for the entire Rebu watershed and for the five micro-watersheds in which Land use/land management projects were experienced changes in the last 7 years. The Land use Land cover dynamics over the entire Rebu watershed for the last two decades has revealed that cropland, settlement, and grassland (38 % to 45 %, 1 % to 2 % and 22 % to29 % has generally increased. Whereas wood land and bare land decreases 32 % to 18 % and 7 % to 7%.At micro watershed while Forest and vegetation has shown increasing trends 12 % to15 %, 28 %to 33 %, 25 % to 30 %, 19% to 28 %, and 21 % to 40 %in D/werebu, Werebu, Misochisa. Kakee and Gurasenbete and bare land and cropland has been decrease17% to 10 %,7 % to 5 % and 7 % to 3 %in Misochisa. Kakee and Gurasenbete. From sample, HHs 79% household was food secured but the remaining were food in secured. The soil fertility and Education were found significant determinant factors for food security. The watershed management intervention made at micro watershed to the major watershed level is required to sustain the harmonized livelihood of the community and the management of SLM.

Key words: *Land use/land cover, watershed management, food security; soil and water conservation practices*

CHAPTER ONE

INTRODUCTION

1.1. Background and Justification

Agriculture sector in the world is one of the most powerful economic sectors to end extreme poverty and to feed a projected 9.7 billion people by 2050( ). Whereas, production and demand of food are not balancing in the world( ). World Bank reports that 2.5 billion people depend on agriculture as their main sources of livelihood. In Ethiopia, agriculture is the main sector of the economy and contributes approximately 42% to the gross domestic product and employs over 80% of the population (ATA, 2013).The agricultural sector's fortune directly affects economic development, food security, poverty alleviation and social welf are of the country.

Food security is a dynamic concept, and the level of their analysis over the years has been considered at global, national, regional, state, household (HH) and individual level. Food security refers to the situation “when all people, at all times, have physical, social, and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life” (FAO, 2010). Many people consider it as a basic human right but approximately about 870 million peoples in the world are to have been undernourished in the period 2010–2012( ). Hunger remains a major challenge for many countries, particularly in Sub-Saharan Africa its levels rose from 777 million people in 2015 to 815 million people in 2016 (FAO *et al*., 2017). About 10% of Ethiopia’s citizens are chronically food insecure and this figure rises to more than 15% during frequent drought years; 2.7 million People require emergency food assistance( ). Currently nutritional status of under age 5 child in Ethiopian are 38 % stunted,10%wastedand 24%areunderweightedin2016 (Taddese,2016).

The main source of food insecurity of Ethiopia is drought and land degradation, population pressure, instability and armed conflict (Mohamed, 2017). Land degradation in the form of soil erosion and nutrient depletion has been a major constraint for the provision of goods and services from rained agricultural. Exploitative and inappropriate land use and management have accelerated land degradation associated with soil erosion practices (Shiferaw&Holden, 1998).

On a global scale, the loss of productive land through soil erosion estimates about 5-7 million ha/year (Kumar & Rama Chandra, 2003)and it is estimated that soil degradation leads to a potential loss of 20 million tons of grain per annum in the world (Ricksonet*al.,* 2015). In Africa, 60% of its cropland is affected at various scales (Muchena*etal.,* 2005). In South Africa approximately 75% of farmers lose more than 21% of their crops yearly due to erosion and 55% said their crops and livestock, as well as their household feeding, suffer due to the problem (Ighodaro, Lategan,&Mupindu, 2016). To address this challenges the government of Ethiopia and non-governmental organization promoting watershed management (WSM) technologies for improving agricultural productivity, HHFS, and rural livelihoods, while simultaneously mitigating environmental degradation (Teshome, deGraaff, &Kassie, 2016).

In Ethiopian, WSM programs starting in the formal way in 1970s after the famine of highly degradedpartofTigrayandWolloarea. From thattime up to thelate1990s, implementationwas top-down, incentive-based (food-for-work) approach that prioritized engineering measures (Shiferaw& Holden, 1998).However, this program was not successful and sustainable due to the implementation approach. Currently different results suggest that watershed management had a positive impact on natural resource conservation, crop-livestock production and productivity, socioeconomic conditions and livelihoods when the involvement of all the stakeholders and farmers is needed during all the phases of conservation management. Hence, necessary measures must be taken to ensure voluntary participation and to remove the misunderstandings of all the concerned participants (Akkaraboyina&Tareke, 2018).

Waliso*Woreda* became one of the priority areas to be supported by the sustainable land management project (SLMP), Rebu is the major watershed selected in the *Woreda* for SLMP, and it is implemented with the financial support from WB and technical support from GIZ.After the implementation of SLMP in Waliso watershed management, there is no evidence to catch-up the effectiveness and change on the food security status of the household Waliso*Woreda*AgriculturalDevelopmentoffice(2013).Effective watershed management activities can reduce ‘decreased’ or ‘fluctuating’ crop yield. In addition, suitable conservation structures, adapted to climatic conditions and slope gradient, need to be implemented (Wolka*etal.,* 2013). Certain regions have trouble in achieving higher food production due to watershed management constraints.Especially, lack of new land, low fertility soil, and scarce water resources.According to

Sisay&Tesfaye, (2003) farmers and rural development experts believe that land tenure insecurity contributes to low agricultural productivity and land degradation. However, there are limitation to study watershed management linkage with food security, which focused on areas targeted with land conservationprogrammes such as,sustainable land management (SLM) project that entailed integrated and concerted efforts on sustainable lands management where the lesson can be used policy and strategy revision and help rolled out to other parts of the country.

1.2. Statement of the Problem

Land degradation in most developing countries is becoming a major constraint to development of rural livelihoods and food security. About 40-75% of the world's agricultural land productivity has reduced due to land degradation (Feyera&Tsetadirgachew, 2015). Land degradation in Ethiopia has been going on for centuries (Hurni, *et al.,* 2010). Similarly, Tesfa&Tripathi (2015) land degradation is responsible for decline of soil fertility.Thereduction of implications of land degradationisextremely important, since the livelihoods of many Ethiopians were entwined with land resources (Adugnaw, 2014).

Watershed management program was recognized as potential engine for agricultural growth and food security in fragile and marginal rain-fed areas (FAO, 2002).As stated by Temesgen, *et al.,* (2014), land degradation is the common problem in Ethiopia. It is one of the major causes of low and declining agricultural productivity and continuing food insecurity and rural poverty. Thus, the ineffective practice of land management has a direct relationship with food security.Consequently, the production and productivity of the land decreased to the extent of disabling the farming community to cover their daily food throughout the year (FAO, 2014).

In some regions of Ethiopia,sustainable land management project started implementation with the objective of reducing land degradation and improve the agricultural productivity of smallholder farmers in order to ensure food security within the framework of watershed based development strategysince 2009/10 (WalisoWoredaAgriculturalDevelopmentoffice,2013). Rebu watershed management was one of the efforts of the government implemented for the last ten years in order to increase productivity and to ensure food security. The practice of physical and biological conservations of soil, water, and area closure in the study area was not still studied whether it has been achieved its goal or not.

In addition, some studies did not show the linkage between watershed management and food security. For example, the study conducted in ShekabyGebre-mariam*et al.*, (2015) focused only on the socio-economic impact of watershed management.The study done by Meaza (2015) also focused only on the contribution of watershed management to climate change.The assessment done by Kebede(2014) showed that watershed management measures have promising effects on improving the quality of cropping land. However, in similar studies, its implementation has major constraints, like, lack of integrating practices, lack of considering socio-economic profile, low perception, and participation of farmers, poor conservation design, improper land use, less maintenance, week monitoring, and evaluation of watershed management.In this regard, such studies do not typically include the contribution of watershed management to food security. Therefore, this study shows the contribution of watershed management practices to rural household food security in the study area.

1.3. Objectives

1.3.1. General Objective:

The overall objective of the paper was to assess the effect of watershed management to rural household food security in Rebu watershed management in Waliso, Oromia regional state.

1.3.2. Specific Objectives:

The study wasdesignedto address the following specific objectives:

- To examine the land use/coverchangesof the study area in between 2000 to 2019,
- To assess the effects of watershed management intervention to household food security in terms of crop yield and livestock production the study area,

1.3.3. Research Questions

This study formulates the following leading questions:

- What isthe land use/coverchangesthe study area in between 2000 to 2019?
- What are the effects of watershed management intervention to household food security in terms of crop yield and livestock production the study area?

1.4. Scope of the study

The scope of this study was to explore the effects of Rebuwatershedmanagement to Rural Household Food Security in terms of crop yield and livestock productioninWaliso*Woreda*.This study was undertaken in one of the watersheds, in Waliso*Woreda*,SouthwestShewa zone of Oromia Region. Theresults of the study provide a useful information or lesson for similar efforts going on in different watersheds in other parts of the country.Understanding the food security linkage of the watershed management and its effects to rural household food security in terms of crop yield and livestock productionin the study area was the focus area.

1.5. Significance of the Study

Conductingresearchonsuchcontemporaryissuesisrelevantandtimelyforfarmers, policymakersandaddsknowledgetotheexistingliteratureonthesubject area. The study provides baseline information about contribution of WSM technologies to HHFS in Waliso*Woreda.*In addition, this study shows synergy between watershed and food security based on empirical evidences from the study area. The output of the study also benefits other researchers to investigate the nexus between food security and watershed management. Generally, this study contributes to the existing academic knowledge by exploring the watershed management roles and contribution to household food security at local level. This study also fills the gap providing knowledge weather there is a simultaneity or interdependence of the decision-making process.

1.6. Limitation of the Study

The absence of adequate socio-economic base line data forced the researcher to depend highly on retrospective with basing the local community as the main source of data. Hence, the study is limited in terms of providing comprehensive idea about overall impact, problems, potential solutions, and opportunities to make inferences for possible policies and practices on issues related to the impact of the watershed management program on food security. Additionally, because of financial constraint, it was impossible to cover more than one major watershed practices. Thus, the study was focused on five micro watersheds of the study area. Therefore, Functioning of watershed associations and users groups and soil fertility test of watershed area will issues that need further research.

1.7. Ethicalconsiderations

In the course of this undertaking, an appropriate acknowledgment and citation have been made for any concepts or ideas taken from the literature. Moreover, formal letter of support was written to WalisoWoreda governmental concerned body from center of food security. Explanation was given to farmer about the purpose of the research. Verbal consent from the respondents was requested before conducting the interview. They were informed that confidentiality of individual farmer household information was to be ensured by using unique identifiers. There were no known risks ordiscomforts associated withthestudy. Participation in this study was entirely voluntary and that they were free to with draw from the study at any timewithoutanyobjection.

1.8. Organization of the Thesis

This thesis is divided in to five chapters. Chapter one of this study starts with the background of the study, statement of the problem, objective of study, research questions, and significance of the study, scope, and limitation of the research. Chapter two represents review of related literature, which encompasses definition of concepts, empirical literature related to food security, land degradation and watershed management practices and conceptualframework. Chapter three describes the research methodology, employed to collect relevant data and how under collected data are analyzed and description of the study area. In chapter four the results and discussion are presented and finally chapter five provides, the conclusion and recommendation based on the results of the findings.

CHAPTER TWO
LITERATURE REVIEW

2.1. Concepts of Food Security

Although Gentilini(2002),identified about two hundred and five definitions of food security and we shall refer to the most commonly accepted definition that was approved by the 1996 World Food Summit and remains one of the important achievements of the meeting. "Food security exists when all people, at all times, have physical, social, and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life" (FAO, 1996). The term "Social" was added to the 1996 definition in 2002. World Food Program(WFP) offers the following definition: "A condition that exists when all people, at all times, and are free from hunger" (WFP, 2009). Although WFP utilizes a definition that seems much simpler, we shall refer to the original WFS definition as it carries with it many elements important for the analysis.

Food security continues to be a vital issue globally. The concept has been defined and measured in a number of ways for decades. Since the World Food Conference in 1974, food security analyses have shifted from global and national levels to household and individual levels (Maxwell, 1996). Broadened this definition, stating that food security exists 'when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life'. In addition to the supply of adequate quantities of food, the focus has shifted to the creation of 'nutritional sovereignty' in which people are capable of feeding themselves self-reliantly with healthy and culturally acceptable foodstuff (Sagar, *et al.,* 2004).

Food security is a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Household food security is the application of this concept to the family level (FAO, 2002). Achieving food security requires that the aggregate availability of physical supplies of food is sufficient, that households have adequate access to those food supplies through their own production, through the market or through other sources, and that the utilization of those food supplies is appropriate to meet the specific dietary needs of individuals (Riely*et al*., 1999).

Household food security situation in rural areas is whether the household can produce sufficient food from own production or sell livestock and purchase food grain of the right quality in the market place. This implies availability of enough food and the capacity of the household to acquire it determines household food security. Therefore, household food security means the complementarities of food availability and accessibility. Availability and accessibility affected by land degradation this implies directly related to decrease agricultural productivity. To solve these problems watershed management has a big role().Sustainable watershed management helps to protect and rehabilitating the environment and reduce soil loss, therefore watershed management used to understand the sustainability of the quality of life and food security of the poor and recognizes the complexity, diversity and continuous change of people's activities and their strategies over time (Degefa, 2008).

In the mid-1970s, food security was conceived as adequate food supply at global and national level, though significantproportion of the population has suffered from hunger and malnutrition (Debebe, 1995).However, meager availability of food at the global level does not guarantee acquisition of food at the household and individual level (Getachew, 1995) and hunger could persist with the presence of adequate food supply at the national and international level (Maxwell, 1996).

In the early 1980s, the concept of food security attained wider attention and the unit of analysis shifted from national and global level to household and individual level. World Bank (1986:1), defined food security as "access by all people at all times to enough food for an active and healthy life". It encompasses food availability and food access through home production, purchase in the market, or transfer (Degefa, 2002) and also stresses an individual access at all times to enough food not just for survival, but for active participation in a society (Maxwell, 1996). This definition implies the time dimension, i.e. long-term sustainability of food security. Sustainability of food security has been introduced as an issue of international concern through the notion of sustainable development. Sustainability in the context of rural household food security is mainly determined by long-term availability of household food production, sustainable food access, and stability of household food consumption (Berry, *et al*., 2015).

2.2. Concept of Watershed Management

Watershed is a land area whose runoff drains into any stream, river, lake, and ocean(). A watershed is defined as any surface area from which runoff resulting from rainfall is collected and drained through a common confluence point. The term is synonymous with a drainage basin or catchment area (Lakew*et al.,* 2005). Watershed boundary is the divide separating one drainage area from another. Terms like catchment or drainage basin are also used to refer to watersheds. Watershed functions are affected by variables such as climate, hydrology, soil types, topography and land use. It plays a significant role in human activities, determines the food, social, and economical security, and provides life support services to rural people.

It is a hydrologic unit that has been described and used both as a biophysical unit and as a socio-economic unit for planning and implementing resource management activities (Solomon *et al.,* 2013). The biophysical unit in a watershed includes its water, soil, and vegetation. While, the socioeconomic unit includes people, their farming system (including livestock) and interactions with land resources, coping strategies, social and economic activities and cultural aspects (Lakew*et al.,* 2005).

Watershed management is the process of guiding and organizing land and other resources use in a watershed to provide desired goods and services without adversely affecting land resources (Brooks *et al*., 1994). Thus, watershed management implies the judicious use of natural resources such as land, water, biodiversity and biomass in a watershed to obtain optimum production with minimum disturbance to the environment (Binyam&Desale, 2014).

Watershed projects aim to maximize the quantity of water available for crops, livestock, and human consumption through on-site soil and moisture conservation, infiltration into aquifers, and safe runoff into surface ponds. In catchments areas of hydroelectric dams, watershed projects typically focus on minimizing soil erosion that deposits sediment into reservoirs and to the maintenance of base flow (Kerr &Chung, 2001).

2.3. Concepts of Land use/Land cover

The International Geosphere-Biosphere Program, the international human dimension program and the land use and land cover change project have referred to land cover, land use and land use and land cover change and land management as follows (Lambin& Geist, 2006). Land cover has been defined by the attributes of the Earth's land surface and immediate subsurface, including biota, soil, topography, surface and groundwater, and human (mainly built-up) structures. Land-cover conversions constitute the replacement of one cover type by another and are measured by a shift from one land-cover category to another, as is the case of agricultural expansion, deforestation, or change in urban extent. Land-cover modifications, in contrast, are more subtle changes that affect the character of the land cover without changing its overall classification (Lambin& Geist, 2006).

Whatever the type of changes in land cover, they encompass changes in biotic diversity, actual and potential primary productivity, soil quality, runoff and sedimentation rates, and other such attributes of the terrestrial surface of the Earth (Lambin& Geist, 2006). Land covers and changes in them are sources and sinks for most of the material and energy flows that sustain the biosphere and geosphere, including trace gas emissions and the hydrological cycle (Lambin&Geist, 2006;Canadell*et al.*, 2006).

Contemporary land-cover change is generated principally by human activity, activity directed at manipulating the Earth's surface for some individual or societal need or want, such as agriculture (Turner *et al*., 1990; Ojima*et al.*, 1994; Walker *et al.*, 1999; Cassman, *et al.*, 2005- cited in Lambin& Geist 2006).

Land use has been defined as the purposes for which humans exploit the land cover. It involves both the manner in which biophysical attributes of the land are manipulated and the intent underlying that manipulation, i.e., the purpose for which the land is used. Exemplary classes denoting intent or purpose are forestry, parks, livestock herding, suburbia, and farmlands. Land management, biophysical manipulation or the techno-managerial aspect of a land-use system, by contrast, refer to the specific ways in which humans treat vegetation, soil, and water for the purpose in question. Examples are the use of fertilizers and pesticides, irrigation for mechanized cultivation in dry lands, or the use of an introduced grass species for pasture, and the sequence of moving livestock in a ranching system(Turner *et al.,*1995; Lambin*et al.,* 2003- cited in Lambin& Geist 2006).

In methodological terms, land cover and changes are visible in remotely sensed data or by generating evidence from secondary statistics, such as (agricultural) census data. Such data require interpretation and ground truth. Land-use as well as land-management information, in contrast, is mainly gained through detailed ground-based analysis, although land use can be inferred in remotely-sensed data under certain circumstances. Regardless, land cover and land use are so intimately linked that understanding of either has required approaches for linking household and community surveys, demographic and agricultural censuses, and market data, among others, to remote sensing and geographical information systems (Fox *et al.*,2003 cited in Lambin& Geist 2006).The intimate linkage between land use and land cover has called for a coupled human-environment or social-biophysical system analysis or models in a much broader earth system perspective (Geist &Lambin 2006).

2.4. Concept of land degradation

Land degradation includes all process that diminishes the capacity of land resources to perform essential functions and services in ecosystems (Hurni*etal.*, 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). Various processes that lower potential productivity leading to long-term, sometimes irreversible, deterioration of land, can trigger Land degradation. These processes are numerous but for the purposes of this paper, primary focus is given to soil erosion and biological, chemical and physical degradation as forms of land degradation in the Oromia region.

Land degradation threaten food security for many of the poorest and most food insecure living in Asia, Africa and Latin America. It also contributes to persistent poverty, and results in decreasing ecosystem resilience and provision of environmental services (Bossio*et al.,* 2004). In addition, environmental decline due to land degradation adversely affects the health, well-being, and livelihood opportunities of the individuals (Temesgen*et al*., 2014).Land degradation has a great effect on economies of developing countries (Ayalneh, 2002). It is one of the most critical environmental issues facing many countries today (Haw *et.al,* 2000). It has abrader concepts and refers to the degradation of soil, water, and climate (Alemneh, 2003). Land degradation includes soil erosion, soil nutrient depletion, changes in soil structure.

