JIMMA UNIVERSITY

COLLEGE OF SOCIAL SCIENCE AND HUMANITIES

DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

SPATIO-TEMPORAL ANALYSIS OF FOREST COVER DYNAMICS AND ASSOCIATED ECO SYSTEM SERVICES IN GEDO FOREST, WEST SHEWA ZONE, CENTRAL ETHIOPIA

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Oct., 2018

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A Thesis Submitted to the School of Graduate Studies of Jimma University in Partial fulfillment of the Requirement of the Master of Science in GIS and RS.

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Jimma, Ethiopia

This thesis has been submitted for examination with my approval as university supervisor:

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DECLARATION

I declare that the thesis entitled SPATIO-TEMPORAL ANALYSIS OF FOREST COVER DYNAMICS AND ASSOCIATED ECOSYSTEM SERVICES OF GEDO FOREST, WEST SHEWA ZONE, AND CENTERAL ETHIOPIA has been carried out by me under the supervision of Dr. Kefelegn Getahun (principal advisor) and Dr. Kenate Worku (co-advisor) Department of Geography and Environmental Studies Jimma University during the year 2017-2018. It is submitted for the partial fulfillment of Masters of Science in GIS and Remote Sensing. I further affirm that it has not been submitted for other universities for the award of degree or diploma and all the sources that I have used have been indicated and acknowledged.

Shiferaw Legesse Chala Signature --------------------------

Place: **Jimma University, Jimma** Date of Submission: -----------------------

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ACRONYMS

EFAP	Ethiopian Forestry Action Program
EFCCA	Environment, Forest and Climate Change Authority
EMA	Ethiopia Mapping Agency
ESP	Ecosystem service Partnership
ESs	Ecosystem Services
ESV	Ecosystem Service Value
ESVf	Ecosystem service values function
ETM+	Enhanced Thematic Maper Plus
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GFRA	Global Forest Resources Assessment
GIS	Geographical Information System
GPS	Global Positioning System
HH	Household
IPCC	Intergovernmental Panel on Climate Change
KI	Key informants
LULCC	Land Use Land Cover Change
MEA	Millennium Ecosystem Assessment
MSI	Multi spectral Imager
MSS	Multi Spectral Scanner
NDVI	Normalized Difference Vegetation Index
OFWE	Oromia Forest and Wildlife Enterprise
SNNPR	Southern Nations, Nationalities and Peoples Region
TEEB	The Economics of Ecosystems and Biodiversity
TM	Thematic Maper
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Conventions on Climate Change
USEPA	United States Environmental Protection Agency
WBCSD	World Business Council for Sustainable Development

Abstract

Forests regulate local and global climate, ameliorate weather events, regulate the hydrological cycle, protect watersheds and their vegetation, water flows and soils, and provide a vast store of genetic information much of which has yet to be uncovered. The deforestation rate and its related consequences have been felt in Gedo forest. This study aimed at analyzing the spatiotemporal aspects, from its forest cover change and its associated ecosystem services of the study area. The forest landscape is located in the; Cheliya; Elu Gelan and Bako Tibe woredas of west shewa zone. The research design used in collecting and analyzing the measures of variables in the research problems for this study were Casual, cross-sectional, and longitudinal designs which are coincided with quantitative and qualitative research designs. By using remote sensing and geographic information system supported with field verifications, the information were extracted from Satellite images to detect the level and rate of forest cover dynamics and the ecosystem services values were quantified over the last 45 years.The land use land cover differences of 45 years of the two marginal years /1973 and 2018/ indicates the decline of forest land, shrub land and grass land. The forest covers of the study area decreased by 71% and the shrub land declined by 55% while the grass land was diminished by 59%. The agriculture land and settlement showed a little increment. The total status of the ecosystem service deliverance of the biome in the study area is observed and turned on between 1973 and 2018, it was decreased from 35.71 million to 21.16 Million US$. Creating awareness ,build up a local communities' power in managing and protecting forest resources, Sustainable land management, Afforestation and reforestation of trees and further studies are recommended to restore the loss in forest and ecosystem services.

Key words; Land use land cover, deforestation, biomes, service values, ecosystem service functions.

CHAPTER ONE

1. INTRODUCTION

1.1. Background of the Study

A forest may be defined as a biological community dominated by trees and other woody vegetation (Verburg, *et al*., 2007). The world's forests are home to 300 million people, while the livelihoods of over 1.6 billion people depend on forests (Chris, 2010). Forest provides goods and services including water, shelter, flood, folder, nutrient cycling, cultural and recreation values. Forest also helps in providing habitat for wildlife and also improves land degradation and desertification (UNFCCC, 2007).Forests regulate local and global climate, ameliorate weather events, regulate the hydrological cycle, protect watersheds and their vegetation, water flows and soils, and provide a vast store of genetic information much of which has yet to be uncovered. Scientists debate the linkages between biological diversity and ecological services (Mooney*, et al.,* 1995).

Approaches to restoring forest ecosystems depend strongly on levels of forest and soil degradation, residual vegetation, and desired restoration outcomes. New forests will require adaptive management as dynamic, resilient systems that can withstand stresses of climate change, habitat fragmentation, and other anthropogenic effects (Chazdon, 2008). Economists are increasingly recognizing that environmental functions or 'ecosystem services' support and protect economic activity and thus have an economic. The economic valuation of ecosystem services is becoming an effective way to understand the multiple benefits provided by ecosystems (Hu, 2007).

Studies conducted on land use land cover changes in Ethiopia focus on the dynamics of land cover changes and their causes (Reid, *et al*., 2000). Agricultural landscapes and forestlands in Ethiopia underwent unprecedented changes particularly during the last century due to the dynamics of political, demographic, socio-economic, and cultural factors. There has been an on-going debate about what some see as the ‘‘commoditization’’ of nature that this approach supposedly implies (Costanza, *et al*.,2006) and what others see as the flawed methods and questionable wisdom of aggregating ecosystem services values to larger scales (Chaisson, 2002). Global ecosystems are under enormous pressure. The pressure comes mainly from the increasing human population, which is attempting to extract resources at an accelerating rate from a planet that is finite (Emmott, S. 2013).

Forecasting forest change is essential to forest management, and over the past century the suite of quantitative modeling tools available to aid forest management decision-making has become increasingly sophisticated, quantitative, spatially explicit, and inclusive of multiple drivers of forest change (Shifley, 2017 *et al;* Mladenoff, 2005).Remote sensing from satellites is the way to gather regularly land-cover information with high spatial, spectral and temporal resolutions over large areas. The satellite based data collection type is feasible because extensive field based survey methods can be difficult and expensive to implement, due to restricted accessibility (Verstraete *et al*., 1996).

Ecological processes and their interactions in forest landscape models can be represented by well-designed computer software (He *et al*., 2002a). The increasing richness and availability of spatially explicit GIS data allow an unprecedented opportunity to account for such differences (Boyle, et al. 2010). Gedo Forest is a dry evergreen montane forest that is found in the high lands of Shewa. It is one of National Forest Priority Areas with an area of about 10,000 ha (Kebede, *et al*., 2016). But for this study an area of 47,663.8ha forest cover dynamics was analyzed spatiotemporally with its associated ecosystem services.

1.2. Statement of the Problem

Globally six million hectare forest lands are changed to other land use land cover type due to logging, agricultural, mining and other human activities (Veldkamp, 2006). About 32% of the global deforestation is due to commercial agriculture; 48% for farm expansion; 14% for logging and 5% for firewood collection (IPCC, 2007:).

Figure 1 .Deforestation and Land use/cover changes

The human use of ecosystem services, particularly provisioning services, has accelerated in the last 50 years and that nearly 60% of the ecosystem services globally are being degraded or used unsustainably (MEA, 2005). Between 1990 and 2000, the extent of Ethiopia's forests (including both forests and woodland) decreased by 1.4 million hectares. By 2005, the forest cover had further declined and was estimated to cover 13.0 million hectares. In other words, Ethiopia lost over two million hectares of forest, with an annual average loss of 140 000 hectares between 1990 and 2005. Currently, the forested area is estimated to be 12.4 million hectares, which represents 11.4 percent of the total land area (FAO, 2015).

Changes in forest land use may significantly affect ecosystem processes and services (Raumann; Cablk, 2008). Ecosystem services represent the benefits that living organisms derive from ecosystem functions that maintain Earth's life support system. These benefits include nutrient cycling, carbon sequestration, air and water filtration and flood amelioration (Costanza, *et al*., 1997). The ecosystem service idea has become an effective bridge between ecological and economic approaches. It is helping to create a more trans disciplinary ecological economics that is better able to understand and manage our complex, interconnected system in the Anthropocentric (Costanza *et al*,.2017).As deforestation rate and its related consequences has already been felt in Gedo forest, the analysis of spatio-temporal forest cover dynamics with its ecosystem service valuation is required. Because many areas of forest land has been converted to different land use systems like agricultural land, grazing land, stony and degraded land. Today it is also very difficult to obtain the basic forest products like fuel wood, charcoal, timber wood, construction equipment and agricultural tools simply. The majority of the societies depend on forest products both for energy source and economic issues. More over the consequences of deforestation related to the ecosystem services is very sever in this study area (many biodiversities has already lost, different forest dwelling organisms have lost their natural habitat, soil has already exposed to devastating agents, climate change problem has exacerbated, etc).

According to Birhanu Kebede (2014) Information on vegetation is required for Gedo to solve an ecological problem: for biological conservation and management purposes; as an input to environmental impact statements; to monitor management practices or to provide the basis for prediction of possible future changes. Because of its accessibility, the vegetation has been severely and unwisely exploited. Consequently, the existing conditions call for a critical mitigating means. The vegetation of this area was intact previously but highly depleted at present (Birhanu , 2014).

Therefore, this study was aimed at analyzing the spatio-temporal dynamics and associated consequences in the evolution of ecosystem services in Gedo forest. The study has also addressed to identify and analyze the major driving forces of forest cover change in the study area to come up with possible recommendations which may contribute to solve the existing problem.

1.3. Objectives of the Study

1.3.1. General objective

The general objective of the study is to analyze the spatio-temporal aspects of forest cover dynamics and associated ecosystem services using GIS and RS techniques in Gedo forest landscape.

1.3.2. Specific objectives

The specific objectives were:

- To assess the major derivers of the forest cover changes.

- To quantify and map forest cover change over 45 years from, 1973-2018.
- To identify the basic forest ecosystem services being changed as a result of this cover change and describe their associated service values.

1.4. Research Questions

Based on the above objectives, this study has tended to answer the following questions;

1. What are the major derivers of the forest cover changes in the study area?
2. How and how much did the cover of Gedo forest changed over the past 45 years?
3. What forest eco system services being changed within forest cover dynamics and their service values?

1.5. Scope of the Study

This study was limited to analysis of the spatiotemporal dynamics of forest cover and associated ecosystem services by using the GIS application and Remote sensing data collaborated with local people's perceptions on forest cover change, driving forces on deforestation, ways of sustainable forest management and analysis for the last 45 years has been made. The dynamics of forest cover with its associated ecosystem services has been assessed and compared separately and together.

The study has been conducted on Gedo forest which is located in the Oromia national regional state, West Shewa zone, in three Woredas: Chelia,Elu Gelan and Bako Tibe woreda where the result could immediately be used for research, education and management purposes. Hence, the result of this study could help to provide information on forest landscape processes to decide on the management of the forest and its ecosystem services.

1.6. Significance of the Study

It is very difficult to make an analysis for land use land cover changes at different times and spaces without the use of GIS application and remotely sensed satellite data. Understanding forest conditions as well as monitoring the changes of various forest cover dynamics and associated ecosystem services analysis can enable the resource managers to design an accurate management planning.Ecosystem services are highly vulnerable to a number of impacts due to the complex effects of human use of natural resources and subsequent land use change. Assessment of the impact of change in land use with respect to ecosystem services is necessary in order to implement appropriate land uses that enhance ecosystem services (Sunsanee; Rajendra, 2016).

The study may have several significances among which, it could create awareness for all concerned stakeholders, the government, experts and the community as the whole. More over this study will help to address the associated problems with Gedo Forest and its result will help as an input to take the measures. Finally this study could help as a reference for other researchers who want to conduct similar or further studies on the study area.

The conclusion can support the foresters and environmentalists to promote conservation of the remaining forests both at local and national levels. In all scopes, this study contributes towards the mitigation and combating the risks to human health; accelerated climate change; increased watershed disruption, loss of water quality; and loss of biodiversity.

1.7. Organization of the Thesis

This research is organized in to five chapters. The first chapter describes about Introduction and general background of the study area where as the second chapter briefly explains about Review of the Related literatures. The third chapter is all about Methods and Materials while the fourth chapter presents Result and Discussion. Finally in the fifth chapter the researcher has concluded the findings and set the Recommendations.

CHAPTER TWO

2. REVIEW OF RELATED LITERATURES

2.1. Concepts and Definitions

2.1.1. Definition of forests

Forests cover 1/3 of the earth's surface and contain an estimated 3 trillion trees. Forests exist in dry, wet, bitterly cold, and swelteringly hot climates. These different forests all have special characteristics that allow them to thrive in their particular climate. There are three major forest zones that are separated according to their distance from the equator:

- The tropical
- The temperate
- The taiga/boreal forests

Tropical rain forests grow around the equator in South America, Africa, and Southeast Asia. They have the highest species diversity per area in the world, containing millions of different species. Most tropical forests receive at least 200 cm (80 inches) of rain in a year. Tropical forests generally have a rainy and dry season. (Motivans *et al*., 2017).

From different vantage points, forests can be seen as a source of timber products, an ecosystem composed of trees along with myriad forms of biological diversity, a home for indigenous people, a repository for carbon storage, a source of multiple ecosystem services, and as social-ecological systems, or as all of the above. In addition, a fundamental and commonly misunderstood distinction exists between the actual features of land and its legal designation. From the ''land cover'' perspective, forests are viewed as ecosystems or vegetation types supporting unique assemblages of plants and animals (Chazdon *et al.,*2016)).

But from the ‘‘land use’’ perspective, forests are landholdings that are legally designated as forest, regardless of their current vegetation. Within this construct, a legally designated ‘‘forest’’ can actually be devoid of trees, at least temporarily. No single operational forest definition can, or should, embody all of these dimensions (Robin *.et al*., 2016).

The definition of “forest” adopted in 2001 by the United Nations Framework Convention on Climate Change was; an area of >0.05–1 ha with >10–30% cover of plants >2–5 m tall at maturity, At the very least, we recommend that natural forest be differentiated from plantations and that for defining “forest” the lower height limit defining “trees” be set at more than 5 m tall with the minimum cover of trees be set at more than 40%. These minor changes in the definition of “forest” will promote the switch from degradation to responsible forest management, which will help mitigate global warming while protecting biodiversity and contributing to sustainable development (Sasaki ; Putz, 2009).

2.1.2. The concept of ecosystem services

A range of services that are of fundamental importance to human well-being, health, livelihoods, and survival are provided by ecosystem (Costanza et al., 1997; Millennium Ecosystem Assessment (MEA), 2005; TEEB Foundations, 2010; TEEB Synthesis, 2010). Interest in ecosystem services in both the research and policy communities has grown rapidly (Braat and de Groot, 2012; Costanza; Kubiszewski, 2012).

In 1997, the value of global ecosystem services was estimated to be around US$ 33 trillion per year (in 1995 $US), a figure significantly larger than global gross domestic product (GDP) at the time. This admittedly crude

underestimate of the welfare benefits of natural capital, and a few other early studies (Daily, 1997; de Groot, 1987; Ehrlich, 1981; Ehrlich and Mooney, 1983; Odum, 1971; Westman, 1977)
In 2005, the concept of ecosystem services gained broader attention when the United Nations published its Millennium Ecosystem Assessment (MEA). Between 2007 and 2010, a second international initiative was undertaken by the UN Environment Program, called the Economics of Ecosystems and Biodiversity (TEEB) (TEEB Foundations, 2010). The TEEB report was picked up extensively by the mass media, bringing ecosystem services to a broader audience. Ecosystem services have now also entered the consciousness of mainstream media and business. The World Business Council for Sustainable Development has actively supported and developed the concept (WBCSD, 2011, 2012).

Hundreds of projects and groups are currently working toward better understanding, modeling, valuation, and management of ecosystem services and natural capital. It would be impossible to list all of them here, but emerging regional, national, and global networks, like the Ecosystem Services Partnership (ESP), are doing just that and are coordinating their efforts (Braat and de Groot, 2012; de Groot *et al*., 2011).

A better understanding of the role of ecosystem services emphasizes our natural assets as critical components of inclusive wealth, well-being, and sustainability. Sustaining and enhancing human well being requires a balance of all of our assets; individual people, society, the built economy, and ecosystems. This reframing of the way we look at nature is essential to solving the problem of how to build a sustainable and desirable future for humanity (Costanza, *et al*. 2014).

"Ecosystem services are the benefits people obtain from ecosystems" (Ecosystems and Human Well-being: Synthesis 2005). Most ecosystem services are grouped into two forms of public goods. The first category of public goods implies that those goods/ services can be enjoyed by everyone, without hurting someone else's enjoyment/ benefit. The other form of public goods is quasi- public goods. This is the idea that if someone uses too much of a good/ service, the enjoyment/ benefit may be reduced to others (King, *et al*., 2000).

Ecosystems are a dynamic complex of plant, animal, and microorganism communities and the non-living environment interacting as a functional unit (MA, 2005). They have the capacity through their natural processes and components to provide goods and services that satisfy human needs (De Groot, 1992; Fisher and Turner, 2008). Ecosystem services (ESs) represent a human centered concept of the benefits derived from nature, and can be broken into four categories: provisioning ESs (e.g. non-timber forest products, fire wood, fresh water, and fish), regulating ESs (e.g. climate regulation, water purification, and pollination), supporting ESs (e.g. habitat for species, soil formation) and cultural ESs (e.g. tourism, recreation) (MEA, 2005).

Recognition of the concept began a few decades ago (Ehrlich, 1981; Ehrlich; Mooney, 1983). The concept of 'ecosystem services' is a relatively recent development, tracing back to the middle of 1960s and beginning of 1970s (De Groot *et al*., 2010; Braat; De Groot, 2012)

The Millennium Ecosystem Assessment (2005) defines ecosystem services as ‘‘the benefits that humans obtain from ecosystems”. Costanza *et al*., (1997) postulate that ecosystem services comprise of ‘‘flows of materials, energy, and information” from the natural environment to the society. Wu (2014) defines ecosystem services as ‘‘benefits that people derive from biodiversity and ecosystem functions”. Other definitions focus on a range of services including: ecosystem benefits to human well-being, ecosystem goods and services to humans, value derivation by humans from ecosystems, direct/indirect positive contribution of ecosystems to human well-being, and utility from ecosystems (Ericksen *et al*., 2012; Fisher *et al*., 2009; Muller and Burkhard, 2012; Sagie *et al*., 2013; Costanza *et al*., 1997).

2.2. Deforestation of World Forest

The rates of deforestation in tropical forests, annual destruction rates seems set to accelerate further and could well double in another decade” (Myers, 1993). Mostly deforestation has occurred in the temperate and sub-tropical areas. Deforestation is no longer significant in the developed temperate countries now and in fact many temperate countries now are recording increases in forest area (Anon, 1990; 2010). In most instances developed nations are located in temperate domains and developing nations in tropical domains. However deforestation was significantly less in tropical moist deciduous forest in 1990-2000 than 1980-1990 but using satellite imagery it was found that FAO overestimated deforestation of tropical rainforests by 23 per cent (Anon., 2001).