2.4.1.Causes of Land Degradation

The major causes of land degradation in Ethiopia are rapid population increase, severe soil loss, deforestation, low vegetative cover and unbalanced crop and livestock production (Girma, 2001). As Gete (2000) also reported that human population is increasing at frighteningly high rate and the productive capacity of soil resources necessary to sustain that population is steadily decreasing because of land degradation. Dense population and inappropriate farming practices combined with intensive rain and rugged topography intensified land degradation problem in the country. The high population growth made steep fragile areas to be included into cultivation, thus accelerating rate of soil erosion (Betru, 2003).

The well-known proximate causes of land degradation include deforestation, overgrazing, limited soil and water conservation measures, limited application of nutrients/ organic matter, burning of dung and crop residues and decline use of fallow (Pender *et al.*, 2004). Food insecurity and poverty may lead to inability to invest in land conservation and the survival strategies may be detrimental to the natural resource bases . Poverty is very likely to contribute to land degradation for many reasons. When people lack access to alternative sources of livelihood, there is a tendency to exert more pressure on a few resources that are available them (Bekele, 2006).

2.4.2.Effects of Land Degradation

The effects of land degradation have a significant impact on various functions such as production, biomass, biological habitat, filtration, and sources of raw material, etc. FAO (2001) reported that the effect of land degradation on agricultural productivity are manifested through their impacts on both, the average and variance of yield as well as the total factor productivity of agricultural productivity. Land degradation is one of the major causes of low and in many places declining agricultural productivity and continuing food insecurity and rural poverty in Ethiopia (IFPRI, 2005). Land degradation leads to decrease both in the quality and number of livestock any change in livestock sector has tremendous effects on the living standards of the rural people as a whole (Adugnaw, 2014).Land degradation reduced livestock productivity because of reduced grazing resources, loss of nutritious plants and grass species. Due to land degradation, increased runoff and reduced infiltration contributes to flooding problem (Bezuayehu*et al.*, 2002).

2.4.3.Land Degradation and Food Security

According to FAO *et al.*, (2014), food security is a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Similarly Clay (2002), stated food security is a flexible concept as reflected in the many attempts at definition in research and policy usage. The continuing evaluation of food security as an operational concept in public policy has reflected the wider recognition of the complexities of the technical and policy issues involved. As per Meskerem&Degefa, (2015) who cited FAO &WFP, (2010) food security as a concept emerged at the United Nations Food and Agriculture Organization, World Food Conference in 1974 considering food availability as the central argument. This indicates that, either the nation could make available food through domestic production or through export to attain food security; therefore, availability and price stability of basic foodstuffs could ensure food supply at the international and national level. Following this, the 1996 World Food Summit targeted to halve the number of hungry people in the world by 2015 and the Millennium Development Goals targeted to reduce the proportion of hungry people by half.

Due to the presence of land degradation, Africa as a whole has become a net food importer since the mid-1980s. However, the economic implications of land degradation are particularly severe in Sub-Saharan Africa because 65% of the population is rural and the main livelihood of about 90% of the population is agriculture. Land degradation declines agricultural productivity and continuing food insecurity (Tilahun*et al*., 2001).

As a result, poverty and food insecurity are concentrated in rural areas Estimates vary considerably but direct losses of productivity from land degradation in Ethiopia are minimally 3 percent of agriculture GDP (Berry 2003). Due to land degradation, increased runoff and reduced infiltration contributes to flooding problem (Bezuayehu*et al*., 2002).Land degradation can contribute directly to poverty by reducing the availability of other valuable goods and services.

2.5. Drivers of Watershed Management

According to Darghouth*et al.,* (2008), upland areas are typically more fragile and less productive environments where natural resource management and food security are commonly linked. With frequently extensive land use practices and a more fragile resource base, uplands are vulnerable to over exploitation and depletion of natural resources (water, vegetation, forests, and soils). With land degradation, agricultural productivity declines, often aggravating the food security problem. Thus, watershed management programs generally have to focus on the farming systems of the poor in upland areas in order to achieve food security and land conservation objectives simultaneously.

2.5.1.Practices of Watershed Management

Due to increase in human population pressure, terrain nature of land, over-cultivation, deforestation, and irregular rainfall pattern, the agricultural production in the study area has been decreasing over time. In order to increase farm productivity and conserve the resource base of the *Woreda.* Primarily, restoration efforts introduced with the objectives repair degraded lands and as well increasing food security through increased food crop production (Adbacho, 1991).As a result, most of the watershed management for the construction of physical soil and water conservation measures and afforestation and agro-forestry components, were practiced to protect farm land degradation. Some widely used structural land restoration measures are soil bunds, stone bunds, stone-faced soil bunds, bench terracing, hillside terraces with trenches and area closures.

2.5.2.Physicalsoiland water Conservation

Physical soil and water conservation are methods, which aimed to reduce the velocity of surface runoff and minimize soil erosion by shortening the length and minimizing the gradient of the slope it also aimed to retain water when it needed or safely dispose excess runoff. The structures mainly involve different types of bunds, terraces, check-dams, water diversion (cut-off drain, water ways) and harvesting structures (micro basins)(Van der Veen A., &TagelG , 2011).Soil bunds are constructed during the dry season that do not interfere land preparation for cropping. The construction is aimed on reduction and stopping velocity of runoff. It increases soil productivity by capturing moisture and crop yields over time. Soil bunds can easily be integrated with grasses, shrubs, growing cash crops, root crops like sweet potato and taro, tubers like *enset,* fruit trees like avocado, growing after their development(Taffa, 1983).

Check dams is used for the gully control may be made of stones, soils or brushwood. In the study area stone is hardly enough to make check dams. Dominantly, the brush woods and soil are used to construct check dams.Areaenclosureinvolves the protection and resting of severely degraded land to restore its productive capacity. This could be via natural rehabilitation or enhanced by additional vegetative and structural conservation measures. Area closure is one of the components of the biological conservation measures and practiced on all land types where soil erosion has becomes serious and the land has lost its productive potential. However, generally the eroded hillsides are the prominent sites of area closure. Area closure is a simple conservation activity carried out on highly degraded lands. The benefits of area closure are conservation-degraded lands, the hillsides, which were previously closed, have become productive, flooding and runoff reduced, has improved water table and revived springs also wild life has returned and environment is improved.

2.5.3.The contribution of watershed management in Ethiopia

The immediate outcomes of watershed management interventions are rehabilitation of natural resources, including recharge of the groundwater table, reforestation of upper catchments, reduction in soil erosion and associated downstream siltation, and regeneration of plant resources. These outcomes in turn contribute to increased agricultural output, diversification of food and income sources, reduced migration, and improved biodiversity. The resultant development impacts include increased food and nutrition security, improved status for women, reductions in poverty and improved natural environment (Chisholm &Tassew, 2012).

Food security, poverty, growing water scarcity, increased land degradation, loss of biodiversity are the major constraints for sustainable development.The current farmers' yields in the developing co untries in dryland areas of the tropics are lower by 2 to 5 folds than the potential yields obtained by researchers and commercial farmers. The community watershed approach espouses the principles of convergence, consortium, collective action, and capacity building to address the issue of equity, efficiency, economic gain, and environment protection. Watershed management is seeing as an ent ry point for improving livelihoods and achieving food security through diversification o the system s and enhancing agricultural productivity through efficient use of natural resources. Capacity build ing is an important pillar.It has resulted in increasing agricultural productivity by to 3folds, doublin g the family incomes, and reducing runoff up to 66% and soil loss by 2/3rd. (Wani,S.,*et al.*, 2010).

2.6. Empirical Literature Review of Food Security

It is evident from different studies that land degradation is a serious problem globally in general and in Africa and Ethiopia in particular. Although the degree of global land degradation is open for debate, estimate that it affects 2.6 billion people in more than a hundred countries, covering over 33 per cent of the earth's land surface. Around 73 per cent of rangelands in dry lands are currently being degraded, together with 47 per cent of marginal rain fed croplands and a significant percentage of irrigated croplands (Gisladotir & Stoking, 2004).Africa accounts for 65 % of the total extensive cropland degradation of the world. According to the World Bank, at least 485 million Africans are affected by land degradation, and Africa is burdened with a US$9.3 billion annual cost due to this phenomenon (Thiombiano &Tourino, 2007).

In Ethiopia, historical documents show that soil erosion and declining fertility are posing serious challenge to agricultural productivity and economic growth through land degradation (Lemenih, 2004). According to Temesgen Gashaw (2015), in Ethiopia, rapid population growth, cultivation on steep slopes, clearing of vegetation and overgrazing are the main factors that accelerate soil erosion. In the Ethiopian highlands, the population has grown very fast on the limited land area and every possible piece of land is put into cultivation to produce food which results soil erosion. Similarly, declining vegetative cover and increased levels of farming on steep slopes in Ethiopian highlands have eroded and depleted soils, so that soil degradation is now a widespread environmental problem. The severity of soil erosion in Ethiopia in general, is the result of the mountainous and hilly topography, torrential rainfall, and low degree of vegetation cover. Similar studies shows that in 1994, the direct cost of loss of soil and essential nutrients due to unsustainable land management is estimated to be about three percent of agricultural GDP or $106 million. As a result, poverty and food insecurity are concentrated in rural areas and every year 20,000-30,000 hectare of cropland in the highlands is brought out of production from soil and the loss of soil productivity leads to reduced farm income and food insecurity, particularly among the rural poor and thus continuing or worsening poverty (Temesgen Gashaw, 2015).

2.7. Analytical framework

This research would follow the analytical framework depicted in (Figure 1) which explains the relationship among variables and WSM, which in turn affects food security. They include demographic and socio-economic factors, farm characteristic and institutional factors of WSM. The outcome of the study would be providing whether WSM intervention is contributing on household food security status of the farmer or not. The linkage and interaction of WSM between household food security statuses are explained as follows.

Age of household head: Age is a continuous explanatory variable. As age of a household increases, it is assumed that employ or business owner could acquire more knowledge and experience. They are more risk averter and their chance to become more food secure increases with age. Thus, food security is positively correlated.

Household head sex: This is a dummy variable with zero for male and one otherwise. Male household heads are expected to have higher income compared to female household heads because of better labor inputs used in male-headed households.

Education level of a household head: In the study area, the head of the household is responsible for the co-ordination of the household activities. It is likely that educated farmers would more readily adopt WSM technologies and may be easier to train through extension support.

Cultivated land size: Total cultivated land is the total sum of the household's own and/or rented in/out from/to other households and measured in hectares. This did not include the grazing and fallowing lands. Farmland is the major input for agricultural production in rural households.

The number of livestock owned: This is a continuous variable measured households with higher livestock holding would lead to higher probability of getting excess livestock for selling and hence generating additional income, particularly the owner of improved varieties of livestock including modern beekeeping could earn higher income.

Off-farm/Non-farm income: This is a continuous variable measured in ETB. It is expected that households with more off-farm/non-farm income could earn more gross income because they might introduce WSM practices.

Income: The total income of the household, this variable was measured by farm activities. It is an important variable in determining a household's agricultural production power for available and access food. The sign for the relationship is expected to be positive which more income has probability of food secure.

Land tenure: When farmers have secured land tenure, they will invest considerable capital in soil water conservation practices which helps to increase productivity in order to ensure food security. In addition, political structure also affects productivity due to instability, conflicts and difficulty to insure infrastructure.

On the other hand, watershed management improves the household food security status through providing an answer to land degradation, alleviate drought, moderate floods, prevent soil erosion, improve water availability and increase food, fodder, fuel and fiber on sustained basis. Watershed management helps to achieve maximum production with minimum hazard to the natural resources and for the well-being of people.

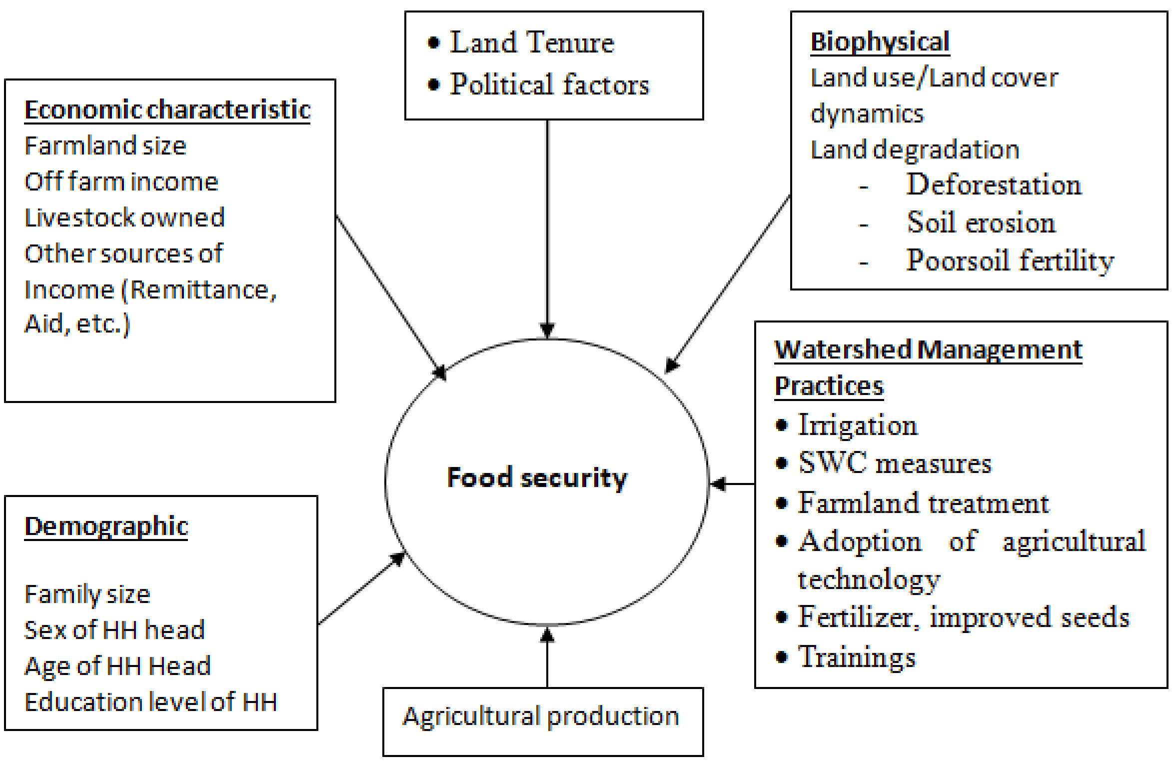

Fig1. Analytical framework of food security and WSM

Source: Adopted from different literature reviewed

CHAPTERTHREE

DESCRIPTION OF THE STUDY AREA, RESEARCH DESIGN AND METHODOLOGY

3.1. Description of the Study Area

The study was carried out in Rebu watershed in Waliso*Woreda* in Southwest Shewa zone of Oromia Region. Geographically Waliso*Woreda* is situated between 8° 15′ 0″ - 8° 45′ 0″ N and 37° 50′ 0″ - 38° 10′ 0″E.Waliso*Woreda* is located in the Southwest Shewa Zone of the Oromia Region, 114 km southwest of Addis Ababa. The relative location or visional position of the *Woreda* has physically contacts with four Woreda, namely Bacho, Goro, Wanchi, and Saden-Sodo and one region namely SNNP. In terms of this *Woreda* location, Bacho, boards Waliso*Woreda* in the North in the west by Wanchi, in the Southwest by SNNP, in the south by Goro and in the east by Sadden Sodo *Woreda* (Fig. 2).

The altitude of the *Woreda* ranges between 1800 to 2300 meters above sea level with maximum and minimum daily temperature of 27°C and 18.7°C respectively (DANRO, 2017). The *Woreda* has two agro-climatic zones with 60% and 40% of *Dega* and *WoinaDega* types respectively. The main season of rainfall of the *Woreda* is summer in the months of June, July and August of which the of mean annual rainfall amounts 1350mm (Woliso *Woreda* annual report, 2013).

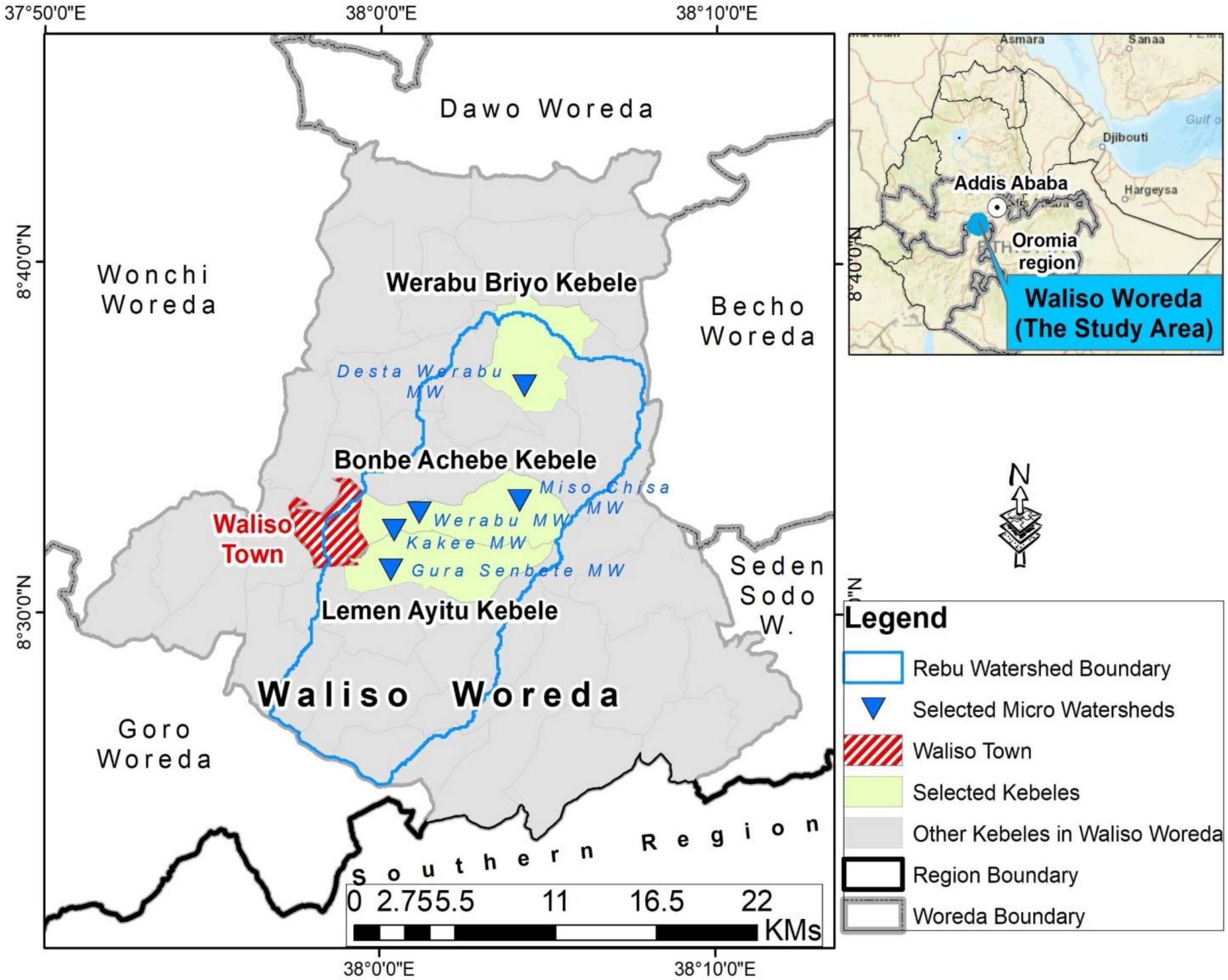

Fig 2Map of the Study Area

Source: CSA 2007, ArcGIS 10.5 Ver

According to CSA (2013), the total population Waliso*Woreda* was projected for 2017 to be 243,402. Of these, 73.6 % resides in the rural part of the *Woreda* whereas the remaining 26.4% dwells in urban areas, largely in Waliso town. The projected population of Waliso town is 61140, among these 30190 and 30950 are numbers of males and females respectively. On average, the rural and urban population densities are estimated to be 233 persons per Km^2 and 4487 persons per Km^2respectively. Estimated from survey data a rural household in the *Woreda* has an average family size of 6 persons per household this makes the total number of households in rural part the *Woreda* was estimated to be 29,848.