However the definition of what is and what is not forest remains controversial. The tropical rainforests capture most attention but 60 per cent

of the deforestation that occurred in tropical forests during 1990-2010 was in moist deciduous and dry forests. However extensive tropical deforestation is a relatively modern event that gained momentum in the 20^{th} century and particularly in the last half of the 20^{th} century. The FAO FRA 2001 and 2010 reports indicates that considerable deforestation in the world during 1990-2010 but this was almost entirely confined to tropical regions. 15% of the world's forest was converted to other land uses between 1850 and 1980.
Deforestation occurred at the rate of 9.2 million hectares per annum from 1980-1990, 16 million hectares per annum from 1990-2000 and decreased to13 million hectares per annum from 2000-2010 .The net change in forest area during the last decade was estimated at -5.2 million hectares per year, the loss area equivalent to the size of Costa Rica or 140 km^2 of forest per day, was however lesser than that reported during 1990-2000 which was 8.3 million hectares per year equivalent to a loss of 0.20 per cent of the remaining forest area each year. The annual net loss was 37 per cent lower than that in the 1990s and equals a loss of 0.13 per cent of the remaining forest area each year during the period (Anon., 2010)

Some smaller countries have very high losses per year and they are in risk of virtually losing all their forests within the next decade if current rates of deforestation are maintained. Indeed some 31 countries do not even make the list because they have already removed most of their forests and even if that remain are seriously fragmented and degraded (Rowe *et al*., 1992)
South America with about four million hectares per year suffered the largest net loss of forests during the last decade followed by Africa with 3.4 million hectares annually and the least Oceania with seven hectares annually. Brazil and Indonesia had the highest net loss of forest during the decade of 1990

but has significantly reduced their rate of loss after this decade. Brazil and Indonesia dominate accounting for almost 40 per cent of net forest loss over the decade of 1990s (Myers, 1993).

2.3. Causes and Agents of Deforestation

In order to save forests, we need to know why they are being destroyed. Distinguishing between the agents of deforestation and its causes is very important in order to understand the major determinants of deforestation.

The agents of deforestation are those slash and burn farmers, commercial farmers, ranchers, loggers, firewood collectors, infra-structure developers and others who are cutting down the forests. Causes of deforestation are the forces that motivate the agents to clear the forests. The existing literature typically distinguishes between two levels of specific factors: *Direct* and *Indirect* causes of deforestation. Direct agents and causes of deforestation, also typically referred to as sources of deforestation, first level or proximate causes (Panayotou, T. & Phantumvanit,1990) are relatively easy to identify but the indirect causes which are usually the main divers of deforestation are the ones that cause most disagreement and the ones that are hardest to quantify (Chakravarty *et al* 2012).Two main forces affecting deforestation are: Competition between humans and other species for the remaining ecological niches on land and in coastal regions. This factor is substantially demonstrated by the conversion of forest land to other uses such as agriculture, infrastructure, urban development, industry and others (Brown, *et al* 1994). The proximate drivers are considered separately for deforestation and forest degradation. We consider commercial and subsistence agriculture, mining, infrastructure extension and urban expansion as direct drivers of deforestation while activities such as logging, uncontrolled fires, and livestock grazing in forests, and fuel wood collection and charcoal production are considered to be drivers of forest degradation (Hosonuma *et al*., 2012).

Underlying drivers consist of interplay of demographic, economic, technological, institutional, and socio cultural factors (Geist; Lambin, 2002).The continued decline of the forests is caused by conversion to agriculture, aquaculture, tourism, urban development and overexploitation (Giri *et al*., 2008). About 35% of mangroves were lost from 1980 to 2000 (MEA, 2005), and the forests have been declining at a faster rate than inland tropical forests and coral reefs. Relative sea-level rise could be the greatest threat to mangroves (Gilman *et al.,* 2008).Predictions suggests that 30–40% of coastal wetlands (IPCC, 2007) and 100% of mangrove forests could be lost in the next 100 years if the present rate of loss continues. As a consequence, important ecosystem goods and services provided by mangrove forests will be diminished or lost (Duke *et al.,* 2007).

2.4. The Role of Forests on Climate Regulation

Forests play an important role in the global carbon cycle and contribute to climate regulation through the long term storage of carbon in forest soils and woody biomass. The forests of the Amazon for example account for about 10% of global terrestrial productivity and biomass (Mahli and Grace, 2000);thus providing a significant sink for carbon and reducing the rate of greenhouse gas increase in the atmosphere. However deforestation, also mainly in the tropics, is a major land use change which promotes the tropics as a source of atmospheric CO2 through the release of carbon into the atmosphere (IPCC, 2007).

Afforestation and reforestation have yet to impact strongly on climate regulation, though some regional sinks have been created through afforestation, such as in China (IPCC, 2007). Forest growth particularly in middle and high latitudes is a current trend caused by the intensification and mechanization of agriculture requiring less land for food production. There is the discussion about liquid bio fuels and their use for carbon mitigation as opposed to using the land for forestry. For significant substitution of fossil fuels by liquid bio fuels existing forest and grasslands would need to be cleared, increasing carbon emissions. Further, if climate regulation is the main objective then increased efficiency of fossil fuel use, conservation of exiting forests and restoring natural forests may be the better policy in the short to medium term (Righelato; Spracklen, 2007).

Forests are also associated with the regulation of water through both effects on runoff and water quality. These forest services are more prominent in tropical areas and there are data available from small tropical catchments that show that runoff and stream discharge increases with increasing deforestation and that the degree of water yield from forests is also dependent on the tree species that dominate in a forest (Sahin; Hall, 1996).

It has been hypothesized that the increased forest production during the 20th century has increased the carbon pools in the soils, causing excess humus leakage to surface waters .Additionally; model simulations indicate increased humus leakage, as an effect of global warming (Lofgren, 2003).

2.5. Forest Ecosystem Services

Healthy forest ecosystems are ecological life-support systems. Forests provide a full suite of goods and services that are vital to human health and livelihood, natural assets we call ecosystem services**.** Many of these goods and services are traditionally viewed as free benefits to society, or "public goods" wildlife habitat and diversity, watershed services, carbon storage, and scenic landscapes (Costanza, *et al*., 2014).

Forests, particularly tropical, contribute more than other terrestrial biomes to climate relevant cycles and processes and also to biodiversity related processes. Forest ecosystem services, as other nature's services, have been claimed to be of great economic value and in valuation studies, ecosystem services like carbon storage or hydrological protection frequently fetch higher values than forest products or alternative land uses. (Robert Nasi *et al*., 2002). Mangroves are highly productive ecosystems with a rich diversity of flora and fauna in the intertidal zones of tropical and subtropical. They are considered of great ecological importance in shoreline stabilization, reduction of coastal erosion, sediment and nutrient retention, storm protection, flood and flow control, and water quality besides their regular economic benefit through various forest products (Giri, *et al*.,2011).During the past decades, however, the situation with regard to the mangrove forests has been deteriorating because of increased demand for land to be allocated to food and industrial production and rural and/or urban settlements (Blasco *et al*. 2001)

Improving agricultural technologies are likely to lead to abandoned land and increased succession forest and opportunities for biodiversity conservation. A major provisioning service from forests is timber production. According to the MA global timber production has increased by 60% in the last four decades Plantations provide an increasing volume of harvested wood, amounting to 35% of the global harvest in 2000. Roughly 40% of forest area has been lost during the industrial era and land forests continue to be lost in many regions resulting in the degradation of this service. (Sampson *et al.*, 2005).

However, forests are now recovering in some temperate countries and thus this service has been enhanced (from this lower baseline) in these regions in recent decades. Global consumption of fuel wood appears to have peaked in the 1990s and is now believed to be slowly declining but remains the dominant source of domestic fuel in some regions. Non-wood products, such as meat (from hunting), fruit and mushrooms, are also provided by forest ecosystems although they have less economic importance now than in the past. Forest genetic resources are also invaluable for the human population for example for their potential in areas such as medical research. Natural biological communities play important ecological roles in producing and sustaining habitable environments. No organisms can exist alone but all depend on multitude interactions among themselves and within the environment. In these interactions plant play the greatest roles: soil formation, nutrient recycling, solar energy absorption and management of biological and hydrological cycles all depend to a significant extent on plants, animals and microbes (Cunningham and Saigo, 1995).

This process mainly takes place in undisturbed areas (in areas where interference of man is very low). In wild areas there is self-sustenance and maintain ecological processes. Hence ecologically, plants represent a library of information (Cunningham, Saigo, 1995)

2.6. Forest Cover Dynamics and Human Impacts in Ethiopia

Forests are considered to be large complex environment that can be destroyed irreversibly and altered and prevented from reestablishment for an extended time by human being mainly by burning forest for the purpose of obtaining areas for hunting and later cattle raising and crop production. Ethiopia is agricultural country with about 85% of the population mainly depending on it. Agriculture occurs throughout the highland of the country with the highest production being in the central and north western areas. High forest was reported to cover 16% of the country in the early 1950s, 3.6% in the early 1980s and only 2.7% by 1989 (Taylor,*et al*., 1984).). Ethiopian highlands were covered by vast forests in ancient times. Therefore, one can deduce the forest cover of Ethiopia in the past was much larger than the present (Teshome, 1997).

According to Tigist (2003), prolonged drought, over population, overstocking, cropping encroachments and soil erosion are characteristics threats to the Ethiopian flora. Deterioration of biodiversity and invasion of undesirable woody species into grasslands are known to be the major constraints to the management of biological resource of Ethiopian dry land areas (EARO, 1999).

The extent of available agricultural land in Ethiopia has enormously increased, particularly during the last hundred years. From 1900 until 1989, about 4.7 million households required arable land for cultivation (Hurni, 2007). Since 1900 about 23 M ha of forest land were cleared, mainly driven by a conversion to arable farmland
(EFAP, 1993).

2.7. Application of GIS and RS in Forest Cover Change Analysis

Previously, detecting and quantifying land use land cover changes and forest cover changes have been conducted by local way which required extensive working time, budget and long research periods. But nowadays Geographical Information Systems (GIS) in conjunction with Remote Sensing (RS) has been recognized as powerful and effective technologies and tools in LU/LCC and detecting and quantifying forest cover change analysis (Weng, 2002; Rimal, 2011).

They provide accurate, cost effective and timely information and methods for monitoring, modeling and mapping of LU/LCC across a range of spatial and temporal scales. The information from GIS and RS also helps to assess the extent, direction, causes, and effects of the LU/LCC (Reis, 2008; Oumer, 2009; Rimal, 2011).

In LU/LCC assessment some studies have utilized both tools GIS and RS techniques separately; others have integrated GIS with RS techniques. GIS is a computer based system that facilitates data entry, stores geographically referenced system data, linksit with non-geographical attributes (in tables), data analysis and data presentation from a geographic perspective (Rimal, 2011). A geographic information system (GIS), geographical information system, or geospatial information system is a system designed to capture, store, manipulate, analyze, manage, and present all types of geographically referenced data. On the other hand, it is a useful tool to measure the LU/LCC trends between two or more time by using statistical and analytical functions (Abdellah *et al.,* 2013). It provides a flexible environment for collecting, storing, displaying and analyzing digital data necessary for LU/LCC detection and tools for land use planning and modeling (Reis, 2008; Rimal, 2011).

In the context of LU/LCC, RS means the ability to detect change on the earth's surface through space-borne sensors (Abdellah *et al.,* 2013). Recently it becomes useful tool for understanding landscape dynamics over time and space, irrespective of the causal factors. This is because of the fact that it provides multi-temporal and multi- spectral remotely sensed data (Rimal, 2011). Application of RS for LU/LCC analysis depends on: (i) sensor capability, (ii) wealth of information captured, (iii) objective of the intended study and (iv) spatial and spectral properties of satellite images acquired by different versions of a particular sensor instrument (Oumer, 2009). Land sat imagery provides a better understanding of land resources. The most important reason for this is a continuous improvement in radiometric and spectral property of images over time (Oumer, 2009). Since the starting of Landsat program in 1972 Landsat Multispectral Scanner (MSS), Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) data have been broadly employed in LU/LCC studies, mainly in forest and agricultural areas using RS (Reis, 2008).

2.8. Change Detection by GIS in Ethiopia

In Ethiopia the expansion of agricultural land and loss of natural vegetation which are associated with population growth, poor economic condition, unclear land tenure right and several other biophysical and socio-political factors increases from time to time. In order to detect and quantify the changes in such agricultural land expansion and loss of forest lands, many researches were carried out in the country (Melaku, 2003). Presently these LU/LCC including forest cover change detections are carried out with GIS and RS technologies. Out of the many researches, studies made by (Meshesha, *et al.*, (2016) at Beresa watershed in Northern Ethiopia, Abiyot *et al.,* (2014) at Banja District in Amhara Region, Tolessa *et al.*, (2017) in

Central Highland, Mezgebu;Workinesh(2017) at Bale Eco region in Oromia Region, Othow *et al*., (2017) at Gog District in Gambela Region, Abate,*et al*., (2014). at Nadda Assandabo Watershed in SNNPR have utilized GIS and RS technologies.

2.9. Studies done on Gedo forest

Many researchers have sighted that the location of Gedo forest is only have vicinity with Cheliya woreda of western Shewa. The research thesis focused on different topics of forest on the particular location. Among the studies: (Kebede, *et al*.,2014). Structure and regeneration status of Gedo dry evergreen montane forest, Yohannes *et al.*,(2015). Carbon Stock Analysis along Altitudinal Gradient in Gedo Forest: Feyissa *et al* (2007) Analysis of genetic diversity in the endangered tropical tree species.

From the above scholars no one has studied the forest cover dynamics between the past years and projected the scenarios for the future. All scholars were focused on the composition and the characteristics of the forest in the study area.

2.10. The Impact of Land Use Change on Ecosystem Services

A landscape is a structural, perceptible and functional layout of an area that results from the complex interaction between its environmental and socio cultural assets (La Mela Veca, D.2016) Land use land cover change, as a consequence of the human influence on the landscape, derived from significant modifications in ecosystems at local, regional and global scales and has consequently influenced global change, especially through its effects on temperature and rainfall. In light of the increasing awareness of such themes, recent international climate agreements stressed the importance of land use and land use change of forest ecosystems as a focal point for understanding the changes on global productions, harvested areas and prices of major crops, which are ultimately also taken into account by economists (Lambin, 2001).

The impact of human activities was recognized much earlier for forests than other ecosystems. The first references can be traced back to Plato (ca 400 BC), who suggested that soil erosion and the drying up of springs could be due to deforestation. Human activities, such as land use change, forest exploitation and management, the impact of industrialization (leading to acidification and eutrophication) has impacted, through changes in geographic distribution, biodiversity and nutritional/toxic status of the upper soil horizon, on almost all forests over recent centuries (Daily, 1997).

Land-use change is one of the most crucial and direct driving factors of changes in ecosystem functions and services (Millennium Ecosystem Assessment (MEA), 2005a; Burkhard *et al*., 2012; Chhabra *et al*., 2006; Kindu *et a*l., 2016). It alters the ecosystem productivity, modifies the physical parameters of the earth's surface, affects nutritional convey between soil and vegetation by changing biochemical cycles, and influences the element and structure of ecosystems (Huang *et al*., 2008; Tang *et al*., 2008; Zang *et al.,* 2011). The dynamic change of land use can bring about changes in the values of ecosystem services (Hu *et al*., 2008; Kindu *et al*., 2016; Kreuter *et al.,* 2001; Polasky *et a*l., 2011).

Despite the forceful governmental intervention in urban planning and land use planning, future land-use changes cannot be accurately forecasted (Liu., 2012). From this point of view, scenario analysis is often integrated into studies about land use change (Labiosa *et al*., 2013; Liu *et al*., 2012). In view of the complexity and uncertainty of the future land use change, there is need for simulation and scenario analysis to evaluate future ecosystem service values under different land use change scenario (Landuyt *et al.,* 2016).

2.11. Ecosystem Services Quantification

Ecosystem services are the benefits provided by ecosystems that contribute to making human life possible (Bateman *et al*., 2011). Ecosystems provide many goods and services that enable and enrich human life, from traditional natural resources, such as timber, fish, and edible plants, to the aesthetic qualities and characteristics of a place, to clean water and air."Ecosystem services are the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life" (Daily, 1997).

Human ingenuity has enabled people to refine, reallocate, and intensify the production of many goods and services by combining natural processes with human-created tools and labor. This has led to extraordinary advances in longevity and material well-being. However, it has also led to declines in some forms of natural capital and many non-marketed ecosystem services (Millennium Ecosystem Assessment 2005).

Scientists, policymakers, and land managers increasingly recognize the varied contributions of healthy, multi-functional ecosystems to human well-being and seek to develop the tools and knowledge necessary to manage these systems to best meet societal objectives (U.S. Environmental Protection Agency 2009).Quantifying and analyzing changes of ecosystem service values (ESVs) is an important tool to raise awareness (Liu *et al*., 2010), contribute to developing knowledge on management of natural capital (Costanza *et al*., 1997), improve decision making for allocation of scarce resources among competing demands formulate polices (Schägner *et al.*, 2013) and provide a stimulus to conserve the ecosystems that offer the most valuable services (Konarska <u>*et al.*,</u> 2002). As a result, interest in ecosystem service values has evolved rapidly in both the scientific communities and policy (Costanza *et al*.,2014).

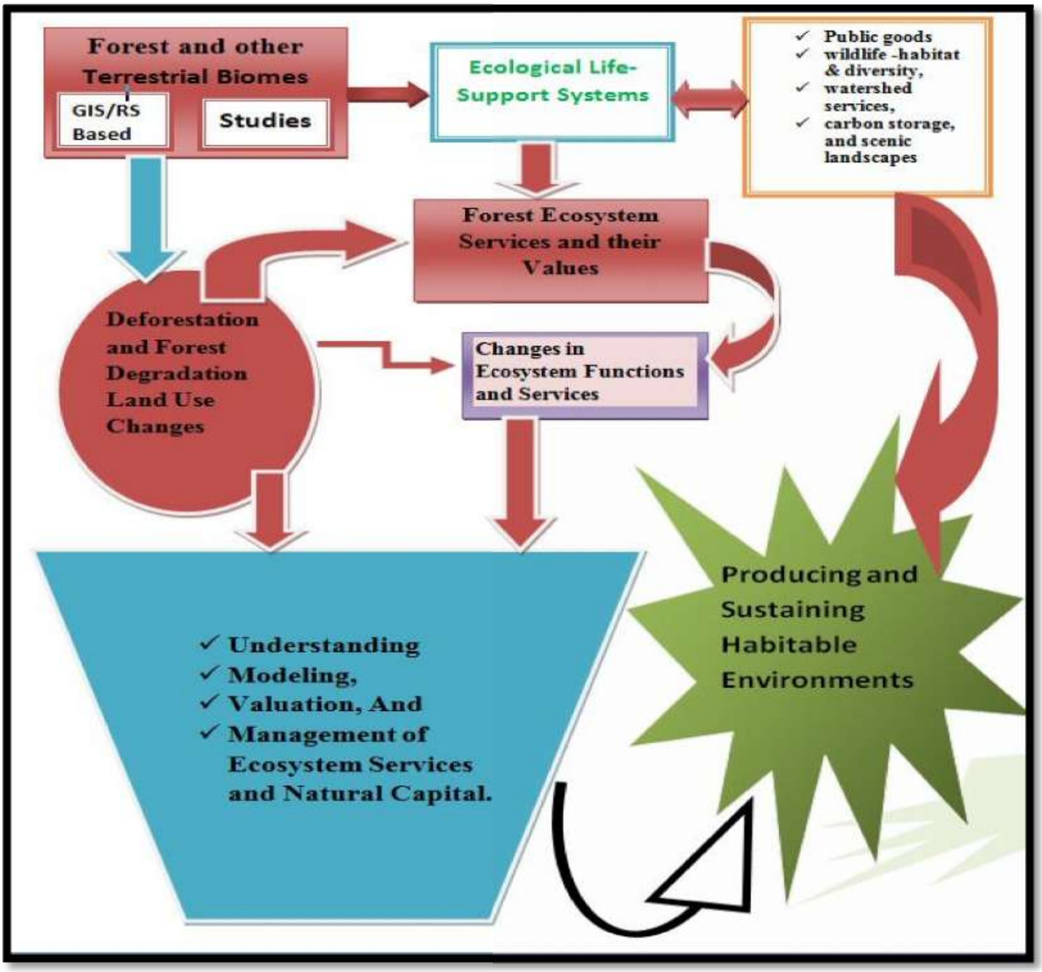


Figure 2 Conceptual framework /analytical framework.

CHAPTER THREE

3. METHODS AND MATERIALS

3.1 .Description of the Study Area

3.1.1. Location

Gedo forest landscape geographically lies between 8°58′30″__9°11′0011″ North Latitudes and 37°10′00″ __37°32′30″ East Longitudes in West Shewa Zone of Oromia National Regional State.

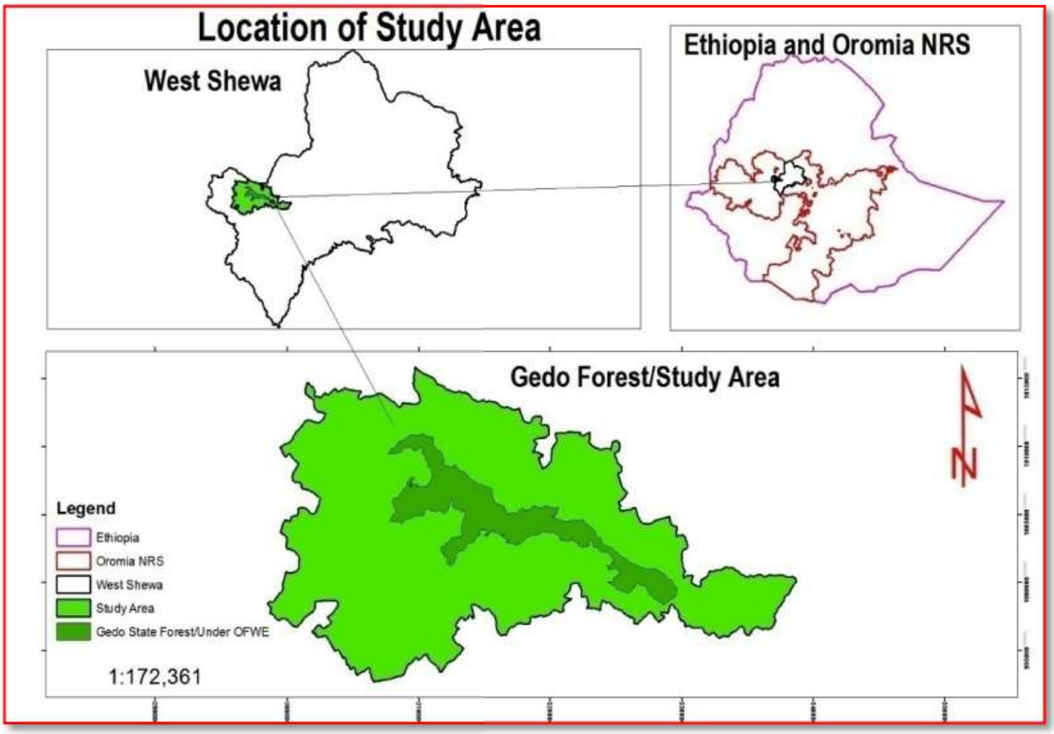


Figure 3. Location Map of the study area

The forest landscape is located in the three *woredas* of west *shewa* zone ; Amongst *Cheliya woreda,* eight rural administrative *kebeles*;, *Elu Gelan* five rural administrative *kebeles*, and *Bako Tibe* eight rural administrative *kebeles* were covered. But many researchers have cited the location of the forest is partially covers *Cheliya woreda* only. The place is located along the road from Addis Ababa to *Nekemte* at about 197 kms. The maximum altitude of the study area reaches 3060 m a.s.l. on the pick of *Keku* Ridge (*Endalew*, 2007).

The forest is one of the 58 national forest priority areas of Ethiopia. The Study area covers the total area of 47,663.8ha of the landscape which includes *Gedo* state forest and the nearby deforested and shrubby structure areas to study the dynamics on forest cover and its ecosystem service.

3.1.2. Climate and topography

Climatic conditions vary widely across Ethiopia, influenced strongly by altitude. Temperature and rainfall are the key variables influencing land cover including forest vegetation and land use potential. (Kefiyalew,2016).

Gedo forest Landscape obtains high rainfall between May to September and low rainfall from December to February. The highest mean annual rainfall of the study area within ten years (2000-2009) was 186.4 mm recorded in July followed by 183.2 mm in August whereas the lowest mean annual rainfall was 15.1 mm recorded in December. The rainfall distribution increases from mid-February to mid-March then decrease slightly in mid-April. From mid-April to mid-September the amount of rainfall is high. The lowest mean temperature over ten years was 8.7ºC recorded in December, whereas the highest was 24.6ºC recorded in February (Birhanu,*et al,*.2014).

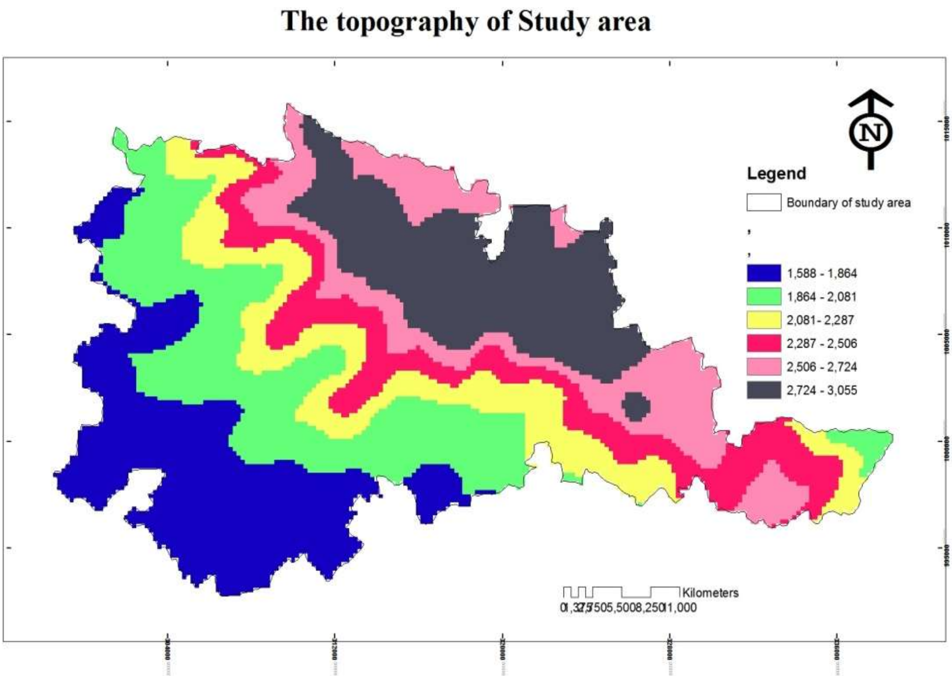


Figure 4. Altitudinal ranges of the study area

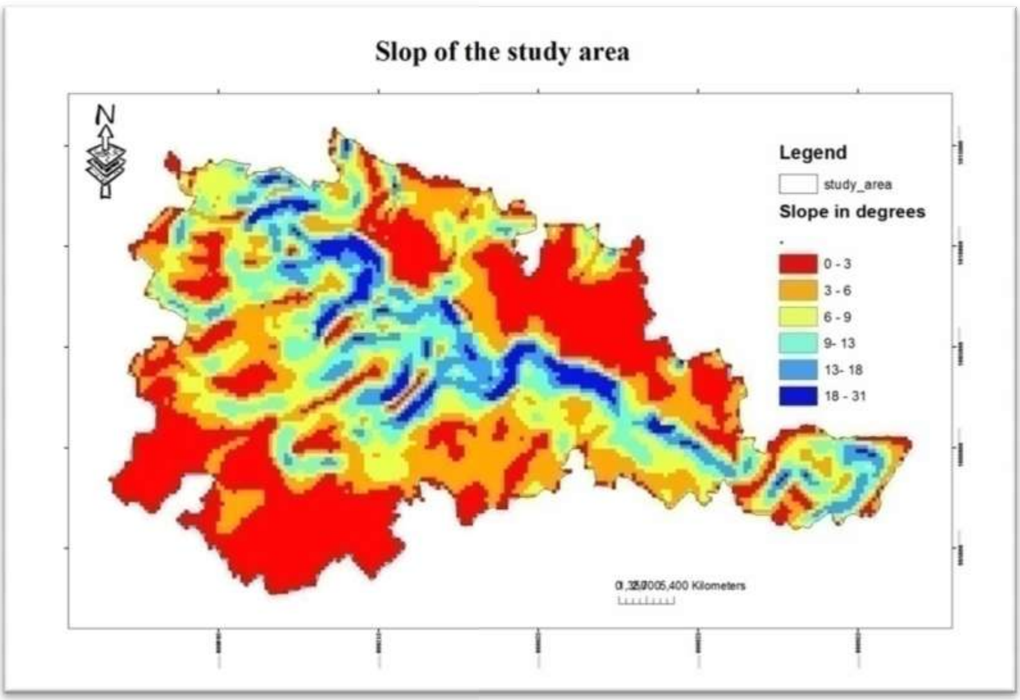


Figure 5. Slop of study area

The topography, slope aspect, inclination of slope and soil type may affect the forest composition. Differences in isolation period at various altitudes may occur according to slope aspect of site, thereby forming a range of microclimates in multifaceted landscapes. Consequently, microclimate is often linked to soil moisture and distribution of particular plant communities (Sharma *et al*.,2010)

The study area /Gedo forest/ is Dry Evergreen Montane forest characterized by relatively high humidity, with a prolonged dry season.

The study area landscape has two watersheds; Abay and Omo while five big river tributaries of Gilgel Gibe and Guder rivers. Over geologic time, changes in disturbance regimes are a natural part of all ecosystems. Even so, as a consequence of climate change, forests may soon face rapid alterations in the timing, intensity, frequency, and extent of disturbances (Dale, 2001).

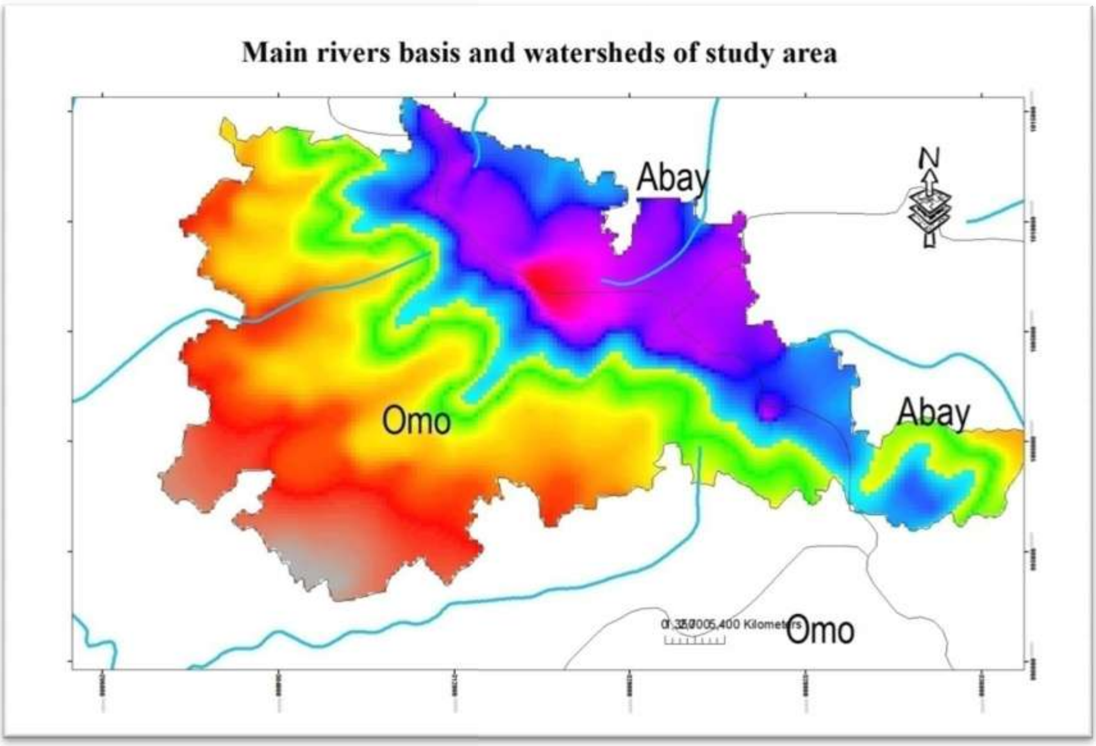


Figure 6.Watersheds of the study area

The remnants and high forests are located and bushed following the high reliefs of the study area. The Dry Evergreen Montane Forest which characterized by relatively high humidity, and a prolonged dry season is the characteristic of Gedo forest landscape. The high rainfall intensity during rainy season creates high land degradation and soil erosion, which leads to loss of soil fertility and
damage to agricultural land (Kebede, 2014).

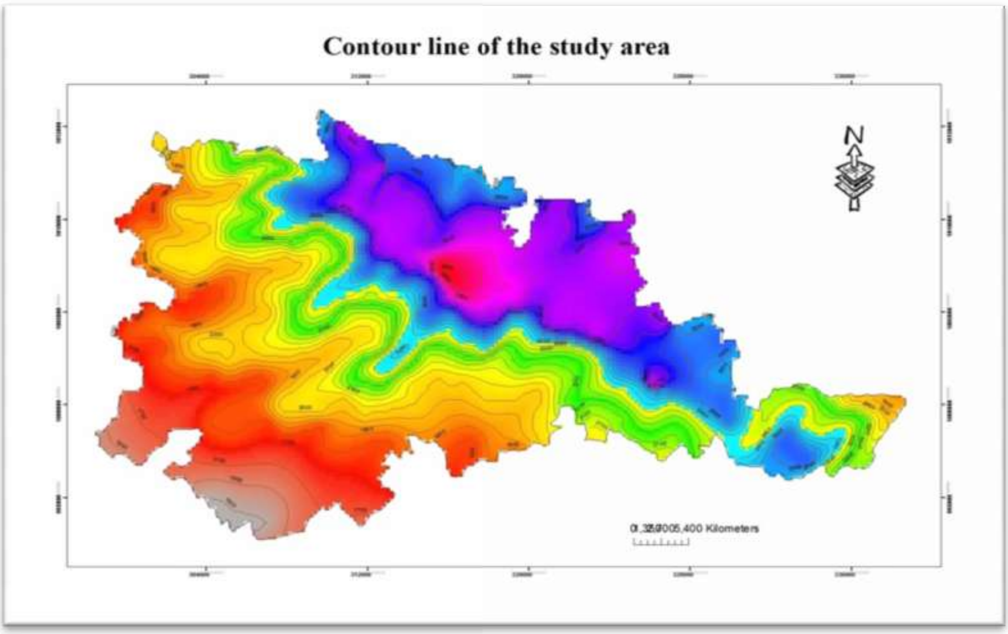


Figure 7.The contour line of Gedo forest

3.1.3. Soil and Geology

The soil and the geological formation history have great relation with the growth of forest. Almost one hundred years ago, topography was indicated as one of the decisive factors for soil formation processes .This results from the crucial importance of land relief for the amount of solar radiation intercepted by the surface of the ground, which influences the ecologically critical factors of microclimate, including near surface temperatures, evaporative demand and soil moisture (Sewerniak, 2017).

Topography results from its connections to soil erosion; however, the significance of this relationship is strictly connected to land use: it is well known that deforestation evidently increases soil erosion, especially in areas of diversified land relief (Dotterweich, 2013).

Studies indicated that, topography affects variability and distribution of vegetation, which is another decisive factor for soil formation .Due to the high importance of topography on the spatial differentiation of soil properties, the subsequent consequences for vegetation, and the potential implications for agricultural production and forest management, the effect of land relief on soils has been investigated in many studies (Sewerniak, 2017)

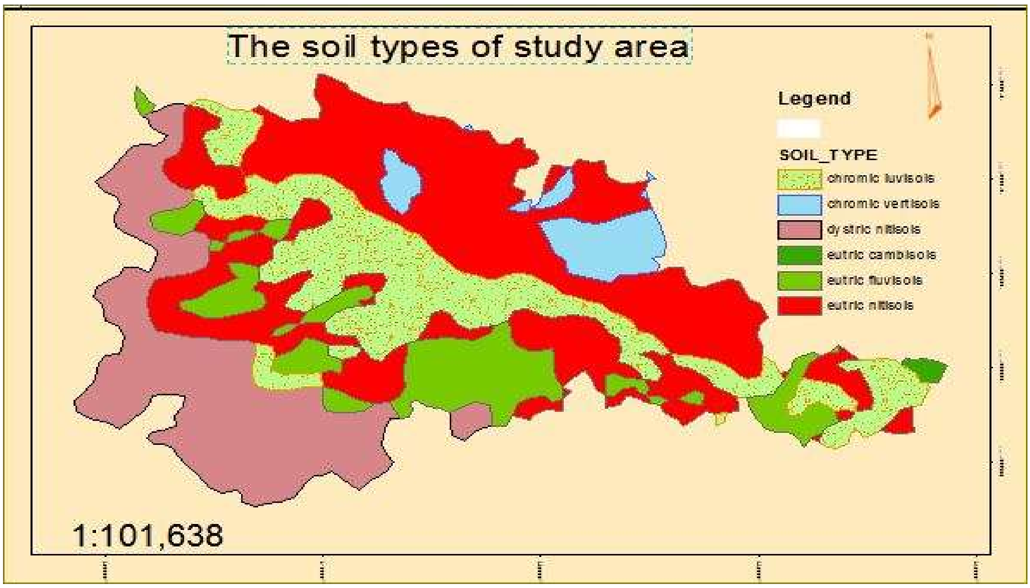


Figure 8. Soil of the study area (EMA, 1996)

The soil of the study area/Gedo forest is characterized by six types of soil classes. Of these soil types, the study area is covered predominantly by Eutric nitisol soil type. Nitisols, one of the 30 soil groups in the classification system of the Food and Agriculture Organization (FAO). Occupying 1.6 percent of the total land surface on Earth, Nitisols are found mainly in eastern Africa at higher altitudes, coastal India, Central America, and tropical islands (Cuba, Java, and the Philippines). They are perhaps the most inherently fertile of the tropical soils because of their high nutrient content and deep, permeable structure. They are exploited widely for plantation agriculture (Bouwman, 1990)The others are Luvisols, Vertisols, Cambisols, Fluvisols and Cambisols (EMA, 1996)

Geology plays determinant factor on forest growth. Geological structure is highly suitable for forest growth. The geological characteristics of Gedo forest as obtained from the printed material by the Ethiopian Mapping Authority (1996) indicates that the area has five types of geological history. These are: Plateau basalts (which are alkaline basalt and traphyte), Adigrat (Triassic middle and Jurassic sandstone), Abay formation (middle Jurassic limestone shale and gypsums), Alluvial and locus trine deposits (Sand silt, clay, diatomite, limestone, and beach sand), Algae group (Biotitic and hornblende granulites and migmatite with Meta sedimentary genesis).

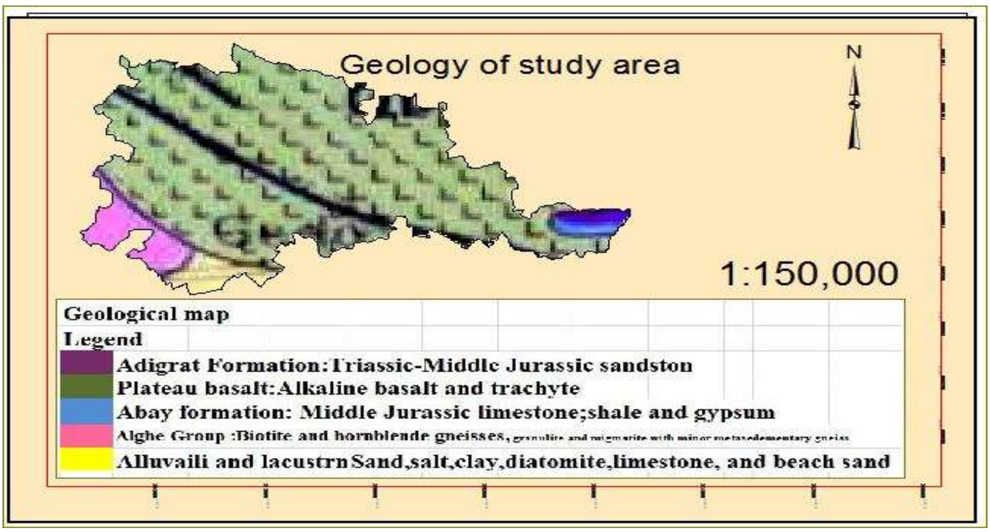


Figure 9 Geology of study area (EMA, 1996)

3.1.4. Population

The study are is located between the adjacent woredas of west shewa: Chelia woreda, with eight rural kebeles,Elu Gelan woreda with five rural kebeles and Bako Tibe worda with eight rural kebeles. Totally 21 rural kebele administrations are included in the study area/Gedo forest. The census data of CSA(2008), indicates that the total number of population in the kebeles of woredas are 37,431 in Chelia, 21,482 in Elu Gelan and 25,814 in Bako Tibe. The total number of population is 84,727. The projected estimates of population number in 2018 is 140,000 while the data of Agricultural and Rural development Offices (2018) from the three woredas indicates that the population in the study area is 152,125 of whom 76156 male and 75,969 are female. The data of Central Statistics Agency (CSA) in 2008 indicates that number of households engaged in the study area is about 8,400 households.