Table: 1 Population urban and rural of Waliso *Woreda*

Item	Sex	2007	2017
Urban Population	Male	19,898	32,155
	Female	20,553	33,220
	Total	40,452	65,375
Rural Population	Male	70,129	89,151
	Female	70,748	89,939
	Total	140,877	179,090
Total Population	Male	27,304	121,306
	Female	28,024	123,159
	Total	181,329	244,465

Source CSA (2014)

In addition to the report prepared by GIZ and Waliso Woreda Agricultural Development office, (2013). The 15 micro-watersheds of Rebu are inhabited by a total of 2869 households among them 360 are female headed accommodating 17214 populations (6 average household sizes) and land holders are 2308 and land less are 561.

3.1.1. Economic activities

Mixed agricultural practices (crop production and livestock rearing) are the major means of livelihood of the study area. Crop production like, wheat, barley, Teff, and *Enset* is the dominant agricultural activities that most of the population of the study area engaged in and are earning their life. The livestock sub-sector plays an important role in the livelihood of the rural people in terms of providing alternative income sources, as a strategy in building resilience to shocks, stress and in contributing to their food security (FAO, 2013).

The major land use categories of the *Woreda* are non-pasture vegetation (patchy natural forest, plantations, woodland, or bush land), pastureland (grazing land), cultivated land, and settlements. According to agricultural and rural development office, agricultural land still accounts for the largest share of the land use types in the *Woreda*, which accounts 72%, 14.7 % is grazing land and 6.3 % of the area is covered by forests. The total land mass of the entire watersheds amounts is

117.3 km^2. Farmland constitutes about 50%, hillside 30%, homestead 11%, grazing land 4%, forest 4%, and gully 0.7%, of the total land size.

3.2. Research Design

In this study mixed research design was applied. Accordingly, time series longitudinal satellite data and cross-sectional data were used to gather information on population at a single point in time address the intended objectives of the study.

Quantitative data collection and analysis, primary data was collected from sample households through questionnaire survey and satellite data (2000-2019). Qualitative data were collected using focus group discussion, field observation, and key informant interview. The study applied both qualitative and quantitative data collection and analysis in parallel form as the research intends the two methods to complement each other for a complete analysis.

3.3. Sampling Techniques

The representative sample was selected from the total population under the study, from the total household farmer's and *kebele* administration of Waliso*Woreda*. The *Woreda* and the watershed were selected purposely due to agro-ecology zone. Five *kebeles* of the watershed were selected using stratified random sampling. Three micro watersheds in *WoinaDega* agro-ecology and two micro watersheds in *Dega* agro-ecology were selected randomly. Finally, proportional sample household were selected in each micro watershed.

Table:2 Selection of Sample Households

Kebele	Micro-watershed	Area (ha)	Total land holds HH	Sampled HHs
BonbeAnchebe	Werebo	478	214	90
LemenAyitu	G/Senbete	182	194	82
BonbeAnchebe	M/Chisa	559	168	71
BonbeAnchebe, LemenAyitu	Kakee	548	108	46
WarebuBriyo	D/Werabu	816	124	52
Total		2583	808	**341**

Source: Researcher's computation

3.4. Sample Size Determination

The sample size is an important feature of any study or investigation in which the aim is to make inferences about the population from a sample. They suggest that it should be carefully fixed because it is essential to draw valid and generalized conclusions. In this study, based on the above suggested sample techniques number of participants or the sample size of the study was determined as stated below.

Rebu major watershed inhabited by 2869 households; among them 2308 households are land-holding households that are under the SLM programme. As the study focuses on collecting information from plots household and make an inference of findings from the whole community, the watershed sample households selected accordingly.

The total sample size computed using the equation developed by Yamane (1967:886)

$$n= N/1+N\,(e)^{2}$$

$$=2308/1+2308(0.05)^{2}$$

$$=341 \text{ households}$$

Where n is the sample size, N is the population size, and e is the level of precision (5%).

3.5. Data type, source and instrument

Data were collected based on demographic, socio-economic and WSM practice (soil bund, stone bund, biological plantation or any combination of them). In addition, information on involvement of households in other soil fertility improving practices was also part of the data collection. As variable that believed to explain the contribution of WSM practices, data collection included:

- Households characteristics: Household age, household sex, household size, household education, household training,
- Economic characteristics: land holding, livestock holding, and agricultural production, Access to services: Access to irrigation, access to extension services, credit services, access to market and assistance.

Income and food security indicators: household income from crop sale, household income from livestock and other livelihoods strategies, indicators for food consumption score (FCS).
Sources of the data were both primary and secondary data. Instruments that were used to collect the primary data include questionnaire survey, focus group discussion (FGD), key informant interview, and personalfieldobservation.Thedetailofcollectionprocedureisdepictedhereunder.

3.5.1. Primary data

The main instrument used for data collection was a structured questionnaire, Focused Group Discussion (FGD), key informant interview (KII) and personal field observation to address specific objectives of the study.

Household questionnaire

Household questionnaires were open and close-ended questions that were pre-tested and also developed in English and translated in to *Afan* Oromo, which is the official working language of the *Woreda*. Interviews were conducted with household heads about socio-economic characteristics; type of WSM practice (soil bund, stone bund, biological plantation, or any combination of them) data was collected. In addition, information on involvement of households in other soil fertility improving practices was also part of the data collection and food security status.

Field observation

In addition to the above data collection methods, the researcher to substantiate and augment the information obtained through other primary data collection tools executed a field visit. Biophysical and socioeconomic conditions of the area were explored through the field observation. In the meantime, experts and administrators in the Woreda and kebeles were briefly interviewed.

Focus Group Discussion (FGD)

FGD was carried out with a mix of participants of Rebu watershed management such as stakeholders that have a special interest in addition to communal benefits from the watershed management. This includes women-headed households, youth, elderly, and community watershed team. They are representative of the economic and social makeup of the micro-watersheds. The participants were respectfully requested for their consent, time and the information. Topics related to issues of watershed management contribution, agricultural practices, livelihood opportunities and challenges, environmental protection, food security status, public services, and the existing support from the government were addressed.

Key informant interview (KII) in addition, some key persons in sample *kebeles*, and the *Woreda* was interviewed to obtain relevant information. The in-depth interview focused on organizing formal interview with the aim of facilitating open interaction between the key informant and the researcher through inviting key figures in the respective institutions relevant for the issue under discussion to participate in open dialogue forum. The KII done face-to-face. Key informant interview was carried out with experts and administrators' at *Woreda* and *kebele* levels as well as the farmers, development agents and local NGO operating in the area.

3.5.2. Secondary data

Secondary data source was also used as source of information. In this regard, additional information was obtained from the governmental and non-government organizations. *Woreda* office of Agriculture was the major counterpart selected for discussion and secondary data collection, while GIZ was the major contact pint for providing secondary information from multiyear plan documents, annual plans, physical activity and financial achievement reports which were vital in designing the research and serve as an input in many pieces of the study.

3.6. Data analysis

3.6.1.Methodological approach to LU/LC change analysis

A mixed quantitative and qualitative research design was employed in order to map the land use/land cover of Rebuwatershedin2000, 2011, and 2019 based on satellite imageries from Land Sat and Google Earth, to identify the main drivers and assess environmental impacts of the change in the main LU/LC categories. A mixed visual and probabilistic classification was used to classify Landsat images of the area in 2000, 2011 and 2019 into the different LU/LC types. A qualitative research approach (actually interview with key informants, observation and description of sites and fields) while identifying the factors for the major changes like expansion of built-up areas, decline of vegetation, expansion of cropland and the impact of the change over the socioeconomic aspects of the communities in the *Woreda.*

Before the detail land use/land management practices in the selected 5 micro watershed was studied, land use/land cover change in the entire Rebu watershed was carried out based on LandSat7 ETM+ imageries for the years 2000 and 2011 and Landsat 8 OLI/TIRS imagery for the year 2019. In order to differentiate vegetation from other land uses like cropland, non-cloudy bright days were selected, actually 26 November, 30 March, and 07 January for the scenes in 2000, 2011 and 2019 respectively.

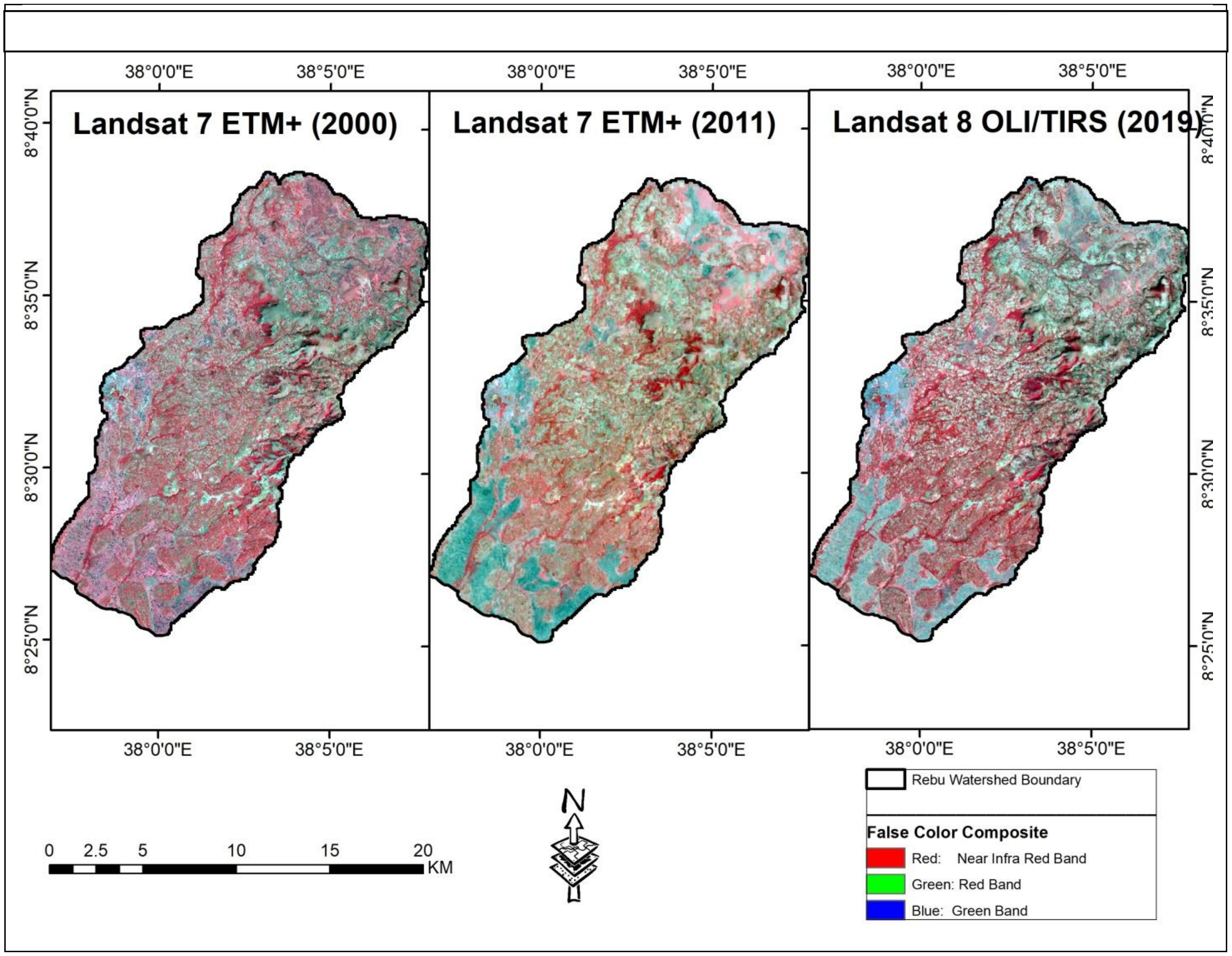

Fig:3 False color composite display of Landsat imageries Rebu WS

Source: Classification of land Sat images from WWW:\\EarthExplorer.USGS.Gov

~~An area populated by red color and is indicator of vegetation including forestlands, woodlands/bush lands and plantations. This darker reddish color is more visible in the 2000 and 2019 imageries of the basin than it is in the 2011imagery of the area. The majority of the watershed especially in 2000 was covered by vegetation. The intensity of the vegetation in 2011 is~~

~~quite shallower than that in 2019.This indicates that vegetation coverage was the highest in the earlier days. The higher vegetation coverage in 2019 than it is in 2011 could be attributed to the rehabilitation and the management of the natural vegetation started in the watershed since 2010.~~

The classification and interpretation of the satellite imageries into a certain LU/LC cover categories was done by image enhancement (by applying smoothing, sharpening and contract stretching),displaying bands in false color composition and natural color composition, and by deriving NDVI (normalized vegetation index) applied on land sat imageries. A false color composite display of green, red and near Infrared bands of the Imageries LandSat7ETM+ (Nov 2000, Mar2011), and LandSat8 OLI/TIRS 9 + (Jan 2019) of the area was displayed. The main intention behind using a false color display of these bands was to differentiate water bodies, vegetation (grassland, woodland, and forestland) and bare soils (degraded land, cultivated land and built up areas) distinctively. As shown in the imageries of the area displayed above, an agglomeration of cyan (light bright blue) colored areas were identified as built-up areas. Besides the darker red tone in the majority of the watershed especially in 2000 and 2010were clearly differentiated to be vegetation area (forestland, woodland, or plantations). Together with a high resolution Google Earth, imagery and GPS data collected at some selected sites and community watershed the lighter and smooth red tone areas in the northern part and at some scattered places in the basin was identified and classified to be grassland. Google earth – displaying the 2005, 2011, and 2019 very high spatial resolution images taken at some selected micro watersheds and visited kebeles in the area allowed us to classify the majority bare land area as cultivated land and some as bare/degraded land.

The enhanced FCC display of the landsat imageries of the area combined with the very high resolution imageries from Google Earth, the Rebu watershed was classified into five major land use categories (Forestland/Woodland/ plantation, grassland, bare/degraded land, cultivated land and built up areas) based on the USGS level I land use/land cover classification (Anderson *et al.*, 1976).

Table: 3Description of the major LU/LC types classified from Land Sat Imageries

LU/LC Type	Description
Forestland/Woodland/	Areas covered with dense trees/woods, shrubs, and grasses – spatially not differentiable pattern- that appears to be a dark or a bright red continuum

Plantations	in FCC display of landSat imageries. Scattered patches covered with trees, which appears to be a mix of dark and light red color in a FCC display of LandSat Imageries.
Grassland	Areas covered with normally irregular shapes/strips in the cropland and largely in the eastern part of the basin with a smooth light red color on a FCC display of dry season Land Sat imageries.
Bare land/Degraded land	Exposed areas probably covered by sandy soils appear to be brighter cyan and they are a continuum of amorphous shaped areas.
Cultivated land	Areas covered with normally regular shapes/patterns of land lots with a smooth darker cyan color on a FCC display of dry season LandSat imageries.
Urban Built-up Area (settlement)	A cluster/block of houses bounded with network of roads/linear feature as towns, which appear to be regularly shaped bright cyan, in a FCC display of land, sat imageries.

Source: Anderson, 1976

The accuracy of the classification of the images into the above LU/LC classes was assessed based on GPS data collected in the visited kebeles and along the way to the visited kebeles and a very high-resolution Google earth imageries clipped for the visited sites and micro-community watersheds. As it calculated using Kappa index the overall accuracy or the matching of user (office based classification) and producer (field reference classification) was found to be 84% for the 2011 image classification and 86% for the 2019image classification. Accuracy assessment for the classification of the 2000 Land Sat image was not processed due to the lack of high resolution for the year 2000 and poor historical records. However, the accuracy of the classification of this image is assumed/inferred to be as high as the accuracies for the 2011 and 2019.

3.6.2. Methods of Data Analysis

There are a number of different research methods available and one should be selected which is most likely to meet the objective of the research and gather the correct type of information. In order to address the specified objectives and to answer the given research questions, the study analyzed the data both qualitatively and quantitatively. Thematic analysis techniques used for obtaining data through interview and field observation.

Quantitative data, collected using questionnaire survey analyzed using latest version SPSS 23 software and excel in order to describing key findings, conditions, states and circumstances disclosed from the data. Measure of central tendencies (mean) and measures of dispersion (standard deviation) were major descriptive techniques that used to summarize and compare the data. In this study relevant data was collected to measure household's food access using FCS Food Consumption Score.

3.6.3.Techniques of Food Security Analysis

There were three different data analysis techniques used to portray the findings of the study. These are land use/land cover dynamics, Descriptive Statistics, and Measuring Food Security,

3.6.4.Assessment of household food security status; Food Consumption Scores (FCS)

The Food Consumption Score (FCS) an index that developed by the World FoodProgramme in 1996. The FCS aggregates household-level data on the diversity andfrequency of food groups consumed over the previous seven days, which weightedaccording to the relative nutritional value of the consumed food groups. The food consumption groups include starches, pulses, vegetables, fruit, meat, dairy, fats, and sugar. If these groups are surveyed in a disaggregated fashion, the consumption frequencies of the different foods in the groups are summed, with the maximum value for the groups capped at 7(table 4).

Table:4 Food consumption groups

	Food Items	Food Groups	Weight
1	Maize, maize porridge, rice, sorghum, millet pasta, bread and other cereals	Main Staples	2
	Potatoes and sweet potatoes, other tubers, plantains		
2	Beans, Peas, groundnuts and cashew nuts	Pulses	3
3	Vegetables, leaves	Vegetable	1

4	Fruits	Fruit	1
5	Beef, goat, poultry, pork, eggs and fish	Meat and Fish	4
6	Milk yogurt and other diary	Milk	4
7	Sugar and sugar products, honey	Sugar	0.5
8	Oils, fats and butter Oil	Oil	0.5
9	Tea, coffee, salt, small amounts of milk for tea.	Condiments	0

Source :(INNDEX, 2018).

The formula, based on these groups, with the standard weights, is:

FCS = (starches*2) + (pulses*3) + vegetables + fruit + (meat*4) + (dairy*4) + (fats*.5)+ (sugar*.5).(WFP, 2019) from https://www.wfp.org/content/meta-data-food-consumption-score-fcs-indicator

Once the food consumption score is calculated, the thresholds for the FCGsshould be determined based on the frequency of the scores and the knowledge ofthe consumption behavior in that country/region(WFP, 2008).