3.1.5. Socio economic activities and land use types

The main economic activities in the study area are small farming and livestock rearing. The agricultural crops grown include cereals 'teff', wheat, and maize, Niger seed, legumes vegetables (tomato, onion, and cabbage), and sweet potato. The major livestock reared are cattle, poultry, mule, horse, sheep, and goat

The smallholder agriculture which is associated with the agro forestry and commercial plantation forest are the main livelihood income generation. The study area lies on the area of 48,000 ha among which the 5676 ha is covered by the state forest which is under the Oromia Forest and wildlife enterprise/OFWE. This state forest is found in the middle of the study area and it uses as the tower for many streams and rivers for the surrounding *woredas* and *kebeles*. Even though no study was done on the ecosystem services obtained by this state forest is not identified and valuated, and also the state of cover change in this forest is not measured before, there is visible situations and reporting from the Enterprise. OFWE report,(2018)

3.2. Research Design

The research design used in collecting and analyzing the measures of variables in the research problems for this study were incorporated many study designs; among which; Casual, cross-sectional, historical, and longitudinal designs which are coincided with quantitative and qualitative research designs are the majors.

3.3. Data and Data Sources

In this study both primary and secondary data were used. The primary data sources were respondents around and in the study area and direct field observation by the researcher. The data collection tools used were questionnaires, Interview of sample households, key informants and Land sat MSS, Land sat TM and Land sat ETM+. The sources of secondary data were in addition, Published and unpublished articles, Documents in the concerned offices, Journals and web sites were used as secondary data. These primary and secondary sources of data were verified and identified by the ground control points that have been collected by the GPS devise and Google earth pro.

3.4. Data Collection

3.4.1. Primary data collection

1. Interview

The primary data was collected from respondents through structured and semi-structured questionnaires that were prepared and distributed for the collection of the data. For this data collection, the elders, the youth, the women in the selected households around the study area of every 21 *kebeles* were considered. More over discussion was made with the key informants /experts (focal persons) of the three *Woredas*. The respondents are four personnel (elders, Youth and women) per a *kebele* and are 126 in number. The rest 25 were expertise from the three *woredas*. The total number of respondents the interview and focus group discussion held with were151 persons. In this interview the sample size formulae $n=N/1+N*(e^2)$ Slovin's Formula (Tajeda, 2012) was considered using 152,125 population number=number of samples, N=Total population=error tolerance/alpha/ level 9%, where 91% confidence level was used.

2. Direct field observation

The researcher has also made a field trip to the study area to obtain some important information and to make some crosschecks on the information obtained from respondents and satellite images. The researcher has used GPS device to collect ground control points deal with image classification.

3. Satellite image

The primary (satellite image) data that have been used in this study were obtained through searching and downloading it from feely available websites and through purchase from Ethiopian Mapping Agency (EMA).Three dates of Land sat imagery data of the years 1973, 1995 and 2018 were used to produce land cover map in general and forest cover map in particular to evaluate the dynamics of forest cover change of the landscape and its associated Ecosystem services. In the first stage, satellite images from 1973, 1995 and 2018 were used to analyze trends of land cover /land use in the area. The date and month of data acquisition were all during the dry season allowing cloud-free images. It was not difficult to classify land use and land cover types on the ground. The selected years of the study were based on the availability of data. This year of study was also selected as initial because of quantitative change analysis over a long period provides a valuable insight in to a forest cover dynamics (DD Koi, *et al*,.2010).Remotely sensed data were processed using ERDAS Imagine 2010/15 software by applying the basic image preprocessing techniques, starting from image rectification, restoration, enhancement, image classification, and accuracy assessment. GIS software was employed for managing, analyzing, combining and mapping spatial data using Arc GIS 10.5 and Google Earth pro.

Table 1 . Image types and sources

Imagery Type	Resolution	Path and Raw	Sources	Imagery Date/ Year
Landsat MSS	57X57	181/54	USGS	02-02-73
Landsat ETM+	30X30	169/54	USGS	28-03-95
Landsat OLS	30X30	169/54	USGS	06-01-18

3.4.2. Secondary data collection

1. Literatures

Secondary data sources such as published and unpublished materials were also used from the literature reviewed from the Google scholars which are related with the study were used.

2. Office reports

The woreda and forestry offices located in the study were also the source of secondary data in the research.

3.5. Data Analysis Methods

By using remote sensing and geographic information system supported with field verifications, the information were extracted from various Satellite images and different digital maps to detect the extent and rate of forest cover dynamics and ecosystem service values over the last 45 years and for these changes descriptive and qualitative socioeconomic data analysis method was used

3.5.1 .Data analysis using GIS tools

ArcGIS 10.5, ERDAS IMAGINE 2010/2015, and Google Earth pro have been employed for classification and the further analysis of data.

The land use/land cover units of the study area has been classified into classes of forest, Shrub land, Grazing land, Agricultural land, Settlement, and Water body. The statistics of land use /land cover change in general and forest landscape dynamics in particular were detected from the remote sensing satellite imagery bands of Land sat one-eight were layer stacked and the supervised classification was done for the major land use land cover types identified before. For this classification, images analysis was done again to view the land use land cover types in the particular years and also changes in the ecosystem service values over the years of 1973, 1995 and 2018 were computed and summarized. In general terms both the remote sensing and GIs technologies were applied on the data collection and data analysis methods .

3.5.2. Data analysis using global data

The secondary global data bases were used to quantify and economically value the main ecosystem services provided by the Forest Landscape and the dynamics of it. Determining the ESV per unit area for each land use type, the service value for each land use type were determined for each service functions, and for the total ESV as follows:

$ESVk=Ak \times VCk$ (1),$ESVt=k\ Ak \times VCk$ (2) $ESVf=k\ Ak \times Ckf$ (3)

Where ESVk, ESVf, and ESVt

Refer to the ESV for land use type K,

Service function f, and

The total ecosystem, respectively;

Ak is the area (ha) for land use type k; VCk is the value coefficient (US\$ ha^{-1} yr^{-1}) for land use type k; and VCkf is the value coefficient (US\$ ha^{-1} yr^{-1}) for land use type k with ecosystem service function type f (Varkey*, et al* 2016).

Table 2 . Average global values of annual ESV/USD /ha^{-1}/$year^{-1}$

	Ecosystem serivces Global average of ESVs USD-1 Year-1																	
Biomes/LULC types	Gas Regulation	Climate Regulation	Disturbance Regulation	Water regulation	Water supply	Erosion control	Soil formation	Nutrient cycling	Waste treatment	Pollination	Biological control	Habitat/refugia	Food production	Raw materials	Genetic resources	Recreation	Cultural	Total values per ha(Sha-1 year-1)
Forest land		223	5	6	8	245	10	922	87				32	315	41	112	2	2007
Shrub land		141	2	2	3	96	10	361	87		2		43	138	16	66	2	969
Crop land		0	2							14	24		54					92
Grass Land	7	0		3		29	1		87	25	23		67		0	2		232
Settlement		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water body				5,445	2,117				665				41			230		8,498

Data on area under different categories of land use land cover type was acquired from the satellite remote sensing imagery which was computed by GIS techniques. Unit value ecosystem service co-efficient estimated for different biomes by de Groot et al. (2012)

under the ecosystem services valuation model were suitably adopted in the study. Once the ecosystem service value per unit area was assigned for each land use land cover type the equations were used to determine service value for each land use land cover type, for each service function and for the total ecosystem service value respectively.

Once the overall the Gedo forest cover dynamics and its associated ecosystem service values have been equated and analyzed the secondary/qualitative data obtained from the key informants and study area respondents data were used in discussions and conclusion parts of the study. This is to make the analysis of cover change and ecosystem services dynamics within the forest.

Table 3 .Biome equivalents for the LULC

LULC classes	Description
Forest land	Land dominated by trees >5 m in height, with canopy cover > 20%
Shrub land	Land dominated by bushes and shrubs <5 m in height with canopy cover >20%
Cropland	Land under cultivation / agriculture
Grass land	Land under grass cover, largely used by domestic animals for grazing and browsing
Settlement land	Land dominated by houses and huts
Water body	Rivers and swampy areas

Table 4. Ecosystem services coefficient and Equivalent biomes

LULC Category	**Equivalent biomes**	**Ecosystem services coefficient US$ha^{-1}yr^{-1}**
Forest land	Tropical Forest	2007
Shrub/Bush land	Forest	969
Crop Land	Crop /agricultural land	92
Grass Land	Grass/Range land	232
Settlement land	Urban	0
Water body	water	8498

3.5.3. Descriptive data analysis

The descriptive and qualitative study design for socioeconomic data analysis was used in explaining the drivers for the dynamics in forest landscape to other landscape type with its values of services of the study area.

3.6. Data Presentation

The result of the analysis had been presented in different forms such as tabulation, graphics and descriptions. To further elaborate the result of the study, clear discussion has been made. Finally based on the result obtained, conclusions have been drowned and recommendations have been forwarded. Seventeen ecosystem functions, grouped into four ecosystem services were identified based on Costanza *et al.* (1997) and the principal-related goods can be found on Bateman *et al*. (2011). The ecosystem functions were then quantified to provide the amount of ecosystem function gained/lost, and were then used to further quantify the overall ecosystem services gained/ lost.

3.7. Ethical Consideration

Emphasis was given for ethical consideration during data collection. The potential respondents informed and obtained consent were protected from harm and discomfort as well as other related ethical issues such as; cultural sensitivity, respect for respondents, free of value judgment and interference, discrimination free preparation and distribution of questionnaires, neutrality, care of moral, attitudinal variations and gender issues.

Furthermore, as the respondents freely reflect their real ideas and responds to the questionnaire, interviews, the researcher had informed the respondents all about the research objectives and covenanted to respondents for erasing their responds after compiling. To help this, Formal letter from Jimma University, college of social science and humanities Department of Geography and Environmental Studies has been written for the proposal development of the research to be held in the study area /Gedo Forest Landscape area.

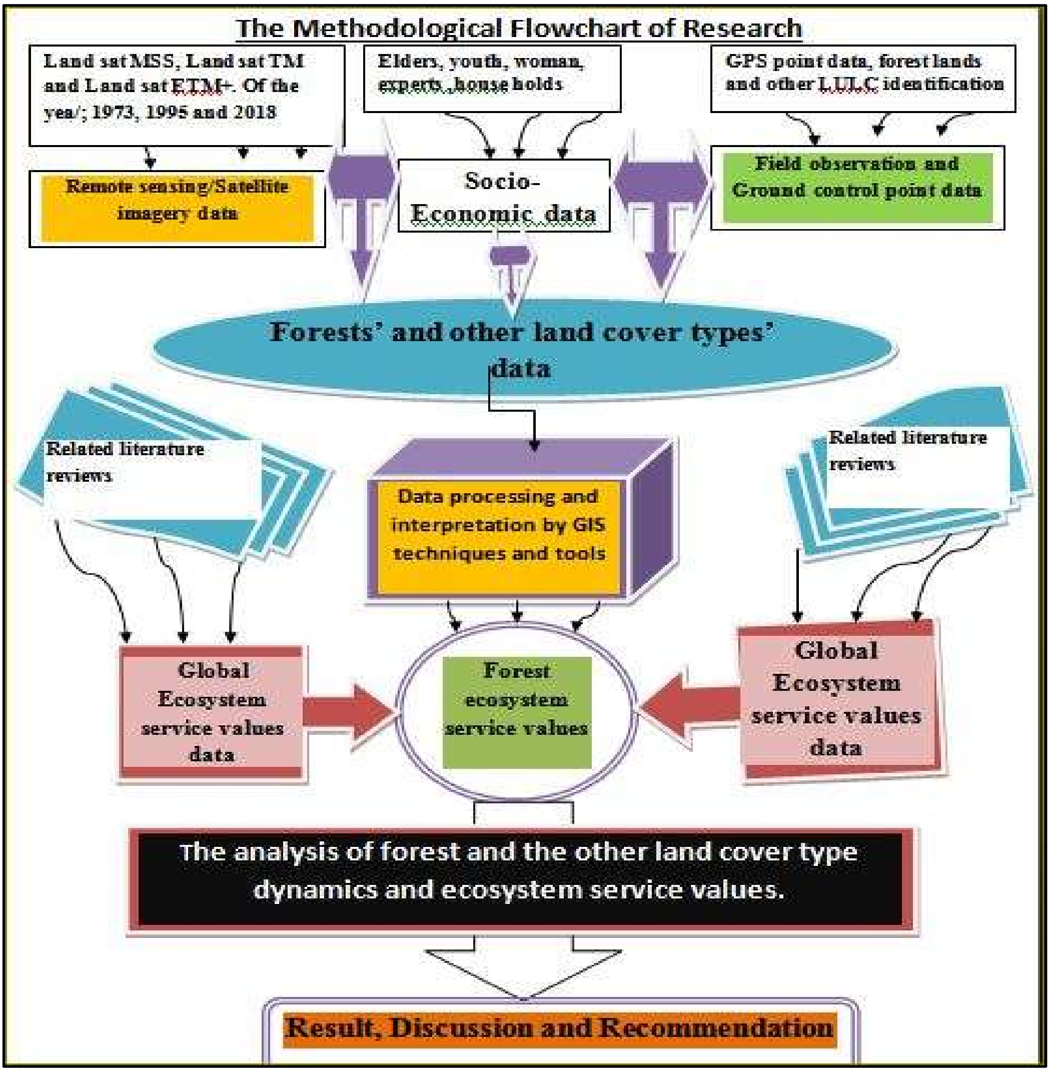


Figure 10. The study methodological flowchart.

CHAPTER FOUR

4. RESULT AND DISCUSSION

4.1. Land Use/Land Cover and Image Classification

Land use/land cover types identified are: Forest land, shrub land, Grass land, crop land, settlement area or built ups and water bodies. The analysis on land use and land cover change in general and the forest and shrubs cover dynamics in particular in the years of 1973 to 2018 for 45 years, the differences in spatial and temporal dimensions showed a great dynamic on the landscape of study area which covers an area of 47,663.81ha.

4.1.1. The land use /land cover classification of 1973

One limitation for conducting time series analyses of land-use changes using remotely sensed data is that satellite data from high-resolution detectors have a relatively short history. Even LANDSAT data cannot be used for analyzing land-use changes prior to 1972 (Kreuter,2001).

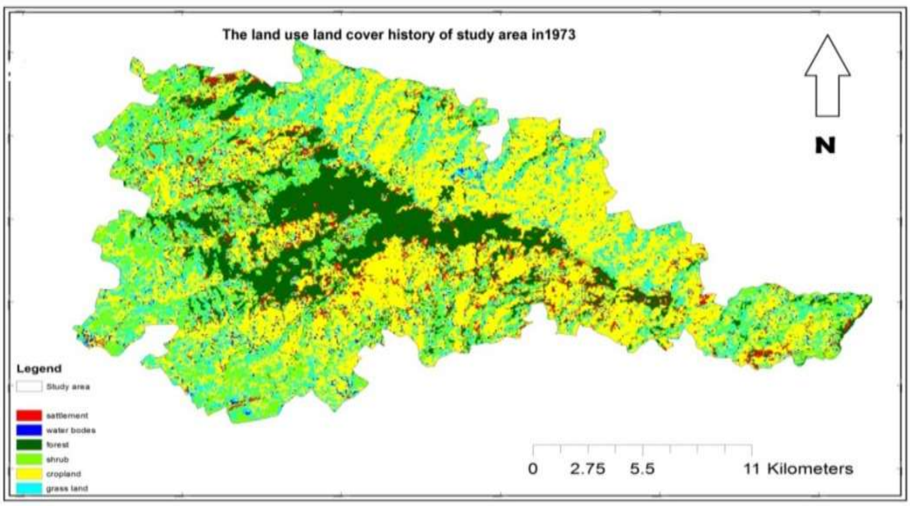


Figure 11. Land use land cover / 1973

The dominant land use land cover type in 1973 was crop land which covered the total area of 21,477.83 ha or 45% of the study area followed by grass land which covered an area of 8,191.05 ha or 17 % and shrub land which covered an area of 7960.05 ha or 17 % of the study area.

The forestland and shrub land together covered an area of 14,795 ha or 31%, which may exceed the coverage of grassland /next to crop.

Table 5. Land use land cover classes by area /1973

Land use/Cover	Area/ha	Coverage by %
Forest land	6,835.89	14
Shrub land	7,960.05	17
Crop land	21,477.83	45
Grass Land	8,191.05	17
Settlement	1,970.20	4
Water body	1,228.79	3
Total	47,663.81	100

The land coved type of the water bodies are about 1,228.79 ha while the land use type that has served the inhabitants as a settlement area was 1,970.79 ha.

4.1.2. The land use land cover classification of 1995

For the land use land cover classification of the year 1995, various sources, including field survey, ancillary data and Google earth supporting were used for the classification to set and implement object-based classification. Six LULC classes were considered for this purpose. The land use and land cover classes identified are Forestland, Shrub land, Cropland, Grassland, settlement and water bodies among which the dominant land use type is occupied by agricultural activities.

The cropland class of the year 1995 covered an area of 34,924 ha or 73% of the total land use land covers capacity of the study area.

The greatest part of the landscape in this year was occupied by the crop land use type which exceeded the whole study years. This may be because of agricultural land expansion on the other land use land cover classes in the year of 1995.

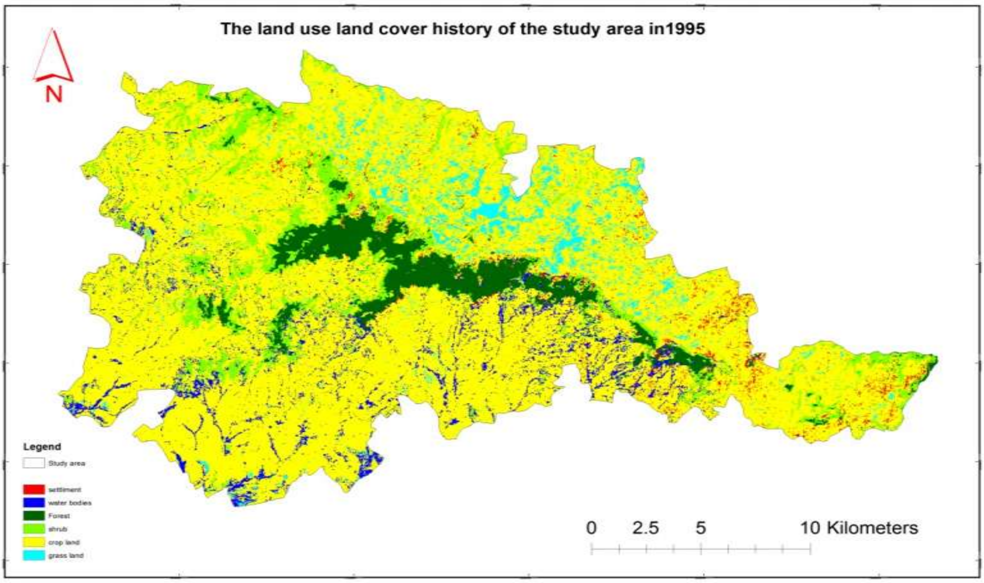


Figure 12. Land use land cover / 1995/

Another reason was during this time it was the transitional period between the *Dergue* and the EPDRF and many forest and shrub lands were converted to farmland over a night.

Table 6.Land use/ land cover in 1995

Land use/Cover	Area/ha	Coverage by %
Forest land	3014.73	6
Shrub land	4696.56	10
Crop land	34924.05	73
Grass Land	2028.33	4
Settlement	672.6	1
Water body	2327.54	5
Total	47,663.81	100

As it was observed in the country many big forests were deforested, burned and settled by forest intruders because of the political collapse .The other land use land cover type next to the cropland is shrub land which stretched out on the area of 4,696.56 ha or 10% of the land, Forestland on 3,014.73 ha or 6% of land .The forest and shrub together covers an area of 7,711 ha or 16 % of the total study area. The rest land use land cover classes are: grass land, Built ups, and water bodies which cover an area of 2,028.33, 672.6 and 2,327.54 ha respectively.

4.1.3. The land use / cover classification of 2018

In this year of land use and land cover class identification certain differences are seen as unlike of the years of 1973 and 1995. Every cover class had been shifted to unusual type of cover class. The classes are like as the 1973 and 1995; Forestland, Shrub land, Cropland, grass land, settlement and water bodies.The widest class of land use /land cover still kept by the agricultural activity that uses cropland which occupies an area of 27,768.87 ha estimated to 58% of the total coverage of the study area while it was declined by 7,155.18ha / 20% from the year of 1995.

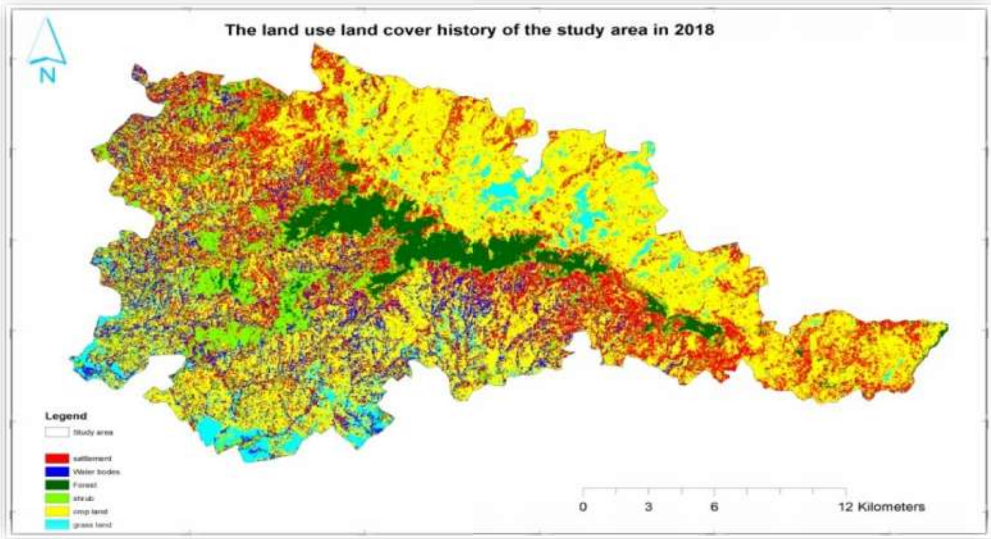


Figure 13. Land use /land cover / 2018/

The land use land cover in this year has changed from the year 1995 by diminishing the coverage of croplands from an usual history. This is because of Afforestation, Reforestation was started to restore the deforested and degraded lands by many forestry projects e.g. REDD+ programs, OFWE and forestry sectors. The increase of forest land may have a regression impact on agricultural land expansion.

This is because of the expansion of agricultural land in 1995 was not only for the need of agricultural land ,but also it was the strategy move to occupy extensive land by casing agricultural productivity increase. This could be understood that after the years of land grabbing the agricultural land was changed to another land use type which allowed decreasing for the cropland from the initial year by far.

Table 7.Land use/land cover in 2018

Land use/Cover	Area/ha	Coverage by %
Forest land	1,976.85	4
Shrub land	3,532.41	7
Crop land	27,768.87	58
Grass Land	3,326.58	7
Settlement	7,899.93	17
Water body	3,159.17	7
Total	47,663.81	100

The remaining land use land covers are grassland which covers an area of 3326.58 ha or 7%, settlement area covers an area of 7899.93 ha or 17% and water body covers an area of 3159 or 7%.

4.2. Land Use /land Cover Dynamics between 1973 and 1995

The 22 years discrepancy was detected by using the GIS tool known as ERDAS Imagine 2010/15. For these years the values are changed in either negatively or positively. According to the matrix done certain shifts are seen between the cover classes of land use types.

Table 8. The Matrix of the dynamics between 1973 and 1995

The matrix of the dynamics between the years of 1973 and 1995

	1995	Forest land	Shrubland	Crop land	Grass land	ettlement land	Water
1973	Forest land	6234.91	3985.32	4557.68	20.54	205.17	803.66
	Shrubland	122.60	3150.75	13511.63	167.20	98.33	1534.09
	Crop land	213.67	1313.78	146552.22	3286.42	1016.71	1680.14
	Grass land	42.73	1545.71	15771.18	1032.48	82.57	620.90
	Settlement	340.84	681.47	2835.84	28.21	133.81	547.25
	Water	6.22	135.88	2326.34	160.15	24.27	206.21

4.3. Land Cover Dynamics between 1995 and 2018

It has a total 22 years difference that comes out with certain cover dynamics. Agricultural activity has a great part in shifting all the other land use land covers to the land use type. But the conversions of agricultural land use types to the other land use land cover types were very weak.

Table 9. The Matrix of the dynamics between 1995 and 2018

The matrix of the dynamics between the years of 1995 and 2018

	2018	Forest land	Shrubland	Crop land	Grass land	ettlement land	Water
1995	Forest land	1978.74	921.33	3.06	0.00	116.28	3.60
	Shrubland	0.09	1896.93	1266.03	0.00	1543.50	115.20
	Crop land	0.00	399.87	69600.06	2447.91	5824.98	24185.70
	Grass land	0.00	0.00	1296.00	729.36	12.42	0.00
	Settlement	0.00	138.33	298.26	0.00	236.52	40.50
	Water	0.00	182.16	1025.10	178.92	215.73	7374.60

4.4. Land Use Land Cover Dynamics between 1973 and 2018

Between these two marginal years 45 years differences of cover dynamics was seen as it can be detected from the matrix of the two years. Every 6 cover types were neither negatively nor positively shifted to the unusual cover types.

Table 10. The Matrix of the dynamics between 1973 and 2018

The matrix of the dynamics between the years of 1973 and 2018

	2018	Forest land	Shrubland	Crop land	Grass land	ettlement land	Water
1973	Forest land	4375.12	4289.03	3549.68	128.20	2652.04	813.20
	Shrubland	18.67	1445.93	9770.27	1280.17	3857.74	2226.35
	Crop land	37.34	1095.34	139409.93	4031.58	7253.28	2296.89
	Grass land	9.13	497.47	12367.34	1829.50	3042.25	1351.95
	Settlement l	120.53	760.93	2067.86	114.93	1105.50	397.68
	Water	0.41	68.25	1801.70	350.80	412.62	225.29

4.5. Change Detections between 1973 and 1995

From the analysis of this land use land cover, forest, shrub and grasslands has decreased. These decreases were forestland by 56%, shrub land by 41% grassland by 75% .The shrinkage in forest land and shrub lands are due to the highly distention in agricultural land by 63 percent between these interval periods.

This decrease of forest land spatially has also incorporated changes of topical high forestland into shrub lands which is a pointer of forest degradation for the demand cultivation land and fuel wood. The momentum at which the dynamics in forest cover and shrub land taken place was very high from 1973 to 1995. It was Grassland also shirked noticeably between 1973 and 1995, due to an expansion of agricultural land and settlements.

Table 11. Change detections between 1973 and 1995

Land use/Cover	Area/ha(1973)	Area/ha(1995)	Changes between the years	
			Area in ha	By %
Forest land	6,835.89	3,014.73	-3,821.16	-56
Shrub land	7,960.05	4,696.56	-3,263.49	-41
Crop land	21,477.83	34,924.05	+13,446.22	+63
Grass Land	8,191.05	2,028.33	-6,162.72	-75
Settlement	1,970.20	672.60	-1,297.6	-66
Water body	1,228.79	2,327.54	+1,098.75	+89
Total	47,663.81	47,663.81	0.00	

4.6. Change Detections between 1995 and 2018

The analysis indicates that the change of forests and shrub land is continuous in downward trends in these two study interval years. This means that the forest was declines by 34% and the shrub land was decreased by 25%. The cropland was also declined as unusual times in this time intervals. It was decreased a little bit by 20%. This decline of agricultural land use type in this time interval was because of unexpected increase of land use type of agriculture in the year 1995.The increment seen in the rangeland by 64% was because of the communal lands and deforested lands in the hands of government which were intruded during the transitional period was restored again in the middle years.

Table 12. Change detections between 1995 and 2018

Land use/Cover	Area/ha(1995)	Area/ha(2018)	Changes between the years	
			Area in ha	By %
Forest land	3,014.73	1,976.85	-1,037.88	-34
Shrub land	4,696.56	3,532.41	-1,164.15	-25
Crop land	34,924.05	27,768.87	-7,155.18	-20
Grass Land	2,028.33	3,326.58	+1,298.25	+64
Settlement	672.60	7,899.93	+7,227.33	+1075
Water body	2,327.54	3,159.17	+831.63	+36
Total	47,663.81	47,663.81	0.00	

4.7. Change Detections between 1973 and 2018

This analysis encompasses the land use land cover deference of 45 years of the two marginal years /1973 and 2018/which indicates the decrease of forest land, shrub land and grass land. The forest cover decreased by 71%, the shrub land declined by 56% and the grass land was diminished by 59%.The agricultural land was increased by 29% between these two marginal years. But it was extremely increased in the transitional period and by the land use land cover restoration made, it was adjusted to the current percentage of increment. The settlement was increased by 301% which was because of population increase and many settlement styles or build-ups were shifted from huts which were similar with croplands to the corrugated iron style which are easily identified during image classification made. The water body seems as if it was increased by 157% showed that the water body especially at the lower riverbanks, in many places the water body land was covered by the dense forest which their canopy cover couldn't allowed for the remote sensing satellite during the initial year of the study.

Table 13 . Change detections between 1973 and 2018

Land use/Cover	Area/ha(1973)	Area/ha(2018)	Changes between the years	
			area in ha	By %
Forest land	6,835.89	1,976.85	-4,859.04	-71
Shrub land	7,960.05	3,532.41	-4,427.64	-56
Crop land	21,477.83	27,768.87	+6,291.04	+29
Grass Land	8,191.05	3,326.58	-4,864.47	-59
Settlement	1,970.20	7,899.93	+5,929.73	+301
Water body	1,228.79	3,159.17	+1,930.38	+157
Total	47,663.81	47,663.81		

4.8. Forest and Shrubs Cover Map In 1973

The forest and the shrub land map in 1973 shows that both together covers an area of 14,795.94 ha or 31%. The deforestation and forest degradation in the area, before 1973 can be guessed from the remnants and shrub lands .Most of the shrub lands are the result of forest degradation. This means when the high forests are degraded, they notably converted to shrub lands. This is because of the need of construction woods, fuel woods and timber extraction.

1973 was the year in which reign Atse Haile Sillasse I ruled Ethiopia as emperor/1930-1974./It was historically told that the forest coverage of Ethiopia was estimated to 30%-40% at a time half of the forest land was privately owned claimed and roughly half was held by the government. There was a little government control over the forestry operations. Data of the study area also suggests that the larger areas of the forest were owned by the private landlords and the peasants. Hither the year of 1973 the land reform of 1975 was nationalised forestlands and sawmills. The result of this classification created a good opportunity in viewing the status of forestry history in the year of Emperor Haile Sillasie I.

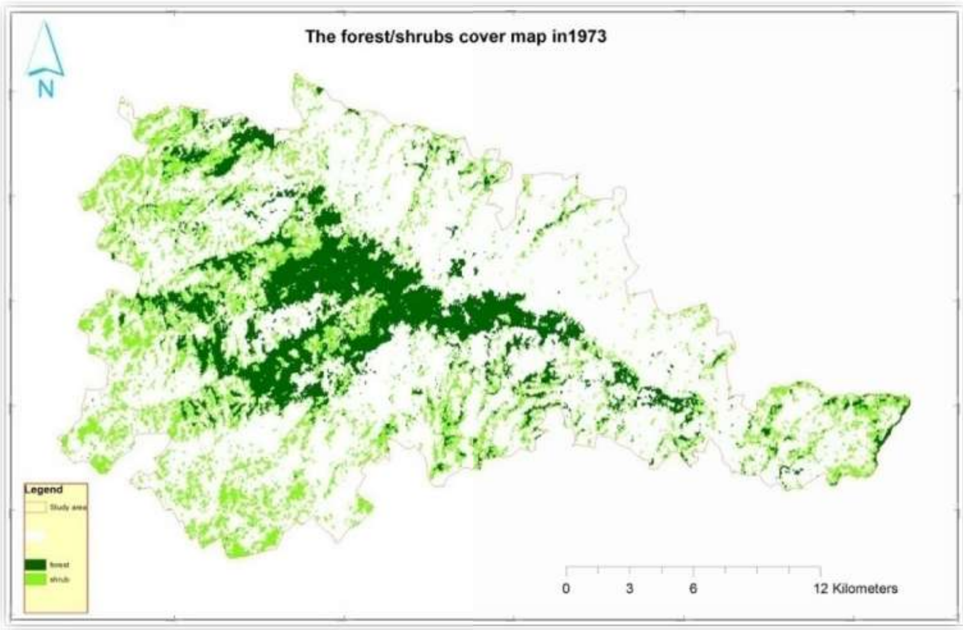


Figure 14. Forest / shrubs Cover Map in 1973

4.9. Forest / Shrubs Cover Map in 1995

In 1995 the forest coverage was 3014.73 ha or 6% and the shrub was 4696.56 ha or 10% of the total LULC of the study area. The status of forestry in the country during this year, it was a time of forest land reform of 1995 was nationalised forestlands. Temporally it was 22 years far from the first study year 1973 .This study year was totally covers and shows the status of forest and shrub lands in the country during the Derg regime and the beginning of the EPDRF.

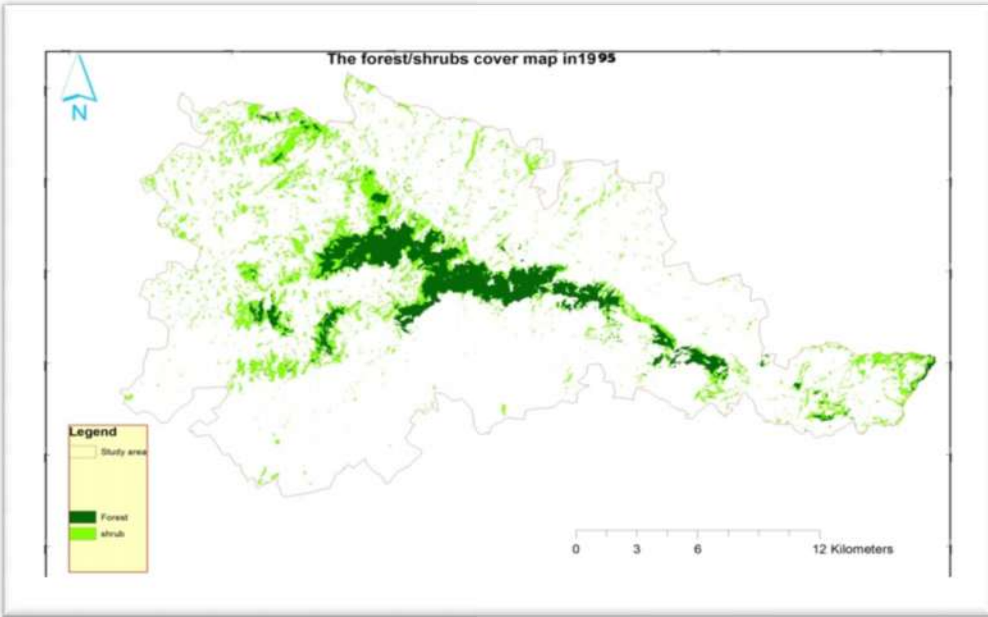


Figure 15. Forest / shrubs Cover Map in 1995

4.10. Forest / Shrubs Cover Map in 2018

This data shows the current coverage of forest and shrub of the study area which basically decreased from the formerly known fact coverage. By this forest and shrub land dynamics, forest was decreased to 1976.85 ha or 4% decreasing by 71% and shrub land to 3532.41 ha or 7% decreasing by 51 % from the initial year/1973.

The rate of deforestation and forest degradation in this time gap were a little bit decreased from the previous years. This was because of the restoration workings and legal enforcements made on the communal recourses across the years.

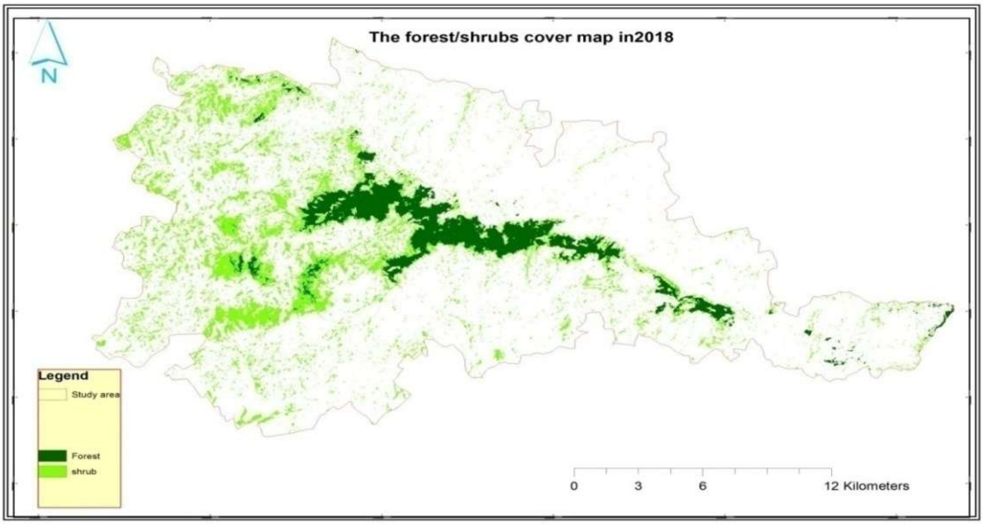


Figure 16 . Forest / shrubs Cover Map in 2018

4.11. Accuracy Assessment

The classification on the satellite imageries were assessed by the help of kappa coefficient ranged from 0.92 to 0.73 and over all accuracy of classification ranged from 97% to 94%.This accuracy assessment is acceptable because of its spot was higher than the range of restrictions 80%. The accuracy of image classification was checked and reclassified according to the land cover land use type to minimize the error of the truthiness of the assessment.

The accuracy test for the classification of land use land cover in the three sequence years are summarized in the Table.

Table 14. Accuracy assessments

	Land use Land cover	Accuracy (%)					
		1973		1995		2018	
		Producer's	User's	Producer's	User's	Producer's	User's
1	Forest land	96	96	66	85	67	86
2	Shrub land	92	100	70	87	75	86
3	Crop land	98	96	100	94	99	98
4	Grass Land	88	93	75	70	100	75
5	Settlement	75	100	50	75	88	94
6	Water body	75	100	66	100	78	88
Over all classification accuracy		96.88		93.75		96	
Over all kappa statistics		0.92		0.73		0.88	

4.12. Ecosystem Services and Values of Land Use/Land Cover Types

The ecosystem service of the study area at each study period had reduced. The services reduced for the forestland, shrub lands and grassland are recorded for the period 1973–1995, 1995–2018 and 1973–2018. The ecosystem service was greatly found with the forest and shrub lands .A global ecosystem service value estimation has been used to evaluate the land use land cover change classes.

4.12.1 The ESVs of 1973

For the seventeen ecosystem services identified by Costanza (1997), the whole land use land cover are evaluated and summarized in the table 15 which indicates that a great value was on nutrient cycling and water regulation ecosystem function. The service given by the land use /cover classes when computed, forestland and shrub land covers about the half percentage of the whole services given by the landscape.