The typical thresholds are:

Table:5 Food consumption score cut off point

FCS	Profiles
0-21	Poor
21.5-35	Borderline
>35	Acceptable

Source:(WFP, 2008).

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter presents the result of the study. The first section descriptive statistics info derived from the survey data carried on the sample respondent households. Demographic, socioeconomic characteristics, land holding size of the households was presented and discussed. In the second section, the LU/LC change analyzed for the entire Rebu watershed and for the five selected micro-watersheds was discussed. In the remainder, section inferred from the sample respondents the information about the contribution of WSM to households food security, practices of WSM, and other related on farm activities and total income of the farmers in the study area was presented and discussed.

4.1. Descriptive Statistics

4.1.1. Demographic and socio-economic characteristics of study participants

A total of 341 respondents were included for the analysis of contribution of WSM practices to HHFS from 2 agro-ecology zone of Waliso *Woreda*.

Sex: The household taken from the total respondents show the male household head dominate and account about 91.74% and the remaining only 8.26 of the sample households are female headed.

Household size: Household size and characteristics are directly related to the supply and demand conditions for basic human needs such as food, shelter, health, and educational facilities, which in turn directly or indirectly influence the decision for watershed activities for a farming system Fikru (2009). Family size and composition affect the amount of labor available for farm, off-farm, and household activities and determines the demand for food. About 52.01% of the household heads in the current study sites consists of 4-6 numbers of family members (Table 6). The next larger household sizes were found to be 7-9household size, which accounts for 27.01%, 8.56% has above 9 numbers of family members and 11.89% of household heads have 1-3 members of family. Average family size at national level 4.8 (CSA 2013)**.**The average family sizes of sample household of micro watersheds were larger family size. This indicates that watershed management interventions did not integrate family planning in its activities.

Marital Status: 95% of the total heads of households surveyed were married (Table 6). Single heads of households were 2.82%, 0.98% were divorced and 0.49% widowed.

Table: 6 Demographic characteristics of the households

Household Demographic		Watershed/field name					
		Kakee (%)	M/chisa (%)	G/Senbete (%)	Werbu (%)	D/Werabu (%)	Total (%)
Sex	Female	6.5	5.6	19.5	0.0	9.6	8.26
	Male	93.5	94.4	80.5	100.0	90.4	91.74
Marital Status	Married	93.5	97.2	89.0	98.9	100.0	95.71
	Single	6.5	2.8	3.7	1.1	0.0	2.82
	Divorce	0.0	0.0	4.9	0.0	0.0	0.98
	Widowed	0.0	0.0	2.4	0.0	0.0	0.49
HH Size	1-3	17.4	8.5	11.0	11.1	11.5	11.89
	4-6	52.2	49.3	45.1	50.0	63.5	52.01
	7-9	30.4	31.0	29.3	27.8	19.2	27.54
	Above 9	0.0	11.3	14.6	11.1	5.8	8.56
HH Training	Not taken	2.2	15.5	0.0	0.0	0.0	3.53
	Conservation of NRM	97.8	84.5	100.0	100.0	100.0	96.47

Source: Own Field Survey, 2019

Household Education status: Educational background of sampled household head is believed to be an important feature that determines the readiness of the household head to accept new ideas and innovations. As educational status of household increases, it is assumed to increase the transfer of relevant technology and as result increase farmers' knowledge about the cause, severity, and consequence of land degradation. The empirical result shows that the educational status of farmers in the study area is considerably medium (average). In the area as a whole, 37.5 % of household heads were unable to write and read (table 6). But Merkineh M, *et al*.,(2018) in Kindo Didaye District, Southern Ethiopia, and Fikru (2009) in Koga watershed said the largest proportion is unable to read and write(no formal education).From the remaining 4.4% have informal education, 42.8% of them attended primary education,15.2% have attended secondary education . Therefore, education was thought to influence household food availability and accessibility. The basic premise here was that educated households have possible advantages of increasing agricultural production and productivity by means of adopting improved technologies and farm practices, which, in turn, would enhance households' food availability.

Table:7 Household educational status

HH Education status	Frequency	Percent
Unable read and write	128	37.5
Informal education	15	4.4
Primary education	146	42.8
Secondary education	52	15.2
Total	341	100

Source: Own survey 2019

Household Age: Three age groups for head of household/s are identified: 20-40, 41-60 and above 60. The majority of the household heads are in the age 41-60 years group. Farmers in this age group are assumed to have a good understanding in the contribution of watershed development.

4.2. Land holding size

Land holding size has significant bearings on farmers' decision to invest in land management practices as well as their choice of land practices and land management methods. The distribution of farm size among the sample households is presented in Table 8: All respondents (100%) replied that they have their own farmland. The survey result showed that only 64 households' posses1-2 hectares land, 276 respondents' posses 0.5-1 hectares land. The survey results show that 1 of the respondents' posses less than 0.5 hectares of land. The situation is similar to country level reality. According to CSA (2013), more than 60% of the farmers in Ethiopia on average, own less than one hectare per family. This result indicates that there is acute shortage of farming land in the study area. Therefore, this small land holding size affect farmers to applied traditional soil and water conservation practices like fallowing system. Farmers who operate on large farms allocate some parts of land for soil conservation structure than those who have small farms.

Table: 8Land holding of sample households

Cultivated Land in Hector	N	Minimum	Maximum	Mean	Std. Deviation
< 0.5	1	46.5	46.5	46.500	
0.5 – 1	276	15.5	84.5	46.830	14.7844
1 – 2	64	20.0	74.5	46.922	13.1831
Total	341	15.5	84.5	46.846	14.4567

Source: Own field survey, 2019

4.3. The land use land cover changes over the Rebu major watershed

The twenty years land use land cover maps of the major Rebu watershed was derived based on Land sat imageries and displayed in Fig 4 given below. As it can be seen from the three maps, Rebu watershed appears to be dominated by vegetation, which includes patches of natural forest, plantations, bush/wood land, grassland, and *Enset*. The area covered by cropland (brown) also appears to have increased over the last two decades and is likely to be the most dominant LU/LC category in the recent future.

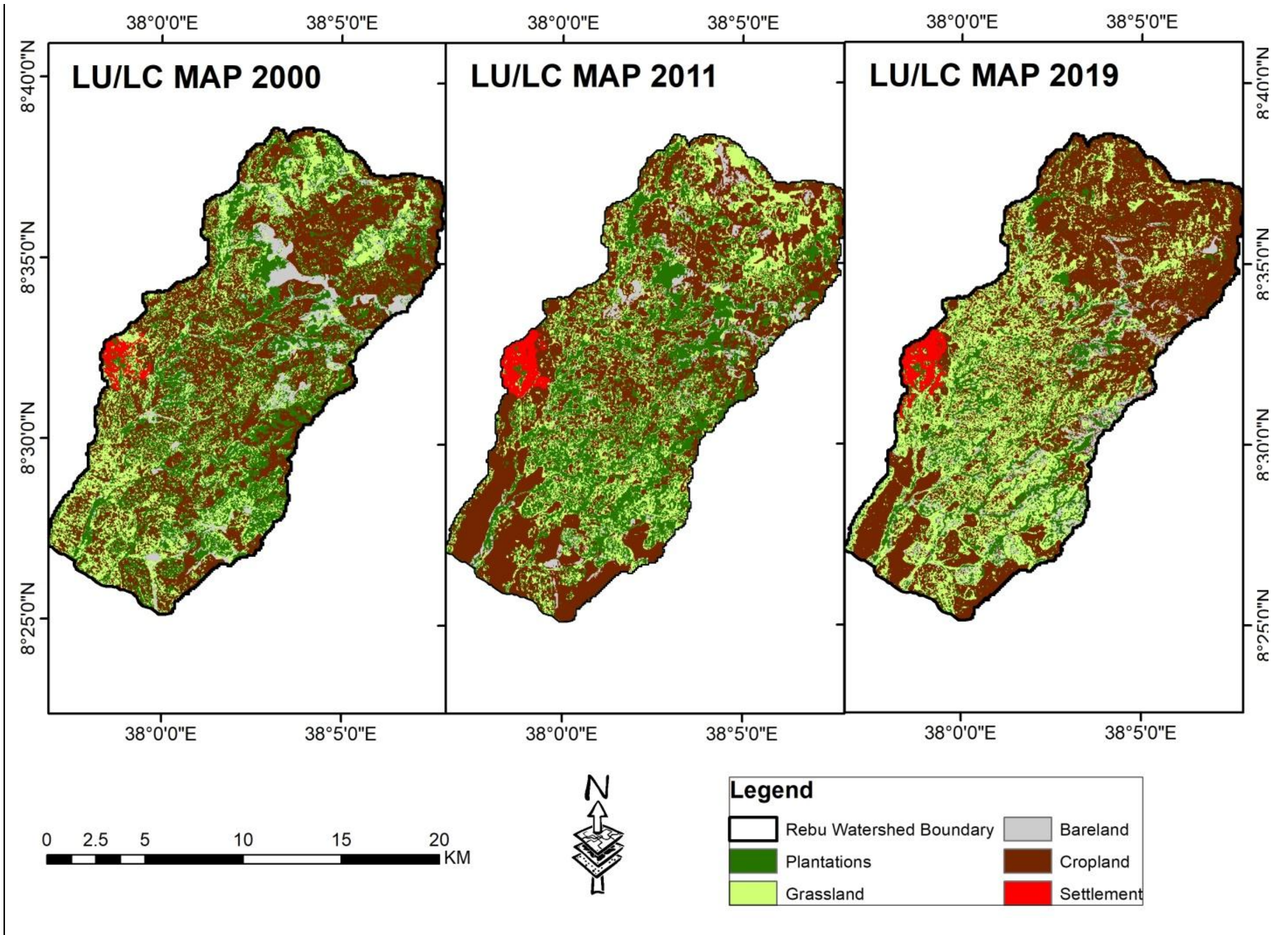

Fig:4 *the 2000, 2011 and 2019Land use/Land cover maps of Rebu watershed*

Source: Classification of land Sat images from WWW:\\EarthExplorer.USGS.Gov

Once generated the land use/land cover maps for the watershed for the years 2000, 2011 and 2019, Arc GIS ver 10.5 and Excel 2010 was used to create the 2000, 2011 and 2019 land use/land cover maps of Rebu watershed (shown on fig 4) above and derive change matrices portrayed in the table below.

Table:9 Percentages of LU/LC in Rebu WS during the period 2000 - 2019

LU/LC type	2000		2011		2019	
	Ha.	%	Ha.	%	Ha.	%
Woodland	8214.1	32.4	7491.8	29.6	4553.8	17.99
Grassland	5528.3	21.8	5586.9	22.1	7444.5	29.4
Bare land	1683.2	6.6	1102.7	4.4	1412.1	5.6
Cropland	9636.8	38.1	10689.6	42.2	11421.6	45.1
Settlement	251.9	1.0	443.2	1.8	483.8	1.9
Total	25314.3	100.0	25314.3	100.0	25315.9	100.0

Source: Classification results of images downloaded from WWW:\\EarthExplorer.USGS.Gov

Over the entire watershed, forest/woodland has declined from 32.4% (8214.1ha) in 2000, to 29.6 % (7491.8 ha) in 2011 and to 17.99% (4553.8 ha) in 2019. Opposed to this declining trend of forest /woodland in the watershed, grassland has shown a steady increasing trend from 21.8% (5528.3 ha) in 2000 through 22.1 % (5586.9%) in 2011 to 29.4% (7444.5 ha) in 2019. Similarly, cropland and built-up areas have shown an increasing trend. This is associated to the natural increase of the rural population everywhere in Ethiopia. As described in chapter 3, the urban and rural population of Waliso *Woreda* has an increasing trend by 4.8% and 2.4% respectively. Compared to the 2000, cropland and built areas have increased by19% (1785 ha) and 92% (232 ha) respectively. Unlike these sharp decline or increase, bare land has shown a decreasing trend from 2000 to 2011 and increasing trend from 2011 to 2019.

The LU/LC matrix below tells that the areal extent of which Land use/Land cover type in 2000has been transformed to which other LU/LC types in 2019.About 34% of forest/woodland, 45% of grassland, 15% of bare/degraded land, 63% of cultivated land and 75% of built-up area in 2000has persisted (remained unchanged) until 2019. From 66.5% (5485 ha) of forestland/woodland in 2000, about 28.9%, 28.8%, 8.1%, and 1% has been changed to cropland, grassland, bare land and built-up area respectively during 2000-2019. In other words, quite a large extent (actually about 67 %) of non-pasture vegetation like the natural forestland, bush land, woodland, and vegetation in 2000has changed to other LU/LC categories in 2019. About 29% of non-pasture vegetation was cleared and cultivated, about 29% of the vegetation especially in the south western part of the watershed was shall owed to be grassland in 2019and about 8% of the non-pasture vegetation has however cleared up and abandoned to be bare/degraded land.

Table: 10LU/LC change matrix in Rebu WS during the period 2000 – 2019

Land use/Land cover types 2000

LU/LC types 2019

Lu/LC type	Woodland		Grassland		Bare land		Cropland		Settlement		Total	
	Ha.	%	Ha.	%	Ha.	%	Ha.	%	Ha.	%	Ha.	%
Woodland	2753	33.5	7280	13.2	152	9.0	917	9.5	22	8.7	4572	18.1
Grassland	2363	28.8	2499	45.2	347	20.6	2214	23	31	12.1	7452	29.4
Bare land	669	8.1	146	2.6	245	14.5	352	3.6	00	0.0	1412	5.6
Cropland	2374	28.9	2026	36.6	937	55.7	6073	63	12	4.7	1142	45.1
Settlement	79	1.0	130	2.3	4	0.2	83	0.9	188	74.5	483	1.9
Total	8238	100	5529	100	1684	100.0	9640	100	252	100	25342	100

Source: Classification results of images downloaded from WWW:\\EarthExplorer.USGS.Gov

While the largest proportion (about 36.6 percent actually) of the pasture land in 2000 was found to be cultivated in 2019, about 13.2 % of the grassland in 2000 was regenerated to non-pasture vegetation (shrub, bush/woodland, forest, etc.) or covered with plantations. However about 2.6% (146 ha) of the grassland was found to be overgrazed, degraded or abandoned to be barren land. About 55.7, 20.6% and 9% of the watershed was used to be bare/degraded land in 2000 but later (probably because of the project interventions during 2011–2019) these percentages of bare/degraded land were rehabilitated or converted to cultivated land, grassland and forest/woodland respectively. As it is witnessed by the farmers themselves, the analysis of satellite imageries tells us that about 10% of the cultivated land in 2000was converted to forest plantations (eucalyptus, acacia, etc.), 23% was changed to pasture land and some 3.6% of cropland in 2000has been changed to be bare/degraded land in 2019. The justification for this however cannot be traced only as a consequence of over-cultivation and land degradation but also the level of error committed while classifying bare land from cultivated which in turn due to similarity of signatures of bare/degraded land (brighter cyan with tine strips or amorphous shapes) and cropland (agglomeration of darker cyan tiny rectangular shapes).

4.4. The land use land cover changes over the sample micro-watersheds

The land use/land cover changes in the five sample micro watersheds (MWS) in which intervention was made during 2011-2018 for restoring the natural land resources (rehabilitating vegetation cover and degraded bare land) was carried out based on very high resolution imageries from Google earth. The 2005, 2011 and 2019 satellite imageries from Google earth was used to see the change during 2011 - 2019 (intervention period) in comparison with the changes during 2005 - 2011.This is appreciate the impact of the intervention made during 2011 – 2019 on the land resources (vegetation, degraded/ bare land, etc.) in the sample micro-watersheds. The same major land use/land cover categories used for classifying the Landsat images of the Rebu watershed (Forest/woodland, grassland, bare land, cropland, and settlement) was used to classify the very high Google earth imageries of the microwatersheds. This is based on the assumption that a significant increase in vegetation (forestland/woodland, grassland etc.) and decline of bare land (degraded land) in 2019 as compared to their extent in 2011 or 2005 would be considered as impacts of the intervention made in the sample micro-watersheds.

4.5. The land use land cover changes over the visited Micro-watershed

The land use land cover change over the period 2005 – 2011 and 2011 – 2019 was derived for the sample micro-watersheds (DestaWerabu, Werabu, Miso Chisa, Kakee and GuraSenbete) from Rebu watershed. These micro-watersheds were visited during the fieldwork. The 2005, 2011, and 2019Google Earth imageries for each micro watershed were classified into the major LU/LC categories.

4.5.1.LU/LC change in DestaWerabu Micro-watershed

Destawerabu is one of the MWS situated in Northern part of Rebu major watershed. As it is shown its LULC map for the years 2000, 2011 and 2019 (fig5), D/Werabu appears to be intensively cultivated, actually about 67% (in 2005), 68% (in 2011) and 70 % (in 2019) of the total catchment size (1789 ha) was found to be cultivated.

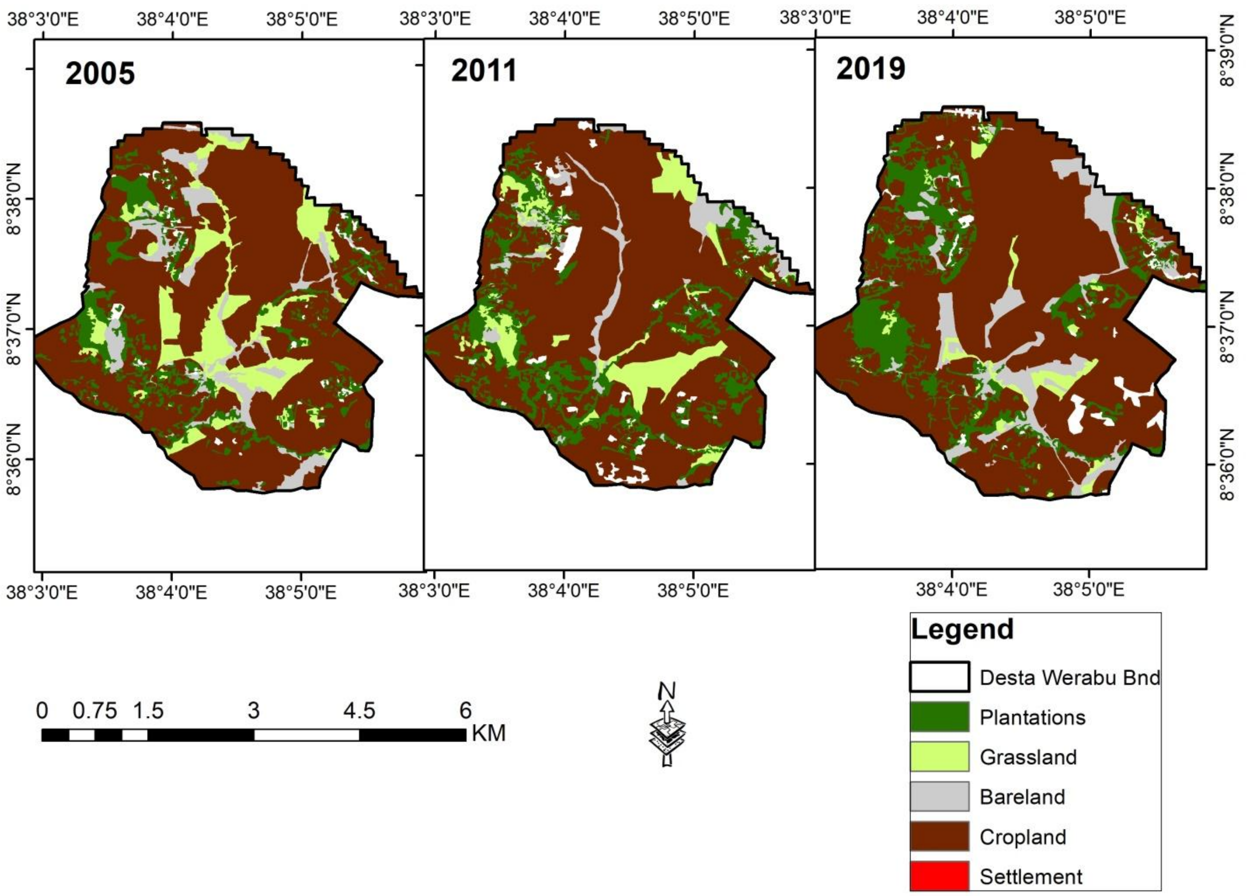

Fig 5: LU/LCMap of D/WerabuMWS in 2005, 2011 and 2019
Source: Classification of GeoeyeImage downloaded from Google earth pro

As shown from the table below, during the 2005 – 2019 periods while woodland, cropland and settlement showed steady increase grassland showed a steady decline. Whereas bare land has showed a somewhat decrease (from 2005 to 2011) and a significant increase (from 2011 – 2019).

Table:11 Percentages of LU/LC in D/Werabu MWS during the period 2005 - 2019

LU/LCtype	2005		2011		2019	
	Ha.	%	Ha.	%	Ha.	%
Woodland	205.5	11.5	271.4	15.17	272.0	15.21
Grassland	213.5	11.9	153.8	8.6	51.3	2.9
Bareland	143.9	8.0	101.4	5.7	165.2	9.2
Cropland	1205.1	67.4	1223.0	68.4	1260.0	70.4
Settlement	20.9	1.2	39.3	2.2	40.3	2.3
Total	1788.9	100.0	1788.9	100.0	1788.9	100.0

Source: Results from classification of Geo eye images downloaded from Google earth

Compared to the 2005, settlement, woodland, bare land and cropland have continuously (especially during the intervention period) increased by about 93%, 32%, 15% and 5% respectively. It is only grassland that has tremendously decreased in 2019 by 76% compared to the 2005 extent of grassland. The decline in grassland is caused by the increase in cropland and settlement. The increase in cropland is ultimately for increasing the amount crop production largely for consumption and food security.

Table: 12 Percentages of LU/LC change in D/Werabu MWS during the period 2005 - 2019

LU/LCtype	Change 2005 – 2011		Change 2011 - 2019		Change 2005 – 2019	
	Ha.	%	Ha.	%	Ha.	%
Woodland	66.0	32.1	0.6	0.2	66.5	32.4
Grassland	-59.8	-28.0	-102.4	-66.6	-162.2	-76.0
Bareland	-42.5	-29.5	63.8	62.8	21.3	14.8
Cropland	17.9	1.5	37.0	3.0	54.9	4.6
Settlement	18.4	88.3	1.02	2.6	19.4	93.2
Total	0.0	0.0	00	0.0	0.0	0.0

Source: Results from classification of Geo eye images downloaded from Google earth

The image analysis as well as field observation for D/werabuMWS has proved that the intervention made in the catchment has contributed to the increase of vegetation and terraces especially on hilly cultivated landscapes.

4.5.2.LU/LC Change in Werabu Micro-watershed

Werabu micro watershed, which is situated in the central part of Rebu watershed, is one of the micro watershed which is broadly observed in the field to have a moderate performance of the project intervention for integrated community watershed management. As both the LU/LC maps and LU/LC table portraying the distribution of the major LU/LC in the Werabu micro watershed, the percent/hectare of land allocated to cropland appears to be the highest. The northeastern part of the *kebeles* seems to have more vegetation and degraded bare land, elsewhere areas covered by cropland and homestead agriculture dominates.

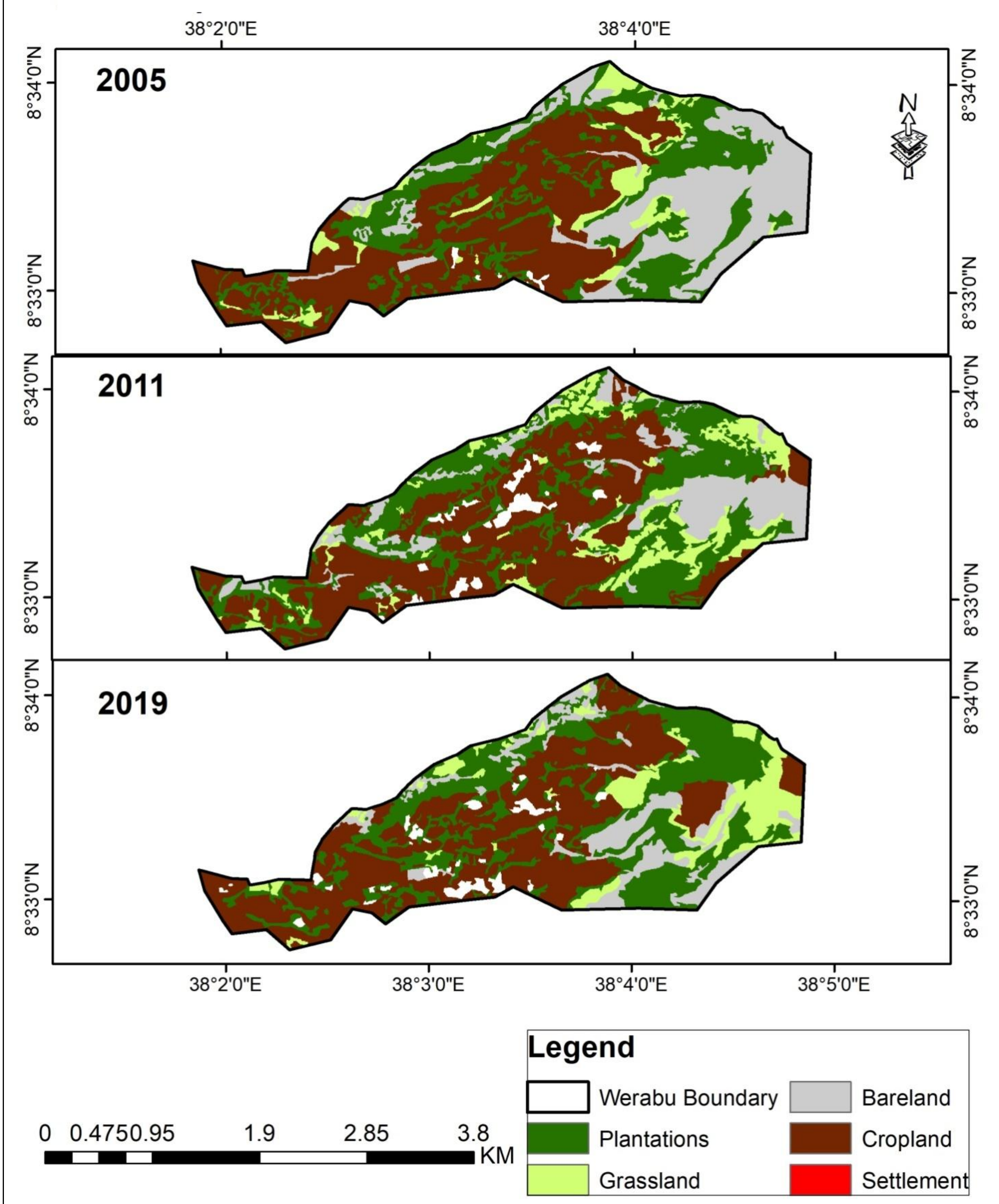

*Fig:6*LU/LC*Map of Werabu MWS in 2005, 2011 and 2019*
Source: Classification of Geoeye Image downloaded from Google earth pro

The (table 13) tells that in 2005 about 40%, 28%, 24% and 7% of the MWS (683 ha of land) almost was covered by cultivated land, forest/woodland, bareland and grassland respectively. This percent distribution in 2005 was slightly changed in 2019, actually to 43%, 33%, 11%, and 11% of cultivated land, grassland, bareland and grassland respectively. During the period 2005 - 2019 the extent of forest/woodland (dominantly of vegetation), cultivated land and grassland increased by about 4.5% (about 31 Ha), 4.1% (28.1 ha) and 2.4% (about 17 ha) respectively. Whereas the extent of bare/degraded land has significantly decreased from 167 ha (24.5%) to 75.9 ha (11.1%). As it is to the other micro watersheds or the entire Rebu watershed, settlement in the Werabu catchment has continuously increased from 2.1 ha in 2005 through 16.7 ha in 2011 to 17.6 ha in 2019 .The significant increase in the pastureland and plantation and significant decline of bare/degraded land at 4.8% and 2.4% per year. Could be associated to the population growth of urban and rural population in the area is increasing project intervention, whereas the increase in the cultivated land and settlement is associated to the population growth in the area.

Table: 13Percentages of LU/LC in Werabu MWS during the period 2005 - 2019

	2005		2011		2019	
LU/LCtype	Ha.	%	Ha.	%	Ha.	%
Woodland	193.6	28.4	220.3	32.3	224.7	32.9
Grassland	46.2	6.8	73.7	10.8	74.3	10.9
Bareland	167.0	24.5	94.8	13.9	75.9	11.1
Cropland	273.7	40.1	277.1	40.6	290.2	42.5
Settlement	2.1	0.3	16.7	2.5	17.6	2.6
Total	682.6	100.0	682.6	100.0	682.6	100.0

Source: Results from classification of Geo eye images downloaded from Google earth

Relative to the 2005 extent of areas used for settlement, covered by grassland, woodland and cultivated land in 2019 has increased by 734%, 61%, 16%, and 6% respectively. Bareland has significantly decreased actually by about 55%.

Table:14 Percentages of LU/LC change in Werabu MWS during the period 2005 - 2019

LU/LCtype	Change 2005 – 2011		Change 2011 - 2019		Change 2005 – 2019	
	Ha.	%	Ha.	%	Ha.	%
Woodland	26.7	13.8	4.3	2.0	31.1	16.0
Grassland	27.4	59.3	0.6	0.8	28.1	60.7
Bare land	-72.2	-43.2	-18.8	-19.9	-91.0	-54.5
Cropland	3.4	1.2	13.1	4.7	16.465	6.0
Settlement	14.6	694.8	0.8	4.9	15.45	734.0
Total	0.0	0.0	0	0.0	0	0.0

Source: Results from classification of Geo eye images downloaded from Google earth

The image analysis as well as field observation in Werabu micro watershed has proved that the intervention made in the catchment has contributed to the increase of vegetation (grassland, woodland) and terraces especially on hilly cultivated landscapes.

4.5.3.LU/LCChange in Miso Chisa Micro-watershed

M/Chisa micro-watershed, situated in central but somewhat North East part of Rebu watershed, is one of the micro watersheds, which is evaluated to have a good performance of the project intervention for integrated community watershed management. Muchlike many micro-watersheds in the Rebu watershed, the MWS is dominantly cultivated except the central part of the MWS, which is dominated by vegetation (grassland, woodland/bushland).

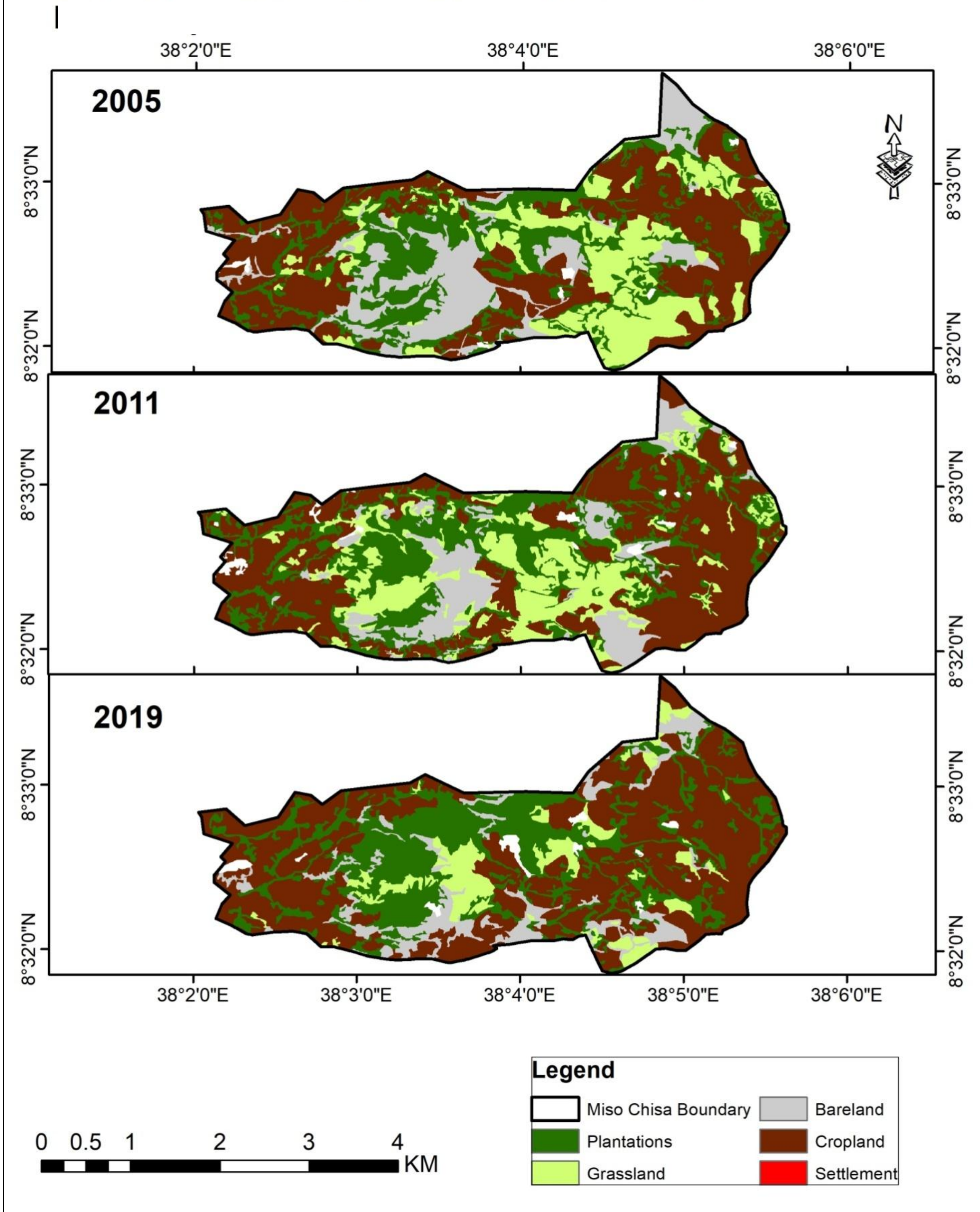

Fig:7LU/LC Map of M/Chisamicro watershed in 2005, 2011 and 2017

Source: Classification of Geo eye Image downloaded from Google earth pro

Out of the 1178 hectares of the M/Chisa MWS, about 40%, 42% and 51% of the catchment was cultivated in 2005, 2011 and 2019 respectively. Like the areal extent of cropland, the area covered by woodland and settlement has continuously increased. The area covered by forest/woodland has increased from 294 ha (25%) in 2005 to 349 ha (29%) in 2019. Similarly the area used for settlement has increased from 7 ha (0.6%) in 2005 to 15 ha (1.3%) in 2019. The increase of the areas used for these land uses was at the expense of the decline bare land from 200 ha in 2005 to 118 ha in 2019 and grassland from 220 ha in 2005 to 97 ha in 2019. The significant increase in the plantation and significant decline of bare/degraded land could be associated to the project intervention, whereas the increase in the cultivated land and settlement is associated to the population growth in the area.

Table: 15 Percentages of LU/LC in M/Ch is a MWS during the period 2005 - 2019

	2005		2011		2019	
LU/LCtype	Ha.	%	Ha.	%	Ha.	%
Woodland	293.5	24.9	312.4	26.5	348.5	29.6
Grassland	219.8	18.7	212.3	18.0	97.0	8.2
Bareland	200.1	17.0	143.9	12.2	117.6	10.0
Cropland	458.1	38.9	496.9	42.2	600.0	50.9
Settlement	6.6	0.6	12.6	1.1	14.9	1.3
Total	1178.1	100.0	1178.1	100.0	1178.1	100.0

Source: Results from classification of Geo eye images downloaded from Google earth

Relative to the 2005, the area occupied by settlement, cropland, and plantation/woodland in 2019 has increased by 125%, 32% and 19%. These increases were at the expense of the decline of pasture land (especially before the intervention) and bare land by 60% and 41% respectively.

Table : 16 Percentages of LU/LC change in M/Chisa MWS during the period 2005 - 2019

	Change 2005 – 2011		Change 2011 – 2019		Change 2005 – 2019	
LU/LCtype	Ha.	%	Ha.	%	Ha.	%
Woodland	18.9	6.5	36.1	11.6	55.1	18.8
Grassland	-7.6	-3.4	-115.2	-54.3	-122.8	-55.9
Bareland	-56.2	-28.1	-26.3	-18.3	-82.5	-41.2
Cropland	38.8	8.5	103.1	20.8	141.9	31.0
Settlement	6.0	90.3	2.32	18.4	8.3	125.4
Total	0.0	0.0	0	0.0	0	0.0

Source: Results from classification of Geo eye images downloaded from Google earth

During the fieldwork and discussion with key informants, the starting of terracing the non-terraced cultivated land and the increasing plantation largely over degraded bare land and over-cultivated land is directly associated to the intervention of the project.

4.5.4.LU/LCChange in Kakee Micro-watershed

Kakee micro watershed, situated in the central part of theRebu watershed, is one of the MWS, which is evaluated to have a good performance of the project intervention for integrated community watershed management. Much like the other micro-watersheds in Rebu watershed, the micro watershed is dominated by terraced and non-terraced cultivated land. The areas along the streams appear to be more dominated by vegetation.