Table 15 .ESVs of 1973

Biomes/LULC	Ecosystem serivces (1973 US$ h-1 year-1																	
	Gas Regulation	Climate Regulation	Disturbance Regulation	Water regulation	Water supply	Erosion control	Soil formation	Nutrient cycling	Waste treatment	Pollination	Biological control	Habitat/refugia	Food production	Raw materials	Genetic resorses	Recreation	Cultural	Total values per ha($ha-1 year-1)
Forest land	0	1524406	34179.5	41015.4	54687.2	1674795.5	68359	6302699.8	594723.3	0	0	0	218748.8	2153308.5	280271.9	765620.8	13671.8	13719651.3
Shrub land	0	1122367	15920.1	15920.1	23880.2	764164.8	79600.5	2873578.1	692524.35	0	15920.1	0	342282.15	1098486.9	127360.8	525363.3	15920.1	7713288.45
Crop land	0	0	42955.7	0	0	0	0	0	0	300689.76	515468.16	0	1159803.4	0	0	0	0	1975961.28
Grass Land	57337.4	0	0	24573.15	0	237540.45	8191.05	0	712621.35	204776.25	188394.15	0	548800.35	0	0	16382.1	0	1900323.6
Settlement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water body	0	0	0	6690652.7		0	0	0	817132.05	0	0	0	50379.57	0	0	282617.1	0	10442087.5
Total	57337.4	2646773	93055.3	6772161.3	78567.4	2676500.8	156151	9176277.9	2817001.1	505466.01	719782.41	0	2320014.2	3251795.4	407632.7	1589983.3	29591.9	35751312.1

4.12.2. The ESVs of 1995

The Land use land cover spatiotemporal status and the ecosystem services values in this year were decreased from the initial year 1973 except for agricultural or cropland land use class.

Table 16 .ESVs of LU/LCs in 1995

Biomes/LULC types	Ecosystem serivces (1995 US $ h-1 year-1)																	
	Gas Regulation	Climate Regulation	Disturbance Regulation	Water regulation	Water supply	Erosion control	Soil formation	Nutrient cycling	Waste treatment	Pollination	Biological control	Habitat/refugi	Food production	Raw materials	Genetic resorses	Recreation	Cultural	Total values per ha($ha-1 year-1)
Forest land	0	672284.79	15073.7	18088.4	24117.8	738608.9	30147	2779581	262281.5	0	0	0	96471.4	949640	123604	337650	6029.46	6053578
Shrub land	0	662214.96	9393.12	9393.12	14089.7	450869.8	46966	1695458	408600.7	0	9393.1	0	201952	648125	75145	309973	9393.12	4550967
Crop land	0	0	69848.1	0	0	0	0	0	0	488937	838177	0	1885899	0	0	0	0	3282861
Grass Land	14198	0	0	6084.99	0	58821.57	2028.3	0	176464.7	50708	46652	0	135898	0	0	4056.66	0	494912.5
Settlement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water body	0	0	0	6690653	2601306	0	0	0	817132.1	0	0	0	50379.6	0	0	282617	0	10442087
Total	14198	1334499.8	94314.9	6724219	2639514	1248300	79141	4475039	1664479	539645	894222	0	2370600	1597765	198749	934296	15422.6	24824405

4.12.3. The ESVs of 2018

Table 17 . ESVs of LU/LCs in 2018

Biomes/LULC ty	Ecosystem serivces (1995 US $ h-1 year-1)																	
	Gas Regulation	Climate Regulation	Disturbance Regulation	Water regulation	Water supply	Erosion control	Soil formation	Nutrient cycling	Waste treatment	Pollination	Biological control	Habitat/refu	Food production	Raw materials	Genetic resorses	Recreation	Cultural	Total values per ha($ha-1 year-1)
Forest land	-	440,837.55	9,884.25	11,861.10	15,814.80	484,328.25	19,768.50	1,822,655.70	171,985.95	-	-		63,259.20	622,707.75	81,050.85	221,407.20	3,953.70	3,967,537.95
Shrub land	-	498,069.81	7,064.82	7,064.82	10,597.23	339,111.36	35,324.10	1,275,200.01	307,319.67	-	7,064.82		151,893.63	487,472.58	56,518.56	233,139.06	7,064.82	3,422,905.29
Crop land	-	-	55,529.46	-	-	-	-	-	-	388,706.22	666,353.52		1,499,295.42	-	-	-	-	2,554,355.16
Grass Land	23,286.06	-	-	9,979.74	-	96,470.82	3,326.58	-	289,412.46	83,164.50	76,511.34		222,880.86	-	-	6,653.16	-	771,766.56
Settlement	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-
Water body	-	-	-	6,690,652.65	2,601,306.09	-	-	-	817,132.05	-	-		50,379.57	-	-	282,617.10	-	10,442,087.46
Total	23,286.06	938,907.36	72,478.53	6,719,558.31	2,627,718.12	919,910.43	58,419.18	3,097,855.71	1,585,850.13	471,870.72	749,929.68		1,987,708.68	1,110,180.33	137,569.41	743,816.52	11,018.52	21,158,652.42

The increasing trends of ESV seen with the water body are not because the increase of water body, but for the distinguishable of water body at the lower banks of the river due to deforestation occurrences. For the avoidance of ESS evaluation biasness the land cover types of water body were kept constant/equals with initial year.

When the three years trends of ESVs are perceived all the values are decreased. But the values of cropland were increased .The decrease in cropland ESV is observed in the later year.

Table 18. Total ESVs for within LULC in the years/Million US$

LU/LC	1973		1995		2018	
Forest land	$	13.72	$	6.05	$	3.97
Shrub land	$	7.71	$	4.55	$	3.42
Crop land	$	1.98	$	3.28	$	2.55
Grass Land	$	1.90	$	0.49	$	0.77
Settlement	$	-	$	-	$	-
Water body	$	10.44	$	10.44	$	10.44
Total	$	35.75	$	24.82	$	21.16

The land use land cover types of cropland was increased by 0.58 US$ million between the two edges of the study years. The trends of ESV of cropland between 1995 and 2018 a little bit (.73M$) shows a decrease because of limiting factors on agricultural activities in the meantime years. The ESV of the grassland was also increased between the years of 1995 and 2018.In the rest years the other land use land covers were decreased.

Table 19 .Degradation of Ecosystem services values

Land use/Land cover Class	ESV(US$ milloins)			ESV(US$ milloins) changes		
	1973	1995	2018	1973-1995	1995-2018	1973-2018
Forest land	$ 13.72	$ 6.05	$ 3.97	$ - (7.67)	$ - (2.09)	$ -(9.75)
Shrub land	$ 7.71	$ 4.55	$ 3.42	$ - (3.16)	$ - (1.13)	$ -(4.29)
Crop land	$ 1.98	$ 3.28	$ 2.55	$ + 1.31	$ - (0.73)	$ +0.58
Grass Land	$ 1.90	$ 0.49	$ 0.77	$ - (1.41)	$ +0.28	$ -(1.13)
Settlement	$ -	$ -	$ -	$ -	$ -	$ -
Water body	$ 10.44	$ 10.44	$ 10.44	$ -	$ -	$ -
Total	$ 35.75	$ 24.82	$ 21.16	$ - (10.93)	$ -(3.67)	$ - (14.59)

When the total status of the ecosystem service deliverance of the biome in the study area is observed and turned on between 1973 and 2018, it was decreased from 35. 75 M US $ million to 21.16 M US $ Million US$ which means a decrease of 14.59 Million $.

4.13. The Ecosystem Services Value Changes

The ecosystem services within the majority biomes /land cover land use type /are in decreasing order in some ecosystem functions as the table below. The seventeen ecosystem services identified by Costanza,(1997) all are evaluated by their spatial coverage for the individual functions of ecosystem services in the landscape of the study area. Erosion control ,Soil formation ,Nutrient cycling, Waste treatment, Pollination, Biological control, Habitat/refugea, Genetic resource, Raw materials and Food production function services of the forest and shrub were the biggest service values that decreased by 66% between the 1973 to 2018.Only the biological control over the ecosystem function was increased a little/by 4% across the years.

It shows that there is a change of ESV across the years in the increasing and decreasing orders. Negative signs are ecosystem services functions in the decreasing order while the +ve signs are ESVf in increasing order. The following table 20 shows the detail.

Table 20. The values of Ecosystem service functions

S. N	ESV functions	ESVf-of 1973	ESVf-of 1995	ESVf-of 2018	ESVf of 1973 /1995		ESVf of 1995/2018		ESVf of 1973/2018	
					Changes b/n the yrs	Changes in %	Changes b/n the yrs	Changes in %	Changes b/n the yrs	Changes in %
1	Gas regulation	0.057	0.014	0.023	-0.043	-75	+0.009	+64%	-0.034	-59
2	Climate regulation	2.647	1.334	0.939	-1.312	-50	-0.396	-30	-1.708	-65
3	Disturbance Regulation	0.093	0.094	0.072	+0.001	+1	-0.022	-23	-0.021	-22
4	Water regulation	6.772	6.724	6.720	-0.048	-1	-0.005	0	-0.053	-1
5	Water supply	2.680	2.640	2.628	-0.040	-2	-0.012	0	-0.052	-2
6	Erosion control	2.676	1.248	0.920	-1.428	-53	-0.328	-26	-1.757	-66
7	Soil formation	0.156	0.079	0.058	-0.077	-49	-0.021	-26	-0.098	-63
8	Nutrient cycling	9.176	4.475	3.098	-4.701	-51	-1.377	-31	-6.078	-66
9	Waste treatment	2.817	1.664	1.586	-1.153	-41	-0.079	-5	-1.231	-44
10	Pollination	0.505	0.540	0.472	+0.034	+7	-0.068	-13	-0.034	-7
11	Biological control	0.720	0.894	0.750	+0.174	+24	-0.144	-16	+0.030	+4
12	Habitat/refugea	0	0	0	0	0	0	0	0	0
13	Food production	2.320	2.371	1.988	+0.051	+2	-0.383	-16	-0.332	-14
14	Raw material	3.252	1.598	1.110	-1.654	-51	-0.488	-31	-2.142	-66
15	Genetic resource	0.408	0.199	0.138	-0.209	-51	-0.061	-31	-0.270	-66
16	Recreation	1.590	0.934	0.744	-0.656	-41	-0.190	-20	-0.846	-53
17	Cultural	0.030	0.015	0.011	-0.014	-48	-0.004	-29	-0.019	-63

4.14. Forest Cover dynamics and the Ecosystem services.

The analysis made by GIS techniques showed that the forest and shrub cover were in decreasing order additionally the analysis of services in the biome also in the decreasing order.

The forest and shrub land had great values among the land use /land covers. The total values differences between 1973 and 2018 /45 years is 15.14 million $ /70%.The nutrient cycling, function services of the forest and shrub was the biggest service values that decreased from 9.18Mil. to 3.10Mil $. /by 66% between the 1973 to 2018.

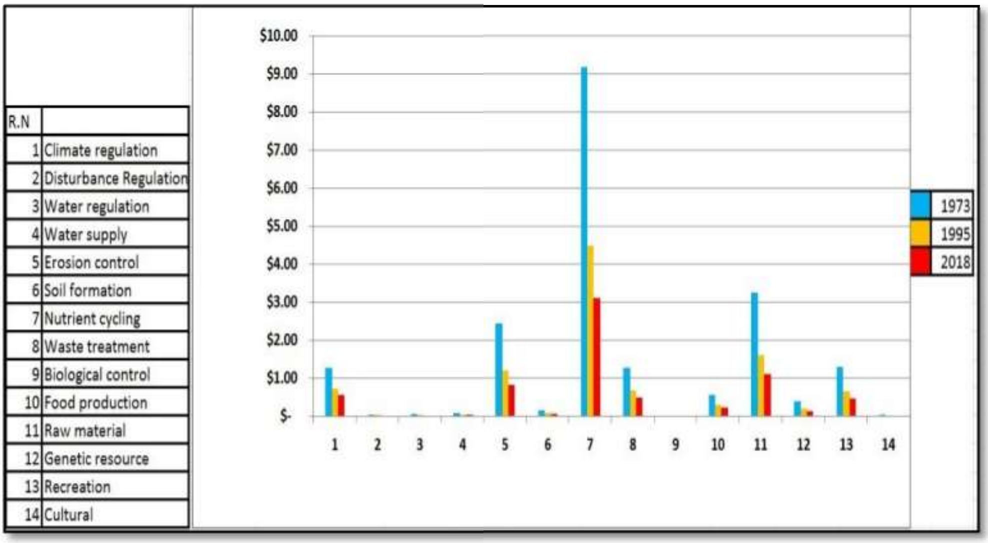
Table 21 . Forest and shrub lands and their ESVs in the years

SN	ESSV functions	1973	1995	2018
1	Climate regulation	$ 1.28	$ 0.73	$ 0.54
2	Disturbance Regulation	$ 0.05	$ 0.02	$ 0.02
3	Water regulation	$ 0.06	$ 0.03	$ 0.02
4	Water supply	$ 0.08	$ 0.04	$ 0.03
5	Erosion control	$ 2.44	$ 1.19	$ 0.82
6	Soil formation	$ 0.15	$ 0.08	$ 0.06
7	Nutrient cycling	$ 9.18	$ 4.48	$ 3.10
8	Waste treatment	$ 1.29	$ 0.67	$ 0.48
9	Biological control	$ 0.02	$ 0.01	$ 0.01
10	Food production	$ 0.56	$ 0.30	$ 0.22
11	Raw material	$ 3.25	$ 1.60	$ 1.11
12	Genetic resource	$ 0.41	$ 0.20	$ 0.14
13	Recreation	$ 1.29	$ 0.65	$ 0.45
14	Cultural	$ 0.03	$ 0.02	$ 0.01
Total		$ 21.53	$ 10.60	$ 6.39

Among the seventeen ESs that identified by Robert Costanza,(1997), the study areas shrub land had fourteen and the forest land had thirteen ESVs. These service values were deteriorated between the years of study /1973 to 2018/from 21.53 m.$ to 6.39 mil. $.,a loss of 15.14 mil.$.

Some the functions of the Ecosystem services of forest and shrubs are in threatening. The graph shows the disturbance regulation, water supply, biological control and soil formation services and functions of forest were in failing order.

Table 22.The trends of the ESV functions



4.15. Socioeconomic Data

The socio economic data of the respondents of the study area regarding: age, sex, religions, household families mean household and education.

The respondents of the study area have a mixture of ages that includes; Youth (from 18-30 years old), middle age (from 30-64 years old), and the elder (above years 64 old). The age category of the respondents is 69% elders, 16% middle age and 15% the youth groups. The sex ratio of the respondents is male 75% and female 25%. The religious status of the respondents are 97% are Christians/ both orthodoxies and Protestants/

The respondents were selected deliberately to extract the forest data history both in the past years and the currently by comparing together. This is only possible by including the elders greater than 65 or 70 years. Their totals were 69% of the whole respondents which covers the greater component.

Table 23. Attribute of the respondents in the study area

SN	Attribute	Unit	Amount	Percentage
1	Total number of respondents	№	126	100%
2	Male respondents	№	95	75%
3	Female respondents	№	31	25%
4	Mean household numbers	№	7	
5	Living strategy	№		
5.1	Farming and animal husbandry	№	121	96%
5.2	Trade	№	3	2%
5.3	Animal husbandry	№	0	0%
5.4	Government employee/Retire	№	1	1%
5.5	Laborers	№	1	1%
6	Mean land holding size	ha	0.95	
8	Religious			
8.1	Orthodox Christian	№	40	60
8.2	Protestant Christians	№	32	48
8.3	Muslim	№	8	12
8.4	Wakefeta	№	3	4
8.5	Others	№	1	2

4.16. Perceptions of the Respondents

The respondents have showed their reflections towards the significance and use of forest in their livelihood activities and daily life sustaining. 96% of the respondents were replied that their daily activity have a coupled with forests and green shrubberies .Their perceptions towards the significance of forest is focused on the provisioning services like food, fuel and fiber than the cultural and regulating services. The 99% of the respondents have explicated that they give the prioritization for agricultural activity rather than to preserve and plant trees on their land occupancy. The terrain of forestland is so appropriate for agricultural productivity to increase they prefer it to cultivate. Their answer towards the question of the driver behind the deforestation was that the human beings rather than other agents.

Figure 17. Agricultural expansion and deforestation

4.17. Forest Cover Changes over the Years

The elderly and some other groups 94 % have justified that the forest today and hindmost are by far differ both in coverage and species diversity. But the rest of the respondents/6% have replied that the change of forest towards the increasing order than the before because of tree plantations by private farmers and the Oromia Forest and wildlife enterprise. Regarding the status of wild animals and tree species in the study area, 69% have replied that there were species lost and 31% have disagreed.48% of the respondents have confirmed that the basis behind deforestation an expansion of agricultural activity that caused the soil productiveness loss and hunt for productive or loam soil in forest land. The subsequent quantity of the respondents 46% are agreeing with the all factors of deforestation and forest degradation: agriculture, logging, firewood and construction purposes.

Focal group discussions held with the respondents and expertise from the woreda expertise indicates that the forest in the three woredas is categorized in to three according to their proprietor or running body.
These are private forests that are growing on an individual farmland, the patched forests that are found on the communal lands and the governments forest that are managed by the governmental enterprise; OFWE.

Regarding the volume of their rivers and streams the 99% of the respondents were replied that the volume was decreased because of the expansion of desert and warms behind deforestation and forest degradation. But the satellite image classification analysis indicated that the water body has shown a little increment. But the GPS control points data has confirmed the answers of the respondents; and the key informants' data were to generalize the analysis on that the satellite image of the old years has detected the area of water bodies' were covered by tree canopy and now days it has been cleaned and the water body could be detected from the space. It does not mean an increase in water boy, rather a deforestation impact on riverside trees along the river banks.
Forest cover changes by Agricultural activities and firewood/charcoal production are among such essential conversion forces. The farmers are currently alarmingly converting the forest land into plots of farmlands in order to increase their crop output and cope with the problems of food shortfalls. The private owned forests and trees found on the farmlands of farmers are not managed well but converted into charcoals and timbres. The community forest and shrub lands are also highly in devastating rate that explains the tragedy of communal. Some rural households are increasingly engaged in charcoal preparation and firewood extraction as money-spinning

occupation strategies. Those economically disadvantaged communities are greatly dependent on forest products that are illegally produced sale to fulfill the livelihood requirements of their family.

Table 24. Interview results from Respondents

SN	Questions		%
1	Deforestation and degradation		94%
2	Afforest ton /increasing of forest		6%
3	The Causes agents of deforestation are human		99%
3.1	The Causes of deforestation is by nature		1%
3.2	Causes of deforestation any other agents		0%
3.3	Purpose do people clear forest for		
		For expansion of agricultural land and fertile soil in forest land	48%
		Because of illegal resettlement	2%
		Logging	0%
		Fire wood	1%
		Construction purpose	3%
		Due to all of the above	46%
4	Tree and animal species eradication or lost?		
		Yes	69%
		No	31%
5	The alternative uses		
6	Fertilizer and supply improved variety seed supply by government or NGOs		
		Yes	54%
		no	46%
7	Work done on conservation and soil fertility		
		Yes	80%
		No	20%
8	Their drinking water source and the forest have a relation		
		Have a relation	89%
		Have not a relation	11%
9	The volume of water increases		1%
10	The volume of water decreases		99%

The combined effect of these factors certainly results in rapid conversion and/or modification of the district of forest cover. 100% of the respondents were bear out that he Many species of trees specially the species for their medication purpose uses were eradicated and the wild animals they used as optional daily food in hazarded events now days they are eradicated. Because of this minimizes in quantity / in number and in diversity loss many services they were getting from the forest and its products are minimized and the majority inordinate amount are stopped totally.

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

The results of this study provided an analysis of spatiotemporal dynamics of forest cover and associated ecosystem services in Gedo forest between the years of 1973 and 2018. The organization of data from the remote sensing satellite and ground based revealed a total forest cover loss of almost 4,859.04 ha between the years 1973 and 2018, which represents almost 71% of its cover. The ecosystem services lost with the deforestation, forest degradation and the land use land cover changes as the total between these two years /1973 and 2018, was 14.59 million US$.

The outcomes of the time series analysis presented an extreme increase in land use land cover changes between the land use types and thus the ecosystem services values between the land use types are significantly diminished between the years of 1973-1995, 1995-2018 and 1973-2018. According to local farmer respondents, and some a discussion held with key informants, the deforestation and forest degradation from time to time is in an increasing order and thus shifting trends has brought a great loss of ecosystem services.

According to the 126 households interviewed, forest cover dynamics at the farm level is related to the agricultural activities which are the main economic and livelihood activity of the communities of an area. The dependency level of the community on forest products and the productive soil in the forest land was some reasons pointed out by the community near the forest.