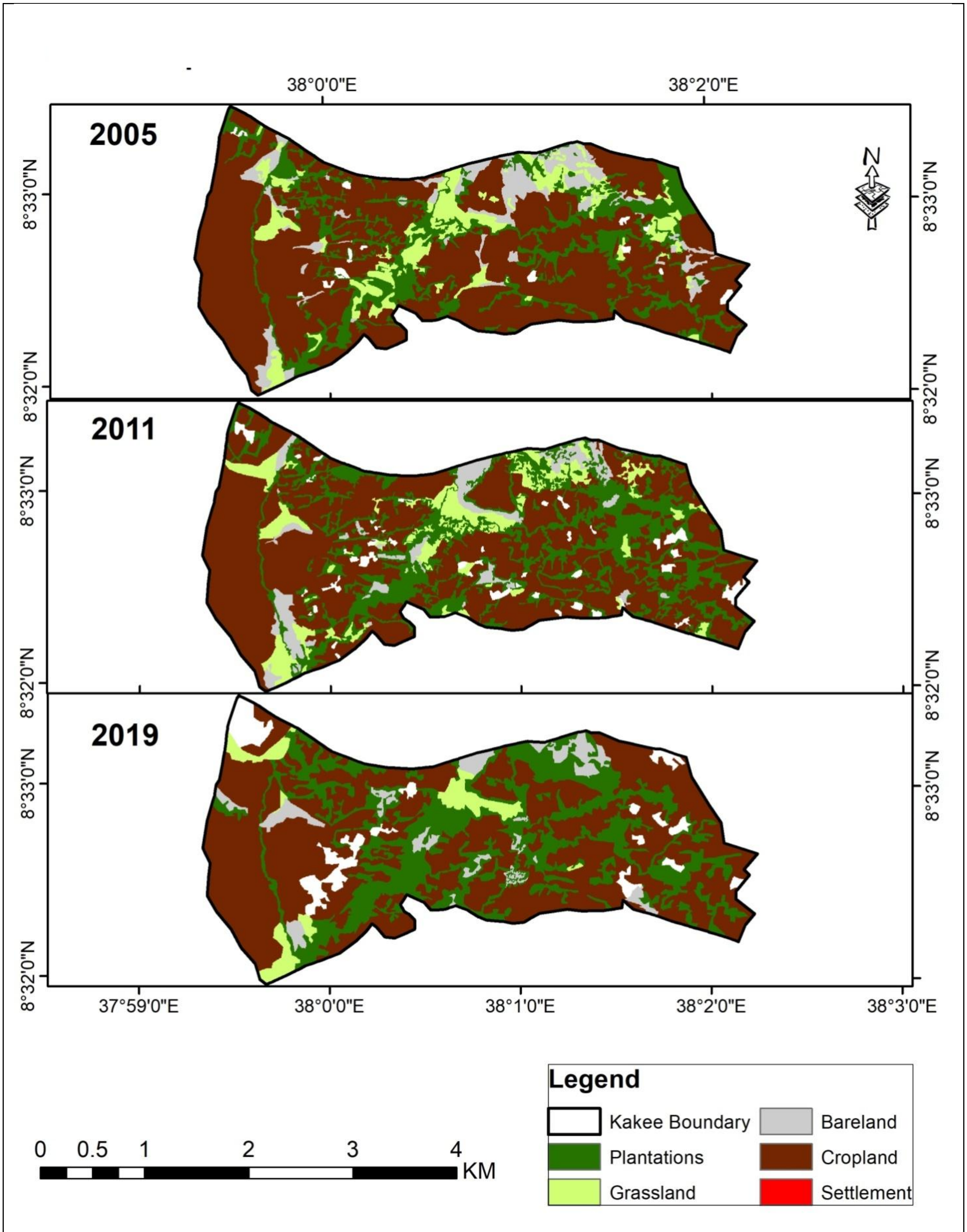

Fig 8: LU/LC Map of KakeeMWS in 2005, 2011 and 2017

Source: Classification of Geoeye Image downloaded from Google earth pro

In 2005, the KakeeMWS which is of about 870 hectares was segmented to about 64% of cultivated land, 19% of bush land/woodland, 8% of grassland, 7% of bare/degraded land and 0.8% of settlement. While the area extent of bare/degraded land grassland and cultivated land decline by about 21, 41 and 55 hectares respectively, the area extent of plantation and settlement have increased by about 82 and 35 hectares of land respectively. Both increase and decline is associated the positive impact of the project intervened in the last 7 years by increasing vegetation over degraded/ bare landscapes and enclosure of degraded cultivated land.

Table:17 Percentages of LU/LCinKakeeMWS during the period 2005 - 2019

	2005		2011		2019	
LU/LCtype	Ha.	%	Ha.	%	Ha.	%
Woodland	165.4	19.0	220.1	25.3	247.1	28.4
Grassland	75.6	8.7	68.7	7.9	34.0	3.9
Bareland	61.9	7.1	47.5	5.5	41.4	4.8
Cropland	560.3	64.4	513.1	59.0	505.5	58.1
Settlement	6.8	0.8	20.7	2.4	42.0	4.8
Total	870.1	100.0	870.1	100.0	870.1	100.0

Source:Results from classification of Geo eye images downloaded from Google earth

Relative to the 2005, the area occupied by settlement and plantation/woodland in 2019 has increased by 514% and 49%. These increases were at the expense of the decline of pasture land (especially before the intervention), bare/degraded land and cropland by 55%, 33% and 10% respectively.

Table:18 Percentages of LU/LCchangeinKakee MWS during the period 2005 - 2019

	Change 2005 – 2011		Change 2011 – 2019		Change 2005 – 2019	
LU/LCtype	Ha.	%	Ha.	%	Ha.	%
Woodland	54.7	33.1	27.0	12.3	81.7	49.4
Grassland	-6.9	-9.2	-34.7	-50.5	-41.6	-55.0
Bareland	-14.4	-23.3	-6.0	-12.7	-20.5	-33.1
Cropland	-47.2	-8.4	-7.62	-1.5	-54.8	-9.8
Settlement	13.9	203.0	21.3	102.9	35.2	514.8
Total	0.0	0.0	0.0	0.0	0.0	0.0

Source: Results from classification of Geo eye images downloaded from Google earth

The image analysis as well as field observation in KakeeMWShas revealed that the intervention made in the catchment has contributed a lot to the increase of vegetation (grassland, woodland) on hilly landscapes, terrace on hilly cultivated landscapes and enclosing degraded cultivated land.

4.5.5.LU/LCChange in GuraSenbete Micro-watershed

GuraSenbete, situated in central but relative the other micro watershed in the southern part of the Rebu watershed, is one of the MWS, which is evaluated to have a good performance of the project intervention for integrated community watershed management. Much like many micro-watersheds in the Rebu watershed, more than 50% of the micro-watershed was cultivated. A significant proportion of the areas along streams are covered by vegetation.

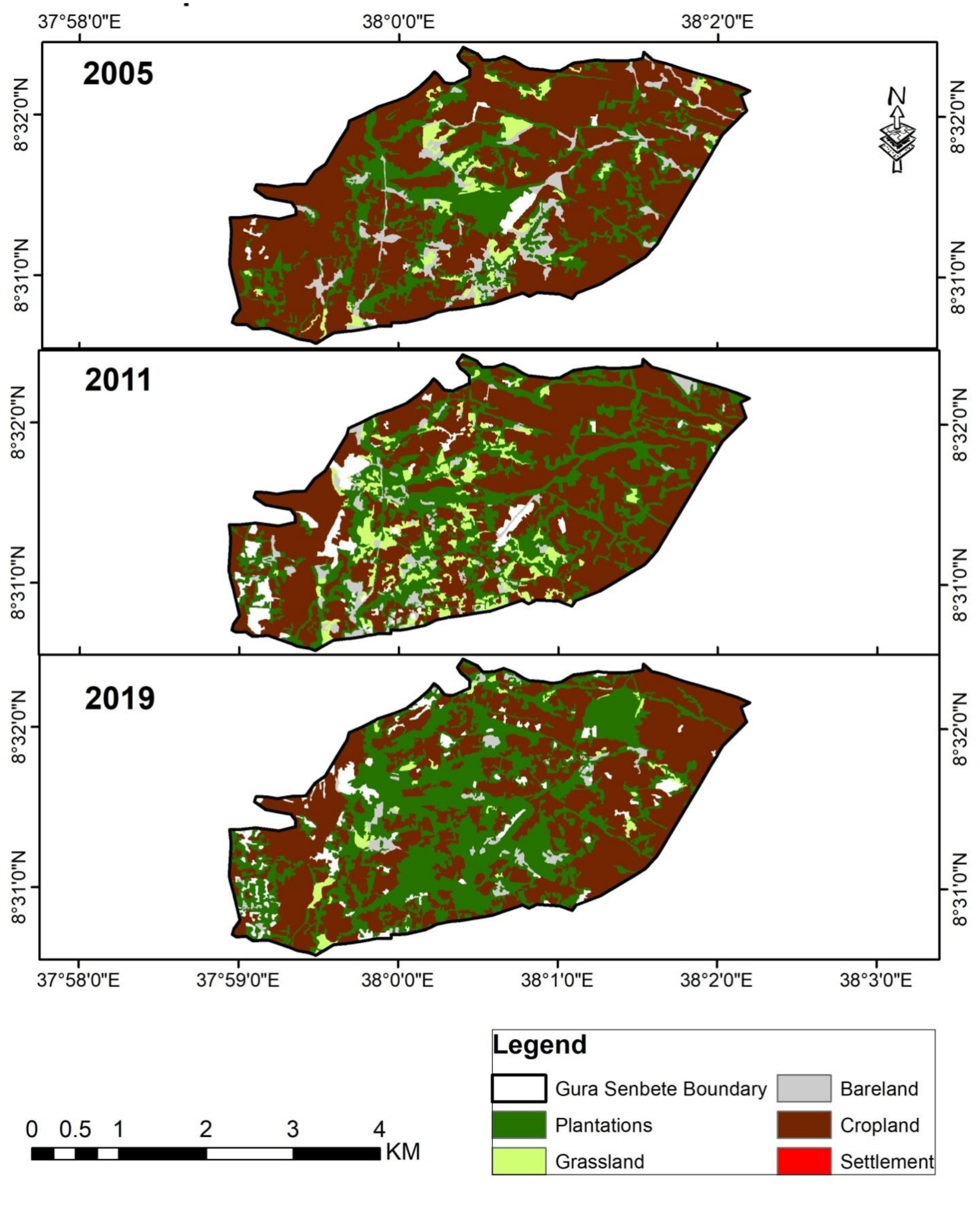

*Fig 9:*LU/LC*Map of G/SenbeteMWS in 2005, 2011 and 2019*
Source: Classification of Geoeye Image downloaded from Google earth pro

Out of the 1257 hectares of the G/Senbete MWS, about 67%, 55%, and 51% of the catchment was cultivated in 2005, 2011 and 2019 respectively. Likewise bare land has continuously declined from 86 ha in 2005 through 53 ha in 2011 to 31 ha in 2019. Unlike the areal extent of cropland and bare land, the area covered by woodland and settlement has continuously increased. The area covered by forest/woodland has increased from 269 ha (21%) in 2005 to 367 ha (29%) in 2019. Similarly the area used for settlement has increased from 14 ha (1.1%) in 2005 to 55 ha (4.4%) in 2019. The increase of the areas used for these land uses was at the expense of the decline of grassland, cropland and bare land in the watershed. The significant increase in the plantation and significant decline of bare/degraded land could be associated to the project intervention, whereas the increase of the area used for settlement is associated to the population growth in the area.

Table: 19 Percentages of LU/LCinG/Senbete MWS during the period 2005 - 2019

	2005		2011		2019	
LU/LCtype	Ha.	%	Ha.	%	Ha.	%
Woodland	269.1	21.4	367.0	29.2	506.9	40.3
Grassland	50.0	4.0	85.8	6.8	20.5	1.6
Bareland	85.6	6.8	53.1	4.2	30.9	2.5
Cropland	837.6	66.7	696.6	55.4	643.3	51.2
Settlement	14.3	1.1	54.0	4.3	55.0	4.4
Total	1256.6	100.0	1256.6	100.0	1256.6	100.0

Source: Results from classification of Geo eye images downloaded from Google earth

Relative to the 2005, the area occupied by settlement and plantation/woodland in 2019 has increased by 284% and 88%. These increases were at the expense of the decline of pastureland (especially before the intervention), bare/degraded land, and cropland by 59%, 63%, and 23% respectively.

Table: 20 Percentages of LU/LCchangeinG/Senbete MWS during the period 2005 - 2019

	Change 2005 – 2011		Change 2011 - 2019		Change 2005 – 2019	
LU/LCtype	Ha.	%	Ha.	%	Ha.	%
Woodland	98.0	36.4	139.9	38.1	237.8	88.4
Grassland	35.8	71.6	-65.3	-76.1	-29.5	-59.1
Bareland	-32.5	-38.0	-22.2	-41.8	-54.8	-63.9
Cropland	-140.9	-16.8	-53.32	-7.7	-194.24	-23.2
Settlement	39.7	277.1	1.0075	1.9	40.675	284.1
Total	0.0	0.0	0	0.0	0	0.0

Source: Results from classification of Geo eye images downloaded from Google earth

In general, the physical data analysis result prove an overview to argue the watershed project intervention contributed to reduce land degradation and improve the ecosystem service performance. Besides to the image analysis revealing the change in LU/LC over the different period of time field observation in G/SenbeteMWS has revealed that the intervention made in the catchment has contributed a lot to the increase of vegetation (grassland, woodland) on hilly landscapes, terracingon hilly cultivated landscapes, enclosing degraded cultivated land and changing livelihood style.

4.6. Socio-economic contribution of watershed management

Through FGD with selected key informants it was discussed that an average production level and income of households in the area has increased . The size of grassland and woodland increased in the area is to mean that the households in the area have got more access to grasses for their livestock and wood as a sources firewood and income.

4.6.1.Participation of Households in Watershed Management

In terms of planning WSM, almost all household have participated.While 98% of the HHs in the area has participated on implementing WSM on communal land resources, only 62% of the households implemented SWC on their farm. The reason for the 38% households who have not implemented SWC on their farm lots is associated to that their farmland is not that much exposed to soil erosion.

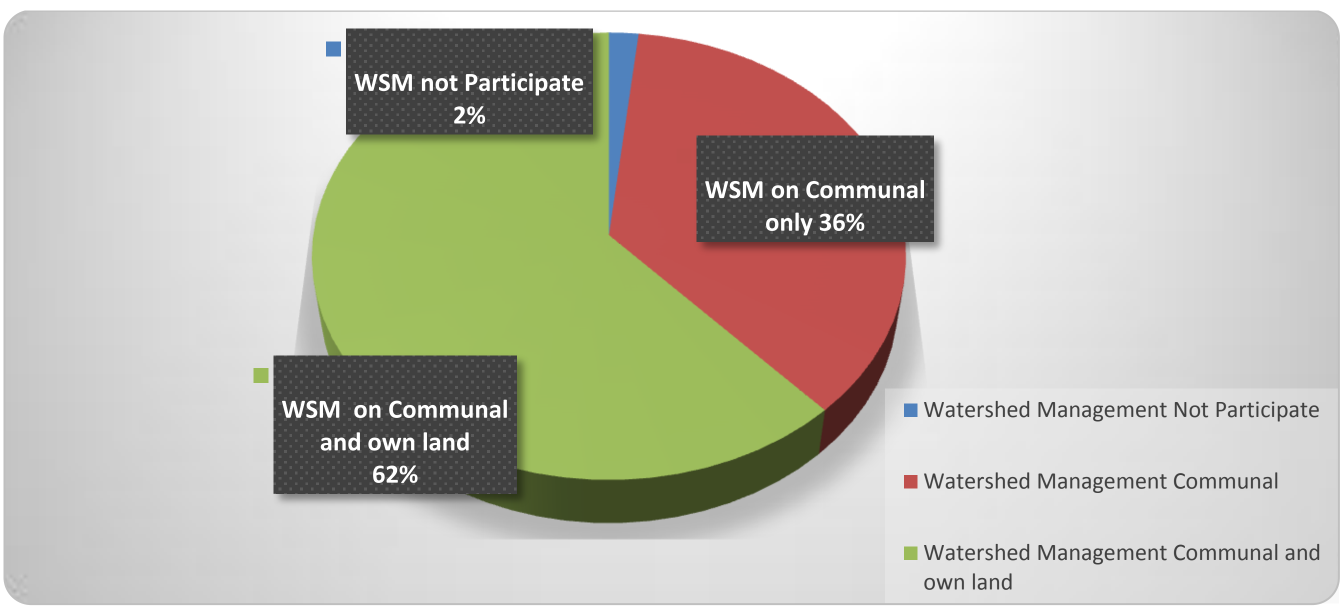

Figure: 10households participation on WSM components.
Source: Own field survey, 2019

4.6.2.Contribution of Watershed Management to Productivity

4.6.2.1.Major Crops Grain Yields

As illustrated in Table 21 in Rebu watershed cereal and pulse crop production are the major sources of food for the sample households. The cereal and pulse grains which are commonly used for home consumption are considered as the main sources of dietary food consumption in the households.

Table-21Aggregated cereal and pulse cropland, production and monetary value at farm gate price in the selected WSM.

	Before watershed			After watershed		
Types of crop	Cultivated land size/Ha	Production quintal	Income Birr	Cultivated land size/Ha	Production/ quintal	Income/birr
Teff	0.4	2.7	3553.1	0.40	4.9	10377
Wheat	0.4	4.4	3335.4	0.50	8.6	13760
Potato	0.2	11.1	7214.3	0.18	23.5	35206
Barely	0.1	1.5	770.5	0.12	2.7	3517
Bean	0.1	0.7	478.9	0.07	1.4	1818
Maize	0.0	0.7	347.5	0.04	1.4	1251
Pea	0.0	0.3	202.3	0.03	0.4	851
Total	1.1	21.5	15902.1	1.34	42.9	66780
Per household landholding and Production	0.9	3.6	2650.4	0.22	7.15	11130

Source: Own field survey, 2019

On average, a household in the study area owns .22 ha of land on which a farm household produces about 7.15quintals of cereal and pulse crops. This is translated into 11,130.00 birr per/year based on farm gate price. This amount of production explains the availability demission of sample household food security. It seems clear that the sample households are at good status of food security in both availability and diversity (see Table 21 for crop varieties). Data from filed observation and key inform interview confirms that the largest proportion the farmland annually covered by wheat, teff and potato in their order of importance. Teffis driven by market demand and wheat and potato are largely for consumption purposes.

Watershed management practices in the study area have been started since 2009;therefore, as indicated in the above table the average crop productivity of the study area is increasing after the introduction of land rehabilitation practices. As a result, the average production increased. According to AWARDO (2014), average crop production increased because of wide practices of soil and water conservation, the use of selected seeds, increasing of farmer's perception and the use of organic and inorganic fertilizer. Crop diversification not only provides a wider choice in production of various crops but also minimizes risk and increases profitability besides harnessing the maximum potential of land, water, human, and climate.

Generally, the implementations of land rehabilitation practices contribute to the increasing of crop production, which results in improvement in farmer's livelihood condition. According to Glover (2005), Successful watershed management lead to major transformations in lives, through increased agricultural productivity and landscapes, through enhanced environmental benefits.

4.6.2.2.Livestock Production

Watershed management has a potential to increase biodiversity and improve the ecosystem service giving performance. In turn, the communicative effect has positive outcome towards ensuring food security and sustainable developmentthroughincreasing livestock production and productivity. Therefore, land rehabilitation practices are essential to the human wellbeing and the livelihood condition of the rural households.

Table-22 Current status of livestock own

Types of livestock	Number	TLU
Ox	1.56	1.71
Cow	1.36	1.36
Calf, heifer or bull	1.43	0.86
Sheep	0.61	0.01
Goat	1.04	0.09

Donkey	0.82	0.01
Horse	0.29	0.23
Poultry	4.21	0.04
Total	11.30	4.31

Source: Own field survey, 2019

On average, a household in the area possesses 1.56, oxen, 1.36 cows, 1.43 Calf, heifer, or bull which together with other types livestock ownership makes a TLU of about 4.31 per household. As discussed in the field with Key informants oxen,horse, donkey is generally used as a tool for plowing, cart and carrying farm products and prestige, cows and hens are used as source of milk and egg for the feeding household members especially children and others like sheep, goats, poultry are used as sources of income.

The KII argued that livestock population size as well as their products has been increasing in the study area due to the availability of grass, proper handling of livestock and guidance and supervision work of the developmental agents. Generally, the involvement of the concerned bodies in WSM practices contributes to restore degraded land and recovery of grazing lands. The improvement of grazing land due to land rehabilitation led farmers to get enough grasses to feed their livestock. Thus, the result indicate that the average number of livestock holding and its products become increasing after land rehabilitation practices. Livestock is an integral part of the farming systems and they are particularly important for increasing the resilience of vulnerable poor people subjected to climatic and income shocks. This is possible through spreading risk and increasing assets.

Table -23 Households livestock owner ship

Tropical Livestock Unit	N	Minimum	Maximum	Mean	Std. Deviation
0-1	25	20.0	64.0	45.380	11.7307
1-3	263	15.5	84.5	47.040	14.5272
1 – 5	53	20.0	83.0	46.575	15.4398
Total	341	15.5	84.5	46.846	14.4567

Source: Own field survey, 2019

84% of Low Tropical Livestock unit households were acceptable consumption and the mean medium Tropical Livestock Unit of the sample households is 47.04 with a standard deviation of 14.53. This is above the cut-off point for acceptable consumption and for being food secure Moreover, the maximumTropical Livestock Unit is 84.5 and the minimum 15.5 resulting in a range of 69 between them.

4.6.2.3.Off farm income of the household

In Waliso*Woreda*Rebu watershed management households have an off farm activities. 45.23 average have low off farm income,44.961 average of respondents have greater than 8000 birr income annually got this indicates off farm activities help households food security.

Table-24 off farm income

Off farm Income	N	Minimum	Maximum	Mean	Std. Deviation
<100	172	17.5	80.0	45.230	12.0810
1001-4000	76	19.0	83.0	48.743	17.1492
4001-8000	29	15.5	82.0	55.621	17.8394
>8000	64	17.5	84.5	44.961	13.7723
Total	341	15.5	84.5	46.846	14.4567

Source: Own field survey, 2019

4.7. Food security status of households in WalisoWoreda

4.7.1.Food consumption score

Food consumption score analyzed the household food security status. Survey result show that 270 HHs are food secure, whereas 71 HHs are food insecure.

Table -25 Food security status of households

	Food Consumption Group				
FCS	N	Minimum	Maximum	Mean	Std. Deviation
Food Insecure	71	15.5	34.5	27.803	4.3781
Food Secure	270	35.0	84.5	51.854	11.7594

Total	341	15.5	84.5	46.846	14.4567

Source: Own field survey, 2019

The mean FCS of the sample households is 51.85 with a standard deviation of 11.76. This is above the cut-off point for acceptable consumption and for being food secures this means because of Rebu watershed; management the production of on farm activities increased and has a positive impact on the food security consumption, which is 35.1. Thus, on average the sample households were food secure. Moreover, the total maximum food secure households are 84.5 and the minimum 15.5. In general, the food security statuses of the respondents are good and acceptable.

4.7.2.Food Consumption in Sample Micro Watershed

From the study, micro watersheds, which are found in Rebu major watershed in each the food security status of the respondents, differeachother's.

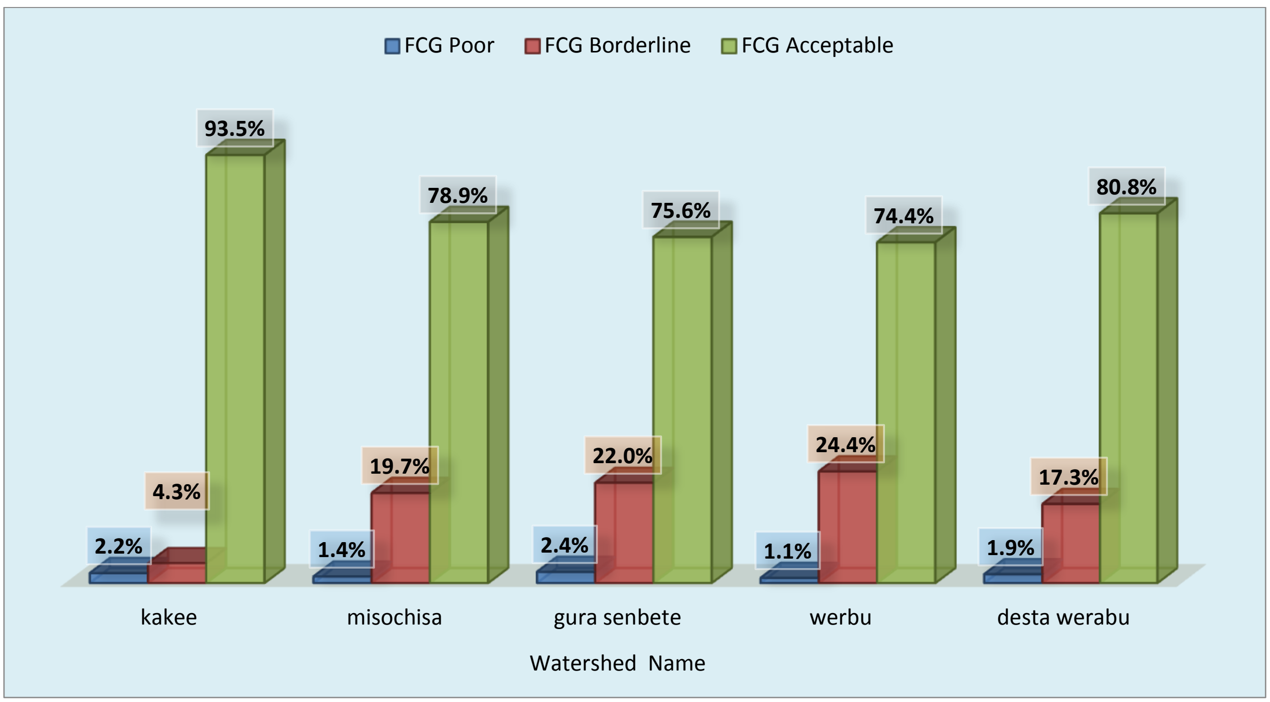

Fig: 11Food consumption in sample micro watershed

Source: Own field survey, 2019

93.5% of Kakeemicro watershed households were acceptable food consumption group and 2.4% of Gurasenbetemicro watersheds household were poor food consumption group.

4.8. Factors affecting food security status of households in the study area

To determine which of the factors significantly influence the variation in FS conditions (Food secured,not secured),Food security status of household was regressed Soil Fertility, Tropical Livestock Unit, HH_Sex, HH Size, Cultivated Land in Hectar, HHHead Age, HH_Educ, Off farm Income, On Farm Income using general logistic regression model.

This table gives an F-test to determine whether the model is a good fit for the data. According to this p value (0.045), it is significant.

Table-26 Summary of the result of regression analysis

Independent variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	2.363	.306		7.721	.000	1.761	2.965
HH_Sex	-.174	.093	-.104	-1.880	.061	-.356	.008
HHHead Age	-.007	.077	-.005	-.095	.924	-.158	.144
HH_Educ	.055	.023	.137	2.328	.021	.008	.101
HH Size	.001	.031	.002	.046	.963	-.059	.062
CultivatedLandinHectar	.024	.067	.021	.357	.721	-.107	.155
Tropical Livestock Unit	-.057	.054	-.059	-1.061	.290	-.163	.049
Off farm Income	-.017	.024	-.044	-.738	.461	-.064	.029
On Farm Income	.041	.029	.095	1.394	.164	-.017	.098
Soil Fertility	-.113	.040	-.189	-2.852	.005	-.191	-.035

***=significant at 1% **=significant at 5% *= significant at10%

Source: Computed from survey data, 2019.

As a result, the regression model fit for FS against variables, is found to be significant (F=1.945, (p-value Sig. = 0.045) to the error level less than 5%. The variation of the dependent variable is explained by the variation of IVs with a coefficient of determination of about$(1-r^2)*100$= 95%. Finally, here is the beta coefficients one to go with each predictor. (Using the“un standardized coefficients,” because the constant [beta zero] is included). Based on this table, the equation for the regression line is:

Y = 2.363 -0.174(HH_Sex) -0.007(HHHead_Age) +0.055(HH_Educ) -0.04(HH_Size) + 0.024(Cultivated Land in Hectar) - 0.057(Tropical Livestock Unit) - 0.017(Off Farm income) + 0.041(On Farm Income) -0.113(Soil Fertility)

Sex of household head: This variable has a strong positive and has not statistically significant relationship with food security of households. It is not surprising to observe inverse relationship between sex of household head and food security of households.

Age of household head: This continuous variable has a negative and significant relationship with food security of households. As age of households head getting higher and higher food security status of the households deteriorate. In fact this is true, if household head gets older and older the opportunity of participating in other income generating activities reduced, because they cannot be competent enough with adults. Studies conducted in Ethiopia by Van der Veen and Tagel (2011) in Tigray region and Messay (2009) in Oromia region found a similar result.

Family size: Family size has also a negative and not significant relationship with food security of households. The composition of the family size is a determinant to household food security. If there are job opportunity and all family members are capable of doing it, they will have a crucial role to generate additional income and may reduce vulnerability to food insecurity. But, the study area is dominated by subsistence farming system and the land size is very small which is unmatched with the need of households, due to this case, family size undermines food security status of the households. Earlier researches conducted by Kakota, Nyariki, mkwambisi and Makau (2013) determinant of household vulnerability to food insecurity in Malawi Haile, H.K, Alemu, Z.G &Kudhlande,G. (2005) causes of household food insecurity in Oromia region have similar findings.

Education level of household head: This is not significant to food security but has a positive prelateship. Education opens a remarkable opportunity of working environment, creates awareness on the introduction of agricultural technologies, and develops risk minimizing and accepting mechanisms. The research outputs of Messay (2011), and Van der Veen and Tagel (2011) substantiate this educated household heads have better food security status than not educated.

Off-farm income: There is a positive and not significant relationship with food security of households. Households participating in off-farm activities have better food security than those who do not participate. The findings ofMisginaAsmelash (2010) found a similar output.

Number of TLU/ household: This has a positive and significant relationship with food security of households. Interestingly, this has a positive impact on the household food security and increase in the number of TLU increases household food security.

Land size in hectare: This also has a positive and significant relationship with food security of households. Since the study area is dominated by subsistence farming system, land size is a priceless resource to the households. The result shows that an increase in land size increases food security to households. This is quite similar with the studies of Fisher and Lewin (2013), Degefa (2005).

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1. Conclusions

The land use/land cover change maps and changes were derived and detected both for the entire Rebu watershed and for the five micro-watersheds in which Land use/land management projects were intervened in the last 7 years. Today watershed development has become the main intervention for natural resource management and rural development. Watershed development programs not only protect and conserve the environment, but also contribute to rural households' food security. The importance of watershed development as a conservation program is being recognized, not only for rainfed areas, but also for high rainfall areas, coastal regions, and catchment areas of dams. With large investment of financial resources in the watershed programme, it is important that the programme becomes successful. Experiences show that the watershed development programmes have produced desired results and there are differences in their impacts. Hence, the watershed impact assessment should be accorded due importance in the future planning and development programmes. According to the study, the rural households in selected micro watersheds are benefits in terms of agricultural productivity, livestock production, and soil fertility. This implies to households get an access and available to food. Inline this the study also found out, as a result of the Rebu WSM forest area coverage, grass coverage, access of wood for fire and grass for forage and that have been made available moderately inside area closer due to physical and biological conservation activities. According to survey, there was technological adoption of WSM measures on private plot as result of knowledge acquired from participation on communal land. In general, the survey result also indicates the participation of local households in implementing WSM on communal land was generally good.The physical SWCactivities were a greater contribution to increase fertility of cultivating land and crop production. Moreover, Marginal gully were changed into productive land.Soil conservation practices can be effective in offsetting soil erosion and increasing productivity by reducing nutrient losses and conserving moisture when appropriately implemented. From all discussions so far, it is generalized that there has been a significant improvement in crop productivity, food availability, water status, income, employment opportunity, social relationship, rehabilitation of degraded lands in the study area.

5.2. Recommendations

The experiences achieved from the interventions in the five and other micro-watersheds in the Rebu watershed has to be up scaled in to make sure land degradation is kept to the minimum and sustainable livelihood and food security of the rural community is sustained through appropriate community watershed management scaled to the entire Rebu watershed.

The implementation of watershed management in the areas is suitable for enhancing food security. Based on the finding of the study the following practical recommendations are pinpointed to overcome some of the constraints and maximize the benefits of the intervention following suggestions are provided based on the finding.Watershed development activities have been found to alter crop pattern, increase crop yields, and crop diversification and thereby provide enhanced employment and farm income. Therefore, alternativefarming system combining agricultural crops, trees, and livestock components with comparable profit should be evolved and demonstrated to the farmers. As far as the contribution of watershed development on the livelihood of watershed inhabitants was concerned the following points were recommended. The ongoing watershed development has to continue in more enhanced manner through advocating and exploiting the merit of building on indigenous knowledge, addressing of farmers priorities and opening the door of participation for local households. Emphasis has to be given to replication of community forestry development and homestead plantation as well as water harvesting structures to maximize the supply of the resource. The local government has to convince farmers to change their attitude in the way of using common poll resources. There is a need for more push on community participation from local administration as well as development agents for the ongoing WSM in the Woreda.

References

Adbacho W. (1991). Biological or Vegetation Cover as a Sustainable Soil Conservation Strategy: A case study of TilkuDemala: School of Environmental Science; University of East Anglia.

AdugnawBirhanu (2014). Environmental Degradation and Management in Ethiopian Highlands: Review of Lessons Learned. *Journal of Environmental Protection and Policy.*Vol.2, No. 1, pp. 24-34.

Akkaraboyina, M. K., &Tareke, B. M. (2018). Community Perception and Participation Towards

Soil and Water Conservation Practices : A Case Study OfGubalafto District Of AmharaRegion, 6(2), 832–837

Alemneh, D. (2003) Integrated Natural Resources Management to Enhance Food Security: The Case for Community-Based Approaches in Ethiopia. FAO, Rome.

Anderson, J., Hardy, E., Roach, J. and Winter, R. (1976). A land use and land cover classification

Berry L (2003). Land degradation in Ethiopia: its impact and extent assessing the extent, cost and impact of land degradation at the national level: findings and lessons learned from seven pilot case studies. Commissioned by global mechanism with support from the World Bank

Berry, EM.,Dernini, S., Burlingame, B., Meybeck, A., and Conforti, P., (2015). Food security and Sustainability: can one exist without the other? Review Article. Public Health Nutrition: 18(13), p. 2293–2302.

Betru, N. (2013). Experiences of the MERET Project of the Ministry of Agriculture in integrated watershed management in Ethiopia NBDC regional stakeholder dialogue, Bahir Dar, 23–24 July 2013.

Bezuayehu T, Gezahegn A, Yigezu A, Jabbar M and Paulos D (2002). Nature and causes of land degradation in the Oromiya Region: socio- economic and policy research working paper. International Livestock Research Institute.

Binyam, A., Desale, K. (2014). The Implication of integrated watershed management for rehabilitation of degraded lands: Case study of Ethiopian Highlands. *Journal of Agric.Biodiver.* Res. 3(6): 78-90

Brooks, K., Ffolliott, N., Gregersen, H., Easter. K.(1994). Policies for sustainable development: The role of watershed management. EPAT/MUCIA Policy Brief No. 6, Department of State, Washington, DC, USA

Bossio D, Noble A, Pretty J and Vries F (2004). Reversing land and water degradation: Trends and'Bright Spot' Opportunities. Paper presented at the SIWI/CA Seminar. Stockholm, Sweden.

Canadell, J., Pataki, D. &Pitelka, L., (2006.)Terrestrial ecosystems in a changing world. Cambridge University Press, Cambridge, 22.

Cassman, K., Wood, S., Choo, P. S., Dixon, J., Gaskell, J., Khan, S., Lal, R., Pretty, J., Primavera, J., Ramankutty, N., Viglizzo, E., Kadungure, S., Kanbar, N., Porter, S. &Tharme, R., (2005). Cultivated systems. In: Scholes, R., Rashid, H. (Eds.). Millennium Ecosystem Assessment: Working group on conditions and trends. Island Press, Washington D. C.

Central Statistical Agency (CSA) (2013). Federal Democratic Republic of Ethiopia, Central Statistical Agency. Population projection of Ethiopia for all regions at Woreda level from 2014-2017. Addis Ababa.

Chisholm, N., Tassew, W. (2012). "Managing watersheds for resilient livelihoods in Ethiopia", in OECD, Development Co-operation Report 2012: Lessons in Linking Sustainability and Development, OECD Publishing

Clay, E., (2002). Food security: Concepts and measurements. Paper for FAO Expert Consultation On Trade and Food Security: Conceptualizing the Linkages, Rome, 11-12 July 2002, p.1-7.

Darghouth, S., Ward, C., Gambarelli, G., Styger, E. and Roux, J., (2008). Watershed Management Approaches, Policies and Operations: Lessons for Scaling Up. Water Sector Board Discussion Paper Series Paper No 11. The World Bank, Washington, DC.

DANRO. 2017. District agriculture and natural resource office of Woliso.

DebebeHabtewold (1995). Food Security: A Brief Review of Concepts and Indicators in Food Security, Nutrition and Poverty Alleviation in Ethiopia: Problems and Prospects, Proceeding of Inaugural and First Annual Conference of the Agricultural Economics Society of Ethiopia.Edited by Mulat et al., Addis Ababa.

DegefaTolossa (2005). Rural Livelihoods, Poverty and Food Insecurity in Ethiopia: A Case Study atErenssa and Garbi Communities in Oromiya Zone, Amhara National Regional State. PhD thesis. Trondheim. Norwegian University of Science and Technology (NTNU).

Girma T (2001). Land Degradation: A Challenge to Ethiopia. International Livestock Research Institute, Addis Ababa, Ethiopia.pp815-823.

GeteZeleke(2000). Landscape Dynamics and Soil Erosion Process Modelling in the Northwestern Ethiopian Highlands.African Studies Series A16. Berne, Switzerland: Geographica Bernensia.

LakewDesta, MenaleKassie, Benin S and Pender J (2005). Land degradation and strategies for sustainable development in the Ethiopian highland, Amhara region: socio-economic and policy research working paper 32. International Livestock Research Institute

Lambin E. F., Geist H. J. & Lepers, E., (2003). Dynamics of land use and cover change in tropical and subtropical regions. Annual Review of Environmental and Resources (25), pp. 205 – 241.

Lambin, E. F., & Geist, H(. 2006). Local Processes with Global Impacts. In:

Land-Use and Land-Cover Cahnge: Local Processes and Global Impact. Berlin, Springer, 2006, pp. 1 – 8.

DegefaTolossa (2002). Household Seasonal Food Insecurity in Oromiya Zone, Ethiopia: Causes. Social Science Research Report Series, No.26: OSSREA, Ethiopia, Addis Ababa

DegefaTolossa (2008). Understanding the realities of Urban poor and their food security situations: A case study at Berta Gibi and Gemachu Safar in Addis Ababa City, Ethiopia. VRF series No 440. Institute of Development Economies, Japan.

FeyeraDeresa and TsetadirgachewLegesse (2015). Cause of Land Degradation and Its Impacts On Livelihoods of the Population in Toke KutayeWoreda, Ethiopia. International *Journal of Scientific and Research Publications,* Volume 5, Issue 5, ISSN 2250-3153.

FAO (2010).Challenges and opportunities for carbon sequestration in grassland systems. A technical report on grassland management and climate change mitigation. Food and Agricultural Organization,Rome

FAO (2014).The State of Food Insecurity in the World. The Multiple Dimensions of Food Security: ISBN 978-92-5-1079164.

FAO.(2017).GIEWScountrybrief-Ethiopia,November2017.

FAO, 2002.The State of Food Insecurity in the World.Rome pp. 4-7.