5.2. Recommendations

To care for further depletion of forest resources that brings the loss of forest ecosystem services in the study area;

- ✓ Creating awareness among the society regarding to optimum utilization of the forest recourses and conservation systems by concerned bodies could play significant role in rehabilitation and minimizing of environmental degradation.
- ✓ It is important to build up a local communities' power in managing and protecting forest resources, so as to enhance the roles of forests in improving the livelihood of farmers and to increase the ecosystem services from forests.
- ✓ Sustainable land management should be based on the participation of local people that recognizes and protects the traditional land management knowledge.
- ✓ Afforestation and reforestation of trees are recommended specially on the shrubby lands possessed by government.
- ✓ Further studies are required on the Ethiopian land use system and its impact on the ecosystem services.

REFERENCES

Admassie, Y. (2000). Twenty years to nowhere: property rights, land management and conservation in Ethiopia Red Sea Pr.

Abate, A., & Lemenih, M. (2014). Detecting and quantifying land use/land cover dynamics in Nadda

Asendabo Watershed, South Western Ethiopia. *International Journal of Environmental Sciences*, *3*(1), 45-50.

Abdullah, A. A., & Wan, H. L. (2013). Relationships of non-monetary incentives, job satisfaction and employee job performance. *International Review of Management and Business Research*, *2*(4), 1085.

Agricultural and rural development office of Bako Tibe woreda,(2018)

Agricultural and rural development office of Chelia woreda,(2018)

Agricultural and rural development office of Eli Gelan woreda,(2018)

Anonymous, 2010. Global Forest Resources Assessment, 2010-Main Report. FAO Forestry

Anonymous,2001. Global Forest Resources Assessment 2000-Main Report. FAO Forestry Paper 140. Rome, Italy.

Anonymous.1990. The Forest Resources of the Temperate Zones, Vol. II. FAO, Rome.

Appiah, M., Blay, D., Damnyag, L., Dwomoh, F. K., Pappinen, A., &Luukkanen, O. (2009).Dependence on forest resources and tropical deforestation in Ghana. *Environment, Development and Sustainability*, *11*(3), 471-487.

Asefa, E., & Hans-Rudolf, B. (2016). Farmers' perception of land degradation and traditional knowledge in Southern Ethiopia—resilience and stability. *Land Degradation &*

Development, *27*(6)1552-1561.

Billington, C., Kapos, V., Edwards, M.S., Blyth, S. and Iremonger, S. (1996) Estimated Original Forest Cover Map a First Attempt. WCMC, Cambridge.

Birhanu, A. (2014). Environmental degradation and management in Ethiopian highlands: Review of lessons learned. *International Journal of Environmental Protection and Policy*,*2*(1), 24-34.

Birhanuk.,TeshomeS.and Ensermu K. (2014) Structure and Regeneration Status of Gedo Dry Evergreen Montane Forest, West Shewa Zone of Oromia National Regional State, Central Ethiopia.

Birhanu Kebede,Barakat, B., Bengtsson, S., Muttarak, R., E., Crespo Cuaresma,J., Samir, K. C.,& Stressing. (2016). Education & the Sustainable Development Goals.

Blasco, F., Aizpuru, M., & Gers, C. (2001). Depletion of the mangroves of Continental Asia. *Wetlands Ecology and Management*, *9*(3), 255-266

Bouwman, A. F. (1990). Global distribution of the major soils and land cover types. *Soils and the greenhouse effect*, 33-59.

Boyle, K.J.; Kuminoff, N.V.; Parmeter, C.F.; Pope, J.C. 2010. The benefit-transfer challenges. Annual Review of Resource Economics. 2(1): 161-182

Braat, L.C., de Groot, R., 2012. The ecosystem services agenda: bridging the worlds of natural science and economics, conservation and development, and public and private policy. Ecosystem. Serv. 1 (1), 4–15.

Brown, K., Pearce, D., & Weiss, J. (1994). The economic value of non-market benefits of tropical forests: carbon storage.

Burkhard, B., Kroll, F., Nedkov, S., Müller, F., 2012. Mapping ecosystem service supply, demand and budgets. Ecol. Indic. 21, 17–29.

Cablk, M. E., Sagebiel, J. C., Heaton, J. S., & Valentin, C. (2008). Olfaction-based detection distance: a quantitative analysis of how far away dogs recognize tortoise odor and follow it to source. *Sensors 8*(4), 2208-2222.

Chaisson, E.J., 2002. Cosmic Evolution: The Rise of Complexity in Nature. Harvard University Press, Cambridge, MA

Chakravarty, S., Ghosh, S. K., Suresh, C. P., Dey, A. N., & Shukla, G. (2012). Deforestation: causes, effects and control strategies. In *Global perspectives on sustainable forest management*. InTech.

Chazdon, R. L. (2008). Beyond Deforestation: Restoring Forests and Ecosystem Services on Degraded Lands. Science, 320(5882), 1458–1460. doi:10.1126/science.1155365

Chazdon, R. L., Brancalion, P. H., Laestadius, L., Bennett-Curry, A., Buckingham, K., Kumar, C. & Wilson,S. J. (2016). When is a forest a forest? Forest concepts and definitions in the era of forest and landscape restoration. *Ambio*, *45*(5), 538-550.

Chhabra, A.,Geist, H., Houghton, R. 2006. Multiple Impacts of Land-use/Cover Change, Land-use and Land-cover Change. Springer, pp. 71–116.

Chris Lang. (2010) How FAO helps greenwash the timber industry's greenhouse gas emissions

Costanza, R., &Kubiszewski,I.(2012).The authorship structure of "ecosystem services"as a trans disciplinary field of scholarship. *Ecosystem Services*.

Costanza, R., 2006. Nature: ecosystems without co modifying them. Nature 443, 749.

Costanza, R., d'Arge, R., De Groot, R., Farber, S., Grasso, M., Hannon, B., ... & Raskin, R. G. (1997).The value of the world's ecosystem services and natural capital. *nature*, *387*(6630), 253.

Costanza, R., de Groot, R., Braat, L., Kubiszewski, I., Fioramonti, L., Sutton, P., ... & Grasso, M. (2017).Twenty years of ecosystem services: how far have we come and how far do we still need to go?. *Ecosystem Services*, *28*, 1-16.

Costanza, R., de Groot, R., Sutton, P., Van der Ploeg, S., Anderson, S. J., Kubiszewski, I., & Turner, R. K.(2014). Changes in the global value of ecosystem services. *Global environmental change*, *26*,152-158.(2014). Changes in the global value of ecosystem services. *Global environmental change*, *26*, 152-158.

Costanza, Robert, Lisa Graumlich, Will Steffen, Carole Crumley, John Dearing, Kathy Hibbard, Rik Leemans, Charles Redman, and David Schimel. "Sustainability or collapse: what can we learn from integrating the history of humans and the rest of nature?." *AMBIO: A Journal of the Human Environment*36, no. 7 (2007): 522-527.

Costanza, Robert. 1997. The Value of the World's Ecosystem Services and Natural Capital. *Nature, Vol.387.*

Costanza, Robert. 2006. The Value of New Jersey's Ecosystem Services and Natural Capital *Gund Institute for Ecological Economics.*

Burlington, VT.

Cunningham, W.P. and Saigo, B.W. (1995). Environmental Science. A Global Concern. Wm.C. Brown .USA. pp. 611

Daily, G. C., Matson, P. A., &Vitousek, P. M. (1997). Ecosystem services supplied by soil. *Nature's services: societal dependence on natural ecosystems*, 113-132.

Daily, G.C.(ed.) (1997).

Dale, V. H., & Beyeler, S. C. (2001). Challenges in the development and use of ecological indicators. *Ecological indicators*, *1*(1), 3-10.

Dale, V. H., Joyce, L. A., McNulty, S., Neilson, R. P., Ayres, M. P., Flannigan, M. D.Sameroff, D.(2001). Climate change and forest disturbances: climate change can affect forests by altering the frequency, intensity, duration, and timing of fire, drought, introduced species, insect and pathogen outbreaks, hurricanes, windstorms, ice storms, or landslides. *AIBS Bulletin*, *51*(9), 723-734.

D Khoi,Y Muyarama-Remote sensing,2010-mdpi.com

De Groot, J. F., & Takin, T. (2011). The Ecosystem services.

De Groot, R. S. (1987). Environmental functions as a unifying concept for ecology and economics. *Environmentalist*, *7*(2), 105-109.

De Groot, R. S., Alkemade, R., Braat, L., Hein, L., & Willemen, L. (2010). Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. *Ecological complexity*, *7*(3), 260-272.

De Groot, R., Brander, L., Van Der Ploeg, S., Costanza, R., Bernard, F., Braat,L., . & Hussain, S. (2012).

Global estimates of the value of ecosystems and their services in monetary units. *Ecosystem services*,*1*(1), 50-61.

De Groot, R.S., 1992. Functions of nature: evaluation of nature in environmental planning, management and decision making. Wolters-Noord Hoff, Groningen.

De Groot, R.S., Alkemade, R., Braat, L.C., Hein, L., Willemen, L., 2010. Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. Ecol. Complex. 7 (3), 260–272.

DeFries, Ruth S., Díaz, Sandra, Dietz, Thomas, et al., 2009. Science for managing ecosystem services: beyond the Millennium Ecosystem Assessment. Proc. Natl. Acad. Sci. U.S.A. 106 (5), 1305–1312.

Dotterweich, M. (2013). The history of human-induced soil erosion: Geomorphic legacies, early descriptions and research, and the development of soil conservation A global synopsis. *Geomorphology*, *20.*

Duke, N.C., Meynecke, J.-O., Dittmann, S., Ellison, A.M., Anger, K., Berger, U., Cannicci, S., Diele, K., Ewel, K.C., Field, C.D.,Koedam, N., Lee, S.Y., Marchand, C., Nordhaus, I. & Dahdouh-Guebas, F.(2007) A world without mangroves? Science, 317, 5834, 41 42.

E. M. Authority (1996). Ethiopia

EARO (Ethiopian Agricultural Research Organization) (1999). Dry land Agriculture Research: Pastoral and Argo-pastoral research

Ecosystems and Human Well-being: Synthesis. 2005. *United Nations Millennium Ecosystem Assessment.* Island Press, Washington, DC

Ehrlich, P., & Ehrlich, A. (1981). Extinction: the causes and consequences of the disappearance of species.

Ehrlich, P.R., Mooney, H.M., 1983. Extinction, Substitution, and Ecosystem Services. Bioscience 33, 248–254

Emmott, S. (2013). Humans: the real threat to life on Earth. *The Guardian*, *13*.

Endalew Amenu (2007). Use and management of medicinal plants by indigenous people of Ejaji area CheliyaWoreda) West Shoa, Ethiopia: an ethnobotanical approach. M.Sc. Thesis, Addis Ababa University, Addis Ababa.

Ericksen, P., De Leeuw, J., Said, M., Silvestri, S., Zaibet, L., 2012. Mapping ecosystem services in the Ewaso Ng'irocatchment.Int.J. Biodivers. Sci. Ecosystem Serv. Manage. 8 (1–2), 122–134.

Ethiopia, C. S. A. (2008). Summary and statistical report of the 2007 population and housing census. *AddisAbaba, Ethiopia: Federal democratic republic of Ethiopia population census commission*, 1-10.

Ethiopian Forestry Action Program .EFAP(1993)

FAO FRA report, 2015: Global Forest Resources Assessment 2015.

FAO FRA report,2010; Global Forest Resources Assessment 2010.

Feyissa, T., Nybom, H., Bartish, I. V., & Welander, M. (2007). Analysis of genetic diversity in the endangered tropical tree species Hagenia abyssinica using ISSR markers. Genetic Resources and Crop Evolution, 54(5), 947-958.

Fisher, B., Turner, R.K., Morling, P., 2009. Defining and classifying ecosystem services for decision making. Ecol. Econ. 68 (3), 643–653

Fisher,B.,Turner,R.K.,2008.Ecosystemservices:classificationforvaluation.Biol.Conserv.141,1167–1169.

Geist H., Lambin E., 2002. Proximate causes and underlying driving forces of tropical deforestation.BioScience52: 143–150.

Gilman, E. L., Ellison, J., Duke, N. C., & Field, C. (2008). Threats to mangroves from climate change and adaptation options: a review. *Aquatic botany*, *89*(2), 237-250.

Giri, C., Ochieng, E., Tieszen, L. L., Zhu, Z., Singh, A., Loveland, T., & Duke, N. (2011). Status and

distribution of mangrove forests of the world using earth observation satellite data. *Global Ecology and Biogeography*, *20*(1), 154-159.

Giri, C., Zhu, Z., Tieszen, L.L., Singh, A., Gillette, S. & Kelmelis, J.A. (2008) Mangrove forest distributions and dynamics (1975–2005) of the tsunami-affected region of Asia. Journal of Biogeography, 35, 519–528.

He, H.S., Larsen, D.R., Mladenoff, D.J., 2002a. Exploring component-based approaches in forest landscape modelling. Environ. Model. Software 17, 519–529.

Hosonuma N., Herold M., De Sy V., De Fries R.S., Brockhaus M., Verchot L., Angelsen A., Romijn E., 2012.An assessment of deforestation and forest degradation drivers in developing countries. Environmental Research Letters, in review.

Hu, H., Liu, W., & Cao, M. (2007). Impact of land use and land cover changes on ecosystem services in Menglun, Xishuangbanna Southwest China. Environmental Monitoring and Assessment, 146(1-3), 147–156. doi:10.1007/s10661-007-

0067-7

Huang, D.-L., Zeng, G.-M., Feng, C.-L., Hu, S., Jiang, X.-Y., Tang, L., Su, F.-F., Zhang, Y., Zeng, W., Liu, H.-L., 2008.

Hurni, H. (2007). Challenges for sustainable rural development in Ethiopia International Change, I. C. (2007). Mitigation of climate change. *Summary for Policymakers*, *10*(5.4).

IPCC, 2007: Summary for Policymakers. In, D., Chen, Z., Averyt, K. B., Miller, H. L., Solomon's., Manning, M., &Tignor, M. (2007).

Kebede, B. (2010). Floristic Composition and Structural Analysis of Gedo Dry Evergreen Montane Forest, West Shewa Zone of Oromia National Regional State Central Ethiopia. Unpublished M. Sc thesis, Addis Ababa University, Addis Ababa.

Kebede, B., Soromessa, T., &Kelbessa, E. (2014). Structure and regeneration status of Gedo dry evergreen montane forest, West Shewa Zone of Oromia national regional State, central Ethiopia. *Science, technology and Arts Research journal*, *3*(2), 119-131.

Kefiyalew S.Dec,2016 ,Dar Es salaam contents of the presentation.(2016)Overview of forest management and climate change in Ethiopia.

Kindu, M., Schneider, T., Teketay, D., &Knoke, T. (2016). Changes of ecosystem service values in response to land use/land cover dynamics in Munessa–Shashemene landscape of the Ethiopian highlands. *Science of The Total Environment*, *547*, 137-147.

King, D. M., Mazzotta, M. J. 2000. Valuation of Ecosystem Services. *US Department of Agriculture Natural Resources Conservation*

Service.

Konarska, K. M., Sutton, P. C., & Castellon, M. (2002). Evaluating scale dependence of ecosystem service valuation: a comparisonof NOAA-AVHRR and Landsat TM datasets. *Ecological economics*, *41*(3), 491-507.

Kreuter, U.P., Harris, H.G., Matlock, M.D., Lacey, R.E., 2001. Change in ecosystem service values in the San Antonio area,Texas. Ecol. Econ. 39, 333–346.

La Mela Veca, D. S., Cullotta, S., Sferlazza, S., &Maetzke, F. G. (2016). Anthropogenic influences in land use/land cover changes in Mediterranean forest landscapes in Sicily. *Land*, *5*(1), 3.

Labiosa, W.,Forney, W.M., Esnard, A.-M., Mitsova-Boneva, D., Bernknopf, R., Hearn, P., Hogan, D.,Pearlstine, L., Strong, D., Lambin, E. F., Turner, B. L., Geist, H. J., Agbola, S. B., Angelsen, A., Bruce, J. W., ... & George, P. (2001).Southwest China. Environmental Monitoring and Assessment,146(1-3), 147–156. doi:10.1007/s10661-007-0067-7

Lambin, E. F. & Veldkamp, A., (2001). Predicting land-use change.

Lambin, E. F., Turner, B. L., Geist, H. J., Agbola, S. B., Angelsen, A., Bruce, J. W., ... & George, P. (2001). The causes of land-use and land-cover change: moving beyond the myths. *Global environmental change*, *11*(4), 261-269.

Landuyt, D., Broekx, S., Engelen, G., Uljee, I., Van der Meulen, M., Goethals, P.L.M., 2016.

Leach, M,& Scoones, I.(Eds.).(2015). *Carbon conflicts and forest landscapes in Africa*. Rout ledge.

Liu, B. (2010). Uncertain risk analysis and uncertain reliability analysis. *Journal of Uncertain Systems*,*4*(3), 163-170.

Liu, Y., Yang, S., Chen, J., 2012. Modeling environmental impacts of urban expansion: a systematic method for dealing with un certainties. Environ. Sci. Technol. 46,8236–8243.

Lofgren, O.(2003). The new economy: a cultural history. *Global Networks*, *3*(3), 239-254

M. E. Assessment, (2005). Ecosystems and human well-being: global assessment reports.

MA (Millennium Ecosystem Assessment) (2005) Mille ecosystems and human well-being: synthesis. Island Press, Washington, DC.

Mace, G.M., Bateman, I., Albon, S., Balmford, A., Brown, C., Church, A., Haines-Young, R., Pretty, J.N.,Turner, K.,Vira, B. And Winn, J. (2011).

Malhi, Y., & Grace, J. (2000). Tropical forests and atmospheric carbon dioxide. *Trends in Ecology & Evolution*, *15*(8), 332-337.

Mamo, G., Sjaastad, E., &Vedeld, P. (2007). Economic dependence on forest resources: A case from Dendi District, Ethiopia *Forest Policy and Economics*, *9*(8), 916-927

Mark A. Cochrane (2013) introduction to a.m.a. Abbeville's article ′

Melaku, Y. (2003). Assessment of irrigation potential using GIS (geographic information system) and RS (remote sensing) for strategic planning case study of Raxo dam area (Portugal) (Doctoral dissertation, MSc thesis, Enscheda, The Netherlands).

Meshesha, D.T., Tsunekawa, A., Tsubo, M., Ali, S.A., Haregeweyn, N., 2014. Land-use change Carpenter, Stephen R., Mooney, Harold A., Agard, John, Capistrano, Doris

Meshesha, T. W., Tripathi, S. K., &Khare, D. (2016). Analyses of land use and land cover change dynamics using GIS and remote sensing during 1984 and 2015 in the Beressa Watershed Northern Central Highland of Ethiopia. *Modeling Earth Systems and Environment*, *2*(4), 168.

Mezgebu, A., & Workineh, G. (2017). Changes and drivers of afro-alpine forest ecosystem: future trajectories and management strategies in Bale eco-region, Ethiopia. Ecological Processes, 6(1), 42.

Mladenoff, D. J. & Scheller, R. M., (2005). A spatially interactive simulation of climate change, harvesting,wind, and tree species migration and projected changes to forest composition and biomass in northern Wisconsin, USA. *Global Change Biology*, *11*(2), 307-321.

Mooney, H. A., & Medina, E. Bullock, S. H., Bullock, S. H., (Eds.). (1995). *Seasonally dry tropical forests*. Cambridge University Press.

Motivans, E., Kuehn, R., & Geist, J. Stoeckle, B. C., Beggel, S., Cerwenka, A. F (2017). A systematic approach to evaluate the influence of environmental conditions on eDNA detection success in aquatic ecosystems. *PloS one*, *12*(12), e0189119.

Müller, F., & Burkhard, B. (2012). The indicator side of ecosystem services. *Ecosystem Services*, *1*(1), 26-30.

Myers, N.(1993).Tropical forests: the main deforestation fronts. *Environmental conservation*, *20*(1), 9-16.

Odum, H. T. (1971). *Environment, power and society*. New York, USA, Wiley-Inter science.

Oromia Forest and Wildlife Enterprise/ OFWE/ report of 2018

Othow, O. O., Gebre, S. L., & Gemeda, D. O. (2017). Analyzing the Rate of Land Use and Land Cover Change and Determining the Causes of Forest Cover Change in Gog District, Gambella Regional State, Ethiopia. *J Remote Sensing & GIS*, *6*(218).

Oumer, N. W. (2009). Development of wireless control system for a spherical robot.

Panayotou, T. & Phantumvanit, D., (1990). Industrialization and environmental quality: paying the price.