FAO, (1996), World Food Summit: Rome Declaration on World Food Security and World Food

Summit Plan of Action, Rome.

FAO and WFP (2010).The state of Food Insecurity in the World. Addressing food insecurity in Protracted crises. Rome, FAO.

Fox, J., R. R. Rindfuss, S. J. Walsh, and V. Mishra, editors.(2003). People and the environment: approaches for linking household and community surveys to remote sensing and GIS.

Kluwer Academic Publishers, Boston, Massachusetts, USA.

G/mariamYaebiy, YayneshetTesfayandDerejeAssefa(2015). Socio-Economic Impact Assessment of Integrated Watershed Management in Sheka Watershed, Ethiopia. *Journal of Economics and Sustainable Development.* Vol.6, No.9

Gentilini, Ugo, (2002), Sviluppodell’aiutoalimentareedaiutoalimentare per lo sviluppo, UniversitàDegliStudi di Roma Tre, Facoltà di Economia

Gisladottir and M. Stocking (2004).Land degradation Control and its Global Environmental Benefits.
GetachewDirriba (1995). Economy at the Cbross Roads: Famine and Food Security in Rural Ethiopia. Addis Ababa: Care International in Ethiopia

Haile, H.K, Alemu, Z.G &Kudhlande ,G. (2005). Causes of household food insecurity in Koredegaga peasant association, Oromia zone, Ethiopia.Working Paper. University of the Free State, South Africa

HurniH.(1998).AgroecologicalbeltsofEthiopia.Explanatorynotes onthreemapsatascaleof1: 1,000,000. Soil conservation research programme. research report 43 (p.30)AddisAbebaandBern:CentreforDevelopmentandEnvironment(CDE)withmap,scale1:5million

Hurni, H., Solomon, A., Amare, B., Berhanu, D., Ludi, E.,Portner, B., Birru, Y., Gete, Z. (2010). Land degradation and sustainable land management in the highlands of Ethiopia. Adoption in High- Rainfall Areas of the Ethiopian Highlands.

Ighodaro, I. D., Lategan, F. S., &Mupindu, W. (2016). The Impact of Soil Erosion as a Food Security and Rural Livelihoods Risk in South Africa,*Journal of Agricultural Science*,8(8),1–12.https://doi.org/10.5539/jas.v8n8p1

KebedeWolka. (2014). Effect of Soil and Water Conservation Measures and Challenges for its Adoption: Ethiopia in Focus. *Journal of Environmental Science and Technology, 7: 185- 199.*
Kassie, M., Holden, S., Köhlin, G. and Bluffstone, R. (2009)Economics of Soil Conservation

Kumar, R., &Ramachandra, T. V. (2003). Water soil and sediment investigation to explore status of aquatic ecosystem. Bangalore: Centre for Ecological Sciences, India Institute of Science.
Lakew, D., Carucci, V., Asrat, W. and Yitayew, A., Eds. (2005). Community Based Participatory Watershed Development. Ministry of Agriculture and Rural Development, Addis Ababa, Ethiopia.
Lemenih, M. (2004) Effects of Land Use Changes on Soil Quality and Native Flora Degradation and Restoration in the Highlands OfEthiopia.ActaUniversitatisAgriculturaeSueciaeSilvestria 306.

Maxwell S. (1996). Food Security: A Post Modern Perspective. Food Policy 21:155-170.

MeazaHadush (2015).the role of community based watershed management for climate change Adaptation in Adwa, central Tigray zone, International Journal of Weather, Climate

Change and Conservation Research, Vol.1, No.1, pp. 11-35.

MeskeremAbi and DegefaTolossa (2015). Household FoodSecurity Status and Its Determinants In GirarJarsoWoreda, North Shewa Zone Of Oromia Region, Ethiopia *Journal of Sustainable Development in Africa* Volume 17, No.7, ISSN: 1520-5509.

MessayMulugeta (2009). Causes of Rural Household Food Insecurity: A Case FromKuyu District, Central Ethiopia.Journal of Sustainable Development in Africa 11 (4). Clarion University of Pennsylvania, Clarion, Pennsylvania

MesayMulugeta(2011). Determinant of agricultural productivity and household food security: Case studies from Kuyu district, Central Ethiopia. LAP LAMBERT Academic publishing.

MisginaAsmelash (2010). Rural household food security status and its determinants: The case of LaelayMaichewworeda, Central Zone of Tigray, Ethiopia. Journal of Agricultural Extension and Rural Development 6(5): 162-167.

Muchena, F. N., Onduru, D. D., Gachini, G. N., &Jager, A. De. (2005). Turningthetides of soil degradation in Africa : capturing the reality and exploring opportunities, Land Use Policy 22:23–31.https://doi.org/10.1016/j.landusepol.2003.07.001

(Mohamed, 2017). Mohamed, A. A. (2017).Food Security Situation in Ethiopia : A Review Study,JournalofHealthEconomicsandPolicy,2(3),8696.https://doi.org/10.11648/j.hep.20170203.11

Ojima DS, Galvin KA, Turner BL II.(1994). The global impact of land-use change.BioScience 44(5):300–4

Riely,F. Nancy Mock, Bruce Cogill, Laura Bailey, and Eric Kenefick , (1999). Food Security Indicators and Framework for Use in the Monitoring and Evaluation of Food AidProgramsWashington, D.C.

Rickson, R. J., Deeks, L. K., Graves, A., & Harris, J. A. H. (2015). Input constraints to food production : the impact of soil degradation, food sec.7,351–364. https://doi.org/10.1007/s12571-015-0437-x

SisayAsefa and TesfayeZegeye (2003). Rural Poverty, Food Insecurity and Environmental

Degradation in Ethiopia: A Case Study from South CentralEthiopia.

Shiferaw, B., & Holden, S. T. (1998). Resource degradation and adoption of land conservation technologies 1n the Ethiopian Highlands : A case study in AnditTid , North Shewa, 18, 233–247.

Solomon, A., Goraw, G., Yihenew, G., Berihun, T. (2013). Evaluation of watershed development Plan and technology adoption level of farmers in AmharaRegion, *the case of SWHISA Project, Ethiopia. Int. J. Scientific Res*. Publ. 3(2): 1-10.

Wani, S., ThawilkalWangahart, Yin Dixin, Zhong Li and N.V. Thang (2010) Community watersheds for food security and coping with impacts of climate change in rain-fed areas *JournalofClimate Change: Watershed Management and Food Security.*

TemesgenGashaw, AmareBantider, &Hagos G/Silassie. (2014). Land Degradation in Ethiopia: Causes, Impacts and Rehabilitation Techniques, *Journal of Environment and Earth Science*, 4, 9.

Tilahun A, Takele B and Endrias G (2001). Reversing the degradation of arable land in the Ethiopian highlands. Managing Africa's soils No. 23. International center for research Agro forestry.pp1-20.

Thiombiano,L., Tourino, I.(2007). Status and Trends in Land Degradation in Africa. Climate and Land degradation PP 39-53

TesfaWorku and S.K.Tripathi (2015). An Evaluation of Watershed Management Practice in Ethiopia: A Preliminary Review International Journal of *Environmental Sciences* Vol. 4 No. 1. Pp. 24-30.

Teshome, A., de Graaff, J., &Kassie, M. (2016). Household-Level Determinants of Soil and Water Conservation Adoption Phases: Evidence from North-Western Ethiopian Highlands. EnvironmentalManagement,57(3),620–636.https://doi.org/10.1007/s00267-015-0635-5

Taffa T. (1983). A Manual on Soil and Water Conservation; Ambo College of Agriculture, Teaching Material, 97pp

Turner, B. L., Clark, W. C., Kates, R. W., Richards, J. F., Mathews, J. T. & Meyer, W. B., (1990).

The Earth as transformed by human action: Global and regional changes in the biosphere over the past 300 years. Cambridge University press, Cambridge, 707.

Turner B. L., Skole, D., Sanderson, S., Fischer, G., Fresco, L. &Leemans, R., (1995). Land-use And land-cover change science/research plan. International Geosphere-Biosphere Programme, Global Change Reputation 7.

Walker, B., Steffen, W., Canadell, J. & Ingram, J. S., (1999). The terrestrial biosphere and global change: Implication for natural and managed ecosystems. Cambridge University Press, Cambridge, 439.

WalisoWoredaAgriculturalDevelopmentoffice,(2013).Annualreport,Rebu Watershed.

WolkaKebede, MogesAwdenegest&YimerFantaw (2013).Farmers' perception of the effects of soil and water conservation structures on crop production: The case of Bokolewatershed, Southern Ethiopia. African *Journal of Water Conservation and Sustainability*Vol.1 (5), pp. 071-080,

World Bank (1986). Poverty and Hunger: Issues and Options for Food Security in Developing Countries .A World Bank Policy Study. Washington, DC., USA.

Appendices

AnnexI: Conversion factors used to estimate tropical livestock units (TLU)

Animal Category	Tropical Livestock Unit (TLU
Ox	1.10
Cow	1.00
Heifer	0.50
Bull	0.60
Calves	0.20
Sheep	0.01
Goat	0.09
Donkey	0.50
Horse	0.80
Mule	0.70

Poultry	0.01

Source: Storck, et at. (1991)

Annex -II Food consumptions

	Food Items	Food Groups	Weight
1	Maize, maize porridge, rice, sorghum, millet pasta, bread and other cereals Cassava, potatoes and sweet potatoes, other tubers, plantains	Main Staples	2
2	Beans, Peas, groundnuts and cashew nuts	Pulses	3
3	Vegetables, leaves	Vegetable	1
4	Fruits	Fruit	1
5	Beef, goat, poultry, pork, eggs and fish	Meat and Fish	4
6	Milk yogurt and other diary	Milk	4
7	Sugar and sugar products, honey	Sugar	0.5
8	Oils, fats and butter Oil	Oil	0.5
9	Spices, tea, coffee, salt, small amounts of milk for tea.	Condiments	0

Annex -III: questionnaires for farmer households

	Woreda	Watershed	Name of Micro watershed	Survey number	Name of *Kebele*
	Woliso	Rebumajor watershed			
Date of Interview:	__________ /__________/____________				
Timeinterview started	2019 year ______Month __________Day ________Hour				

SECTION I. DEMOGRAPHICAND SOCIAL CHARACTERISTICS OF RESPONDENTS (QUESTIONS FOR FARMING HOUSEHOLDS)

101	Age of the household head	[--------------------------------------]
102	Sex of the household head (respondent)	1.Female ☐ 2.Male ☐

<table>
<tr><td>103</td><td>What is the current marital status of the household head?</td><td>1. Married ☐ 2. Single ☐ 3. Divorce ☐ 4.Widowed ☐</td></tr>
<tr><td>104</td><td>What is the family size of your household (Those who are alive)</td><td><table><tr><th>Age</th><th>Male</th><th>Female</th><th>Total</th></tr><tr><td><15</td><td></td><td></td><td></td></tr><tr><td>15-64</td><td></td><td></td><td></td></tr><tr><td>>64</td><td></td><td></td><td></td></tr></table></td></tr>
<tr><td>105</td><td>What is education level of household head</td><td>1.Unable to read and write ☐ 3.Primary school ☐
2.Non-formalEducation/Adult Education ☐ 4.High school ☐</td></tr>
<tr><td>106</td><td>Besides formal education at school, have you received any training</td><td><table><tr><td>1=Never</td><td>☐</td></tr><tr><td>2=Agricultural Production</td><td>☐</td></tr><tr><td>3=Natural Resource management</td><td>☐</td></tr><tr><td>4=Non-agricultural (business/enterprise)</td><td>☐</td></tr><tr><td>5= Other (Specify)_________________</td><td>☐</td></tr></table></td></tr>
<tr><td>107</td><td>Religion of the household</td><td><table><tr><td>1=Orthodox</td><td>☐</td><td>3=Protestant</td><td>☐</td></tr><tr><td>2=Muslim</td><td>☐</td><td></td><td></td></tr></table></td></tr>
</table>

SECTION II.ECONOMIC CHARACTERISTICS OF RESPONDENTS (QUESTIONS FOR FARMING HOUSEHOLDS)

202.1.1 Main Crop Production

Type of Crops and Production (in qun) in 2010/11	Area /Hec	Production /qun
1.“Teff”		
2.Barley		
3.Wheat		
4.Maize		
5.Sorghum		
6.Chickpea		
7.Lentil		
8.Pea		
9.Bean		

10.Vegetables (Tomato, Carrot, Onion, Potatoes, etc)		
11.Others (Specify), _____		

202.1.2 Livestock Production

Type of livestock	Number	Type of livestock	
1.Ox		6. Donkeys	
2.Cow		7. Mules/horse	
3.Calf, heifer or bull		8. Chicken	
4.Sheep		9.Others(Specify), _____	
5. Goat			

202.1.2.1 Which livestock dev't activities did you practice?

1 Feed development	Yes =1 ☐	No =0 ☐
2 Feed conservation	Yes =1 ☐	No =0 ☐
3 Improved breed	Yes =1 ☐	No =0 ☐

2. Off farm activities

Off farm activities	Yes=1 No=0	Annual Income by (birr)
2.1.Petty Trading		
2.2Charcoal		
2.3. Firewood Sale		
2.4. Sale of Eucalyptus tree		
2.5Others(Specify), ____________		

3. Nonfarm activities

Nonfarm activities	Yes=1 No=0	Annual Income by (birr)
3.1Support from Relatives/individuals including remittance		
3.2 Support from Government		
3.3 Employed in Government/NGOs		
3.4 Others (Specify), __________________		

203. Experience in Agriculture -------------------years

204. The most dominant farming activities of the household carrying out for living.

1= Crop production ☐ 2= Livestock Rearing ☐ 3= Mixed Farming ☐

Household Asset (land) 2018/19

205 Do you hold cultivable land?	Yes =1 ☐ No=0 ☐		
If yes, how many pieces of land ha	______________		
206 Plot Characteristic	Plot 1		
206.1Total size of land (ha/timad)			
206.2 Size of Crop land			
206.3 Size of fallow land			
206.4 Size of grazing land			
206.5 Size of Other purpose land			
206.6 Distance from home (minutes of walk)			
206.7 Slope of the Plot	☐		
206.7.1 Slope of the Plot	1. Flat 2. Gentle 3. Steep		
206.8 Type of Soil	☐	☐	☐
202.8.1 Type of Soli	1. Clay 2. Sand 3. Loam 4. Other		
206.9 Perceived soil fertility	☐	☐	☐
202.9.1 Perceived Soil fertility	1. Very Poor 2.poor 3. Average 4. Good 5. Very Good		
206.10 Perceived severity of soil loss	☐	☐	☐
206.10.1 Perceived severity of soil loss	1Very Poor 2.poor 3. Average 4.Good 5 Very Good		
206.11 Land ownership	☐	☐	☐
206.11.1 Land Ownership	1. Own 2. Rented in 3. Rented out 4. Share cropped in. 5. Share cropped out		
206.12 Land certificate given?	Yes =1 ☐ No=0 ☐		

Input Utilization and Crop Production in 2010/11

Input Utilization

207 Did you use and Agricultural input during 2010/11	Yes =1 ☐ No=0 ☐
If yes, proceed to the following question	

Type of Input	Plot 1	Price/kg
207.1Seed (Type/kg)		
207.2 DAP (kg)		
207.3 UREA/NPS (kg)		

207.4 Manure/Compost		

SECTION III.ACCESS TO SERVICES (QUESTIONS FOR FARMING HOUSEHOLDS)

Do You have access to irrigation	Yes =1 ☐ No =0 ☐
If yes, size of irrigable land (ha/timad)	
Did you get extension support from DAs in 2010/11	Yes =1 ☐ No =0 ☐

If yes, how frequent?	1. Weekly ☐ 2.Bi weekly3. ☐Monthly☐4. Rarely☐

Did you get Credit in the last year?	Yes =1 ☐ No =0 ☐

If yes, where did you get the credit?	1. Bank ☐ 2.Microfinance☐ 3.Neighbors ☐ 4. Any Other (specify)__________

Did you get any assistance in the last year?	Yes =1 ☐ No=0 ☐

If yes, what type of assistance?	1. Food ☐ 2. Seed 3. ☐Fertilizer ☐4. hand tools ☐ 5.Other (specify)__________

How far is the main market from your home? (km/time taking to walk)	

SECTION IV.PARTICIPATION ON WATERSHED DEV'T ACTIVITIES (QUESTIONS FOR FARMING HOUSEHOLDS)

Did you participate on watershed Development Activities	Yes ☐	No ☐
If yes, which watershed development component you participated?	1.Communal☐2.On-farm	3.Both ☐ ☐
Do you feel the participation in WSM improved your livelihood?	Yes =1 ☐	No=0 ☐

If participated on farm soil and water conservation activities, please complete the following

SWC Activities	Plot 1
404.1 soil bund	
404.2 Stone bund	
404.3 soil bund with biological plantation	
404.4 Stone bund and soil bund with biological plantation	
404.5 Other (specify)	

Which soil fertility measures did you practice?

405.1 Compost	Yes =1 ☐	No=0 ☐
405.2 Green Manuring	Yes=1 ☐	No=0 ☐
405.3 Crop Residue	Yes =1 ☐	No =0 ☐
405.4 Other specify	Yes =1 ☐	No =0 ☐

Is there any change in forest land coverage when compared to the past? Yes=1 No=0

SECTION V.FOOD CONSUMPTION SCORE /DATA (FCS)

601 would like to ask you about all the different foods that your household members have eaten in the last 7 days. Could you please tell me how many days in the past week your household has eaten the following foods? (For each food, ask what the primary source of each food item eaten that week was, as well as the second main source of food, if any)

Food item	DAYS eaten in past week (0-7 days)	Sources of food (see Food item codes below)	
		Primary	Secondary
Maize/Teff/wheat/sorghum and other cereals			
Rice			
Bread/Wheat			
Pulses /beans/peas/chick peas/nuts			
Milk and milk products			
Meat			
Poultry			
Egg			
Fish and sea-food			
Potato including sweet potato			
Dark green vegetables-leafy			
Other vegetables			
Sugar/honey			
Fruits			
Oil			
Other food items			

Food Score Codes

Purchase =1	Own production =2	Traded goods/services, barter =3	Borrowed = 4
Received as gift= 5	Food aid =6	Other (specify) =7	

Annex –IV: Focus Group Discussions (FGD) Guidelines

(NB: FGD participants are those farmers who were participated in the watershed management development in the past years)

*Kebele/*Community: ___________________

1. What do you know about the watershed management in your area?
2. What special benefits or advantages the household obtained from watershed management?
3. What factors affect the participation of the households in the watershed development?
4. Is there any change in forest land coverage when compared to the past? Yes? No? If yes, how?
5. Are grazing areas improved compared to the past? Yes? No? If yes, how?

Annex –VQuestions for Key Informants Interview

1. General Information

(NB: Kebele leaders and project officers are included in the interview)

Name of informants____________________________

Age__________

Occupation ____________________

Sex__________

Educational status_______________

Number of micro watersheds: ______________________

1.1 What were the community participation on the watershed management practices

____

1.2 To what extent has the watershed management succeeded in improving capacity of your Woreda to manage the land resources in a sustainable way?

____

____

1.3 What are the key success factors for watershed management in your Woreda?

____

____

1.4 What was the condition of the area before the WSM implementation?

____

1.5 How often the Woreda provide technical support to Development Agents and farmers?

____

____

1.6.What are the main watershed management practices in your area?

____

____