Polasky, S., Nelson, E., Pennington, D., Johnson, K.A., 2011. The impact of land-use change on ecosystem services, biodiversity and returns to landowners: a case study in the state of Minnesota. Env.Res. Econ. 48, 219–242.

Reid, R.S., Kruska, R.L., Muthui, N., Taye, A., Wotton, S.,Wilson, C.J., Mulatu, W., 2000.Land-use andland-cover dynamics in response to changes in climatic, biological and socio-political forces: the case of southwestern Ethiopia. Land sc. Ecol. 15, 339

Reis, S. (2008). Analyzing land use/land cover changes using remote sensing and GIS in Rize, North-East Turkey. *Sensors*, *8*(10), 6188-6202

Reusing, M. (2000). Change detection of natural high forests in Ethiopia using remote sensing and GIS techniques. *International archives of photogrammetric and remote sensing*, *33*(B7/3; PART 7), 1253-1258.

Righelato, R., &Spracklen, D. V. (2007). Carbon mitigation by bio fuels or by saving and restoring forests? *Science*, *317*(5840), 902-902.

Rimal, B. (2011). Application Of Remote Sensing And Gis, Land Use/Land

Cover Change In Kathmandu Metropolitan City, Nepal.*Journal Of Theoretical & Applied Information Technology*, *23*(2).

Robert N. Wunder, S., & Campos, J. J. (2002). *Forest ecosystem services: can they pay our way out of deforestation?*

Robin L. Chazdon, Pedro H. S. Brancalion, Lars Laestadius,Aoife Bennett-Curry, Kathleen Buckingham, Chetan Kumar, Julian Moll-Rock, Ima Ce´lia Guimaraes Vieira, Sarah Jane Wilson When is a forest a forest? Forest concepts and definitions in the era of forest and landscape restoration Ambio 2016,45:538–550 DOI 10.1007/s13280-016-0772.

Rowe, R.; Sharma, N. P. and Bowder, J. 1992. Deforestation: problems, causes and concern.In: Managing the world's forest: looking for balance between conservation and development, ed. Sharma, N. P.Pp 33-46. Kendall/Hunt Publishing Company, Iowa.

Sagie, H., Morris, A., Rofe`, Y., Orenstein, D.E., Groner, E., 2013. Cross-cultural perceptions of ecosystem services: a social inquiry on both sides of the Israeli-Jordanian border of the Southern Arava Valley Desert. J. Arid Environ. 97, 38–48.

Sahin, V., & Hall, M. J. (1996). The effects of afforestation and deforestation on water yields. *Journal of hydrology*, *178*(1-4), 293-309.

Sampson, R. J., McAdam, D., MacIndoe, H., &Weffer- Elizondo, S. (2005). Civil society reconsidered: The durable nature and community structure of collective civic action. *American journal of sociology*, *111*(3), 673-714.

Sasaki, N., & Putz, F. E. (2009). Critical need for new definitions of "forest" and "forest degradation" in global climate change agreements. *Conservation Letters*, *2*(5), 226-232.

Schägner, J. P., Brander, L., Maes, J., &Hartje, V. (2013). Mapping ecosystem services' values: Current practice and future prospects. *Ecosystem Services*, *4*, 33-46.

Semaw, S., 2000. The World's oldest stone artifacts' from Gona, Ethiopia: their implications for understanding stone technology and patterns of human evolution between 2_6–1_5 million years ago. J. Archaeol. Sci. 27 (12), 1197–1214.

Sewerniak, P., Jankowski, M., & Dąbrowski, M. (2017). Effect of topography and deforestation on regular variation of soils on inland dunes in the Toruń Basin (N Poland). *Catena*, *149*, 318-330

Sharma, C. M., Baduni, N. P., Gairola, S., Ghildiyal, S. K., &Suyal, S. (2010). Effects of slope aspects on forest compositions, community structures and soil properties in natural temperate forests of Garhwal Himalaya. *Journal of Forestry Research*, *21*(3), 331-337

Shifley, S. R., He, H. S., Lischke, H., Wang, W. J., Jin, W., Gustafson, E. J., ... & Yang, J. (2017). The past and future of modeling forest dynamics: from growth and yield curves to forest landscape models. *Landscape Ecology*, *32*(7), 1307-1325.

SunsaneeArunyawat and Rajendra P. Shrestha Assessing. Land Use Change and Its Impact on Ecosystem Services in Northern Thailand, Sustainability 2016, 8, 768; doi:10.3390/su8080768

Tang, L., Zeng, G.-M., Shen, G.-L., Li, Y.-P., Zhang, Y., Huang, D.-L.,

2008. Rapid detection of pictogram in agricultural field samples using a disposable immunized bran-based electrochemical sensor. Environ. Sci. Technol. 42, 1207–1212.

Taylor, F. W., Wagner, F. G., McMillin, C. W., Morgan, I. L., & Hopkins, F. F. (1984). Locating knots by industrial tomography-A feasibility study. *Forest Products Journal 34 (5): 42-46*.

TEEB Foundations, 2010.The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations. Earth scan, London and Washington

Tekle, K., & Hedlund, L. (2000). Land cover changes between 1958 and 1986 in Kalu District, southern Wello, Ethiopia. *Mountain research and development*, *20*(1), 42-51.

Teshome Soromsa (1997). An Ecological study the Low land Vegetation of Key Afer –Shala &Southwest of Lake Chamo, Southern Ethiopia. M.Sc. Thesis, Addis Ababa, Ethiopia

TigistWondimu (2003) Study of Useful Plants in the Semi a-arid parts of Doddotaa –SireeWoreda an Ethino botanical approach. M.Sc. Thesis, Addis Ababa, Ethiopia

Tolessa, T., Gessese, H., Tolera, M., & Kidane, M. (2018). Changes in Ecosystem Service Values in Response to Changes in Landscape Composition in the Central Highlands of Ethiopia.*Environmental Processes*, *5*(3), 483-501.

Tolessa, T., Senbeta, F., & Abebe, T. (2017). Land use/land cover analysis and ecosystem services valuation in the central highlands of Ethiopia. *Forests, Trees and Livelihoods*, *26*(2), 111-123.

Tolessa, T., Senbeta, F., & Abebe, T. (2017). Land use/land cover analysis and ecosystem services valuation in the central highlands of Ethiopia. *Forests, Trees and Livelihoods*, *26*(2), 111-123.

U.S. Environmental Protection Agency 2009).

UNFCCC (2007) Investment and Financial Flows to Address Climate Change. UNFCCC, 81.

US Environmental Protection Agency; Puskin, J. S. (2009). Perspective on the use of LNT for radiation protection and risk assessment. *Dose-Response*, *7*(4), dose-response.

Varkey, L. M., Kumar, P., Mridha, N., Sekhar, I., & Sahoo, R. N. (2016). Ecosystem Services and Fishery Production Dynamics of Wetland Ecosystem: An Appraisal of Alappuzha District of Kerala, India.*Fishery Technology*, *53*(2), 162-169.

Veldkamp, Verburg, P. H., Schulp, C. J. E., Witte, N., &, A. (2006). Downscaling of land use change scenarios to assess the dynamics of European landscapes. *Agriculture, Ecosystems & Environment*, *114*(1), 39-56.

Verburg P., Wassenaar, T., Gerber, P., . H., Rosales, M., Ibrahim, M., & Steinfeld, H. (2007). Projecting land use changes in the Neotropics: The geography of pasture expansion into forest. *Global Environmental Change*, *17*(1), 86-104.

Verburg, P. H., Schulp, C. J. E., Witte, N., &Veldkamp, A. (2006). Downscaling of land use change scenarios to assess the dynamics of European landscapes. *Agriculture, Ecosystems & Environment*,*114*(1), 39-56.

Verburg, P.H., Over mars, K.P., Huigen, M.G.A., de Groot, W.T. and Veldkamp, A. (2006) Analysis of the Effects of Land Use Change on Protected Areas in the Philippines. Applied

Geography, 26,153-173.

Verstraete, M. M., Pinty, B., & Myneni, R. B. (1996). Potential and limitations of information extraction on the terrestrial biosphere from satellite remote sensing. *Remote Sensing of Environment*, *58*(2),201-214.

Wami, F. O., Tolasa, T., & Zuberi, M. I. Forest degradation: An assessment of Gedo Forest, West Shewa,Oromia Regional State, Ethiopia.

Weng, Q. (2002). Land use change analysis in the Zhujiang Delta of China using satellite remote sensing, GIS and stochastic modeling. *Journal of environmental management*, *64*(3), 273-284.

Westman,W.E. (1977).How much are nature's services worth. *Science*,*197*(4307),960.964

Yohannes H, Soromessa T, Argaw M (2015) Carbon Stock Analysis along Forest Disturbance Gradient in Gedo Forest

Zang, S., Wu, C., Liu, H., Na, X., 2011. Impact of urbanization on natural ecosystem service values: a comparative study. Environ. Monit. Assess.179, 575–588

APPENDICES

APPENDIX: 1- QUESTIONNAIRES

This is only for the purpose of research thesis Submitted to the School of Graduate Studies of Jimma University in Partial fulfillment of the Requirement of the Master of Science in GIS and RS.

1. Do the area of the forest of this "kebele" decreasing or increasing from time to time?

A. Increasing from time to time B. Decreasing from time to time

2. If your response for question No is increasing by whom/? / By what?

A. By people B. By nature

C. Any other agent, Specify___________________________________

3. If your response for question No 1 is decreasing by whom? / By what?

A. By people B. By nature

C. Any other agent, Specify____

4. If the agent for deforestation / forest destruction/ is human being, for what purpose do people clear forest?

A. For expansion of agricultural land
B. Because of illegal resettlement / Land grabbing
C. Illegal logging of trees
D. For energy consumption primarily Fuel wood
E. For construction purposes
F. Due to all agents or causes listed above
G. If any other cause than the above specify---------------------------------------

5. Based on question number "4", among the causes of deforestation listed from A to G, which one is the major cause (ranked First)? 1. A,2. B , 3. C, 4. D, 5. E, 6. F, 7.G

Arrange in rank order. 1 to 7

6. If forest land has been used for other purposes and forest coverage declined, how you evaluate the rate of forest cover changes and dynamics in the last 45years?

1. The last 0—22 years------ 1. No change 2. Slow decline 3. Moderate decline 4.High decline 5. Rapid decline
2. The last 23-45 years------1. No change 2. Slow decline 3. Moderate decline 4. High decline 5. Rapid decline
3. The last 0-45 years 1. No change 2. Slow decline 3. Moderate decline 4. High decline 5. Rapid decline

7. What are the major services human man beings get from forest?

____

____

8. Is there tree species that were present in the past but now exterminated or eradicated? 1. Yes 2. No

9. If your answer for question no 8 is yes, what are these species? ------------

10. For question 9, what eradicated them?___________________________

11. What are the services the community missed as a result of the extinction of these species?______________________________________

12. Is there Government organ/ NGO/ that provides you another alternative? 1. Yes 2. No

13. Fertilizer supply   1. Available 2. Not available

14. Work done on conservation and soil fertility 1. Available 2. Not available

APPENDIX 2: CHECKLIST OF INTERVIEWS,

2.1. Respondents

1. Name---

2. Sex---

3. Place of birth; Woreda------------,Kebele----------------------

4. Addres

Woreda---

Kebele--

5. Age-----years

6. Education level---

7. Position/Job---

8. Number of house hold members--

9. The main livelihood /economic income generating activities---------------,

10. Land holding size------------ha/or by another unit----------------

11. Number of cattle------------------------

12. Construction of the house is by hut? Or corrugated iron**?** -------------------

2.2. Key Informants

1. Name---

2. Sex--

3. Place of birth; State--------------Zone-------------Woreda------------,Kebele-

4. Address

Woreda-----------------------*Kebele*---

5. Age-----years

6. Education level---

7. Position--

8. Experience--------------------years

APPENDIX 3. LAND USE/COVER CLASSES BY PERCENTAGE

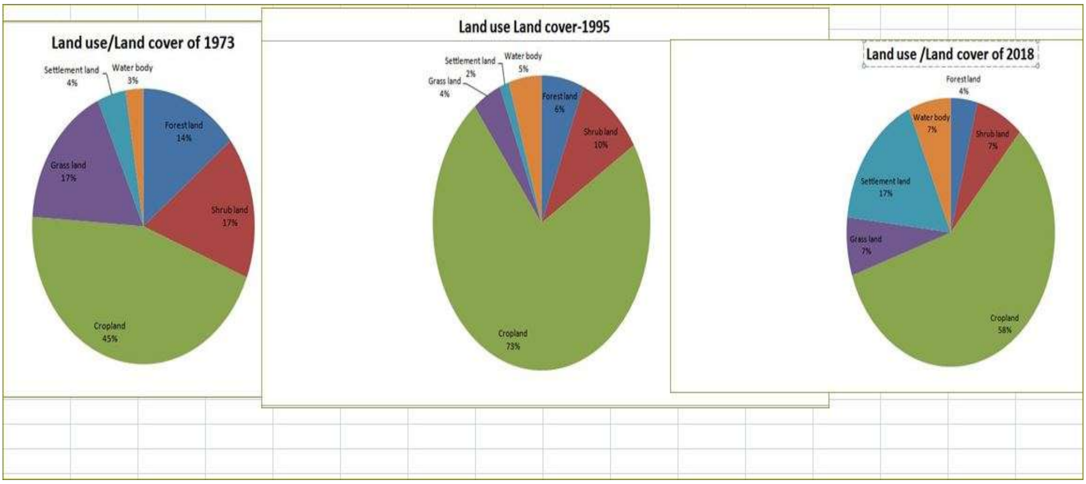


Figure 18. Land use/ cover

APPENDIX 4. LAND/USE LAND COVER CLASSES

LULC classes	Description	colour
Forest land	Land dominated by trees >5 m in height, with canopy cover > 20%	
Shrub land	Land dominated by bushes and shrubs <5 m in height with canopy cover >20%	
Cropland	Land under cultivation / agriculture	
Grass land	Land under grass cover, largely used by domestic animals for grazing and browsing	
Settlement land	Land dominated by houses and huts	
Water body	Rivers and swampy areas	

Table 25 Land uses definitions

APPENDIX.5 THE STUDY AREA WOREDAS AND ADMINISTRATION KEBELES

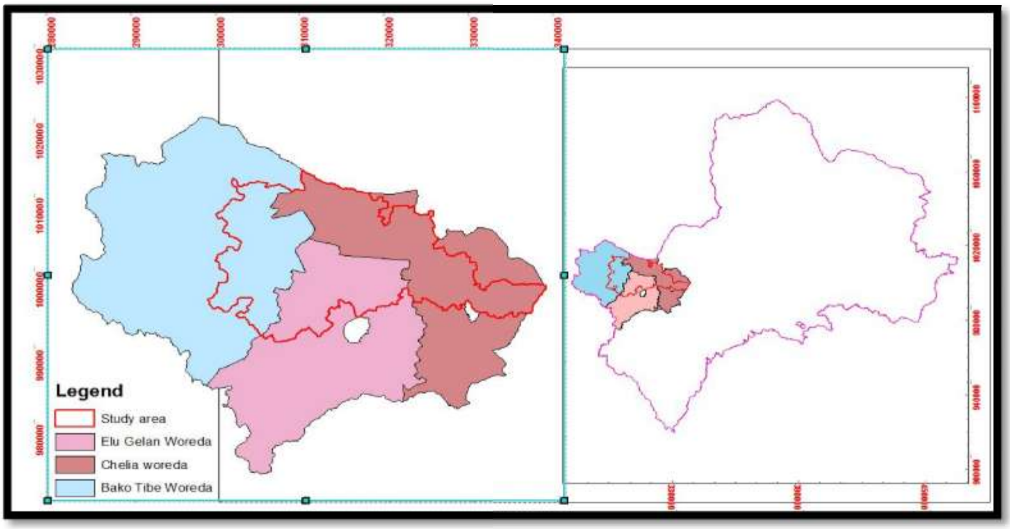


Figure 19 The study area woredas

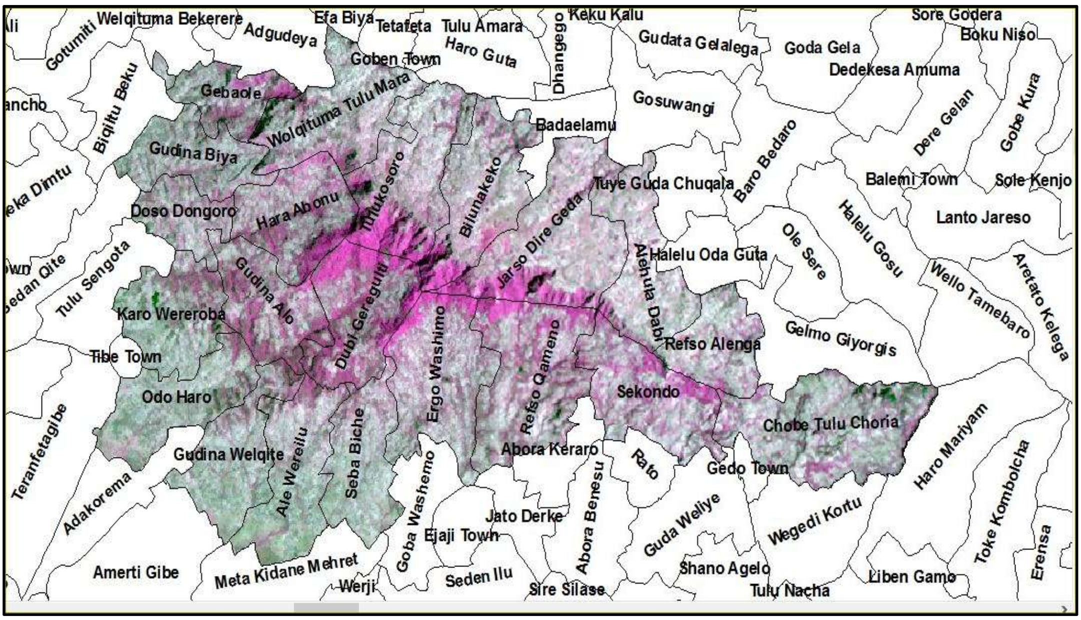


Figure 20 Rural administration Kebeles of study area

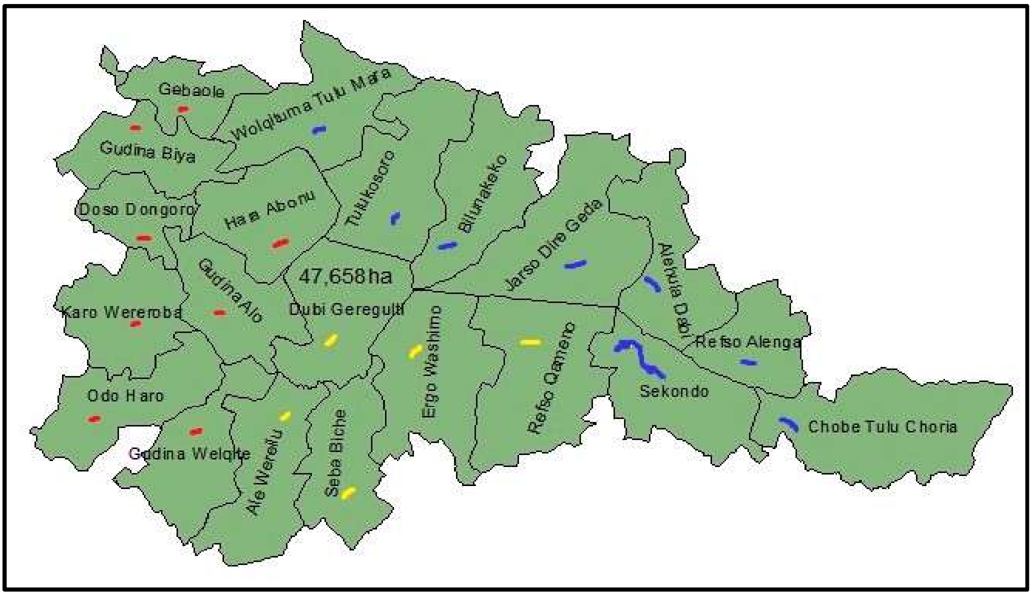


Figure 21. Rural Administration Kebeles of Study Area

APPENDIX.6 FOREST AND SHRUB COVER MAPS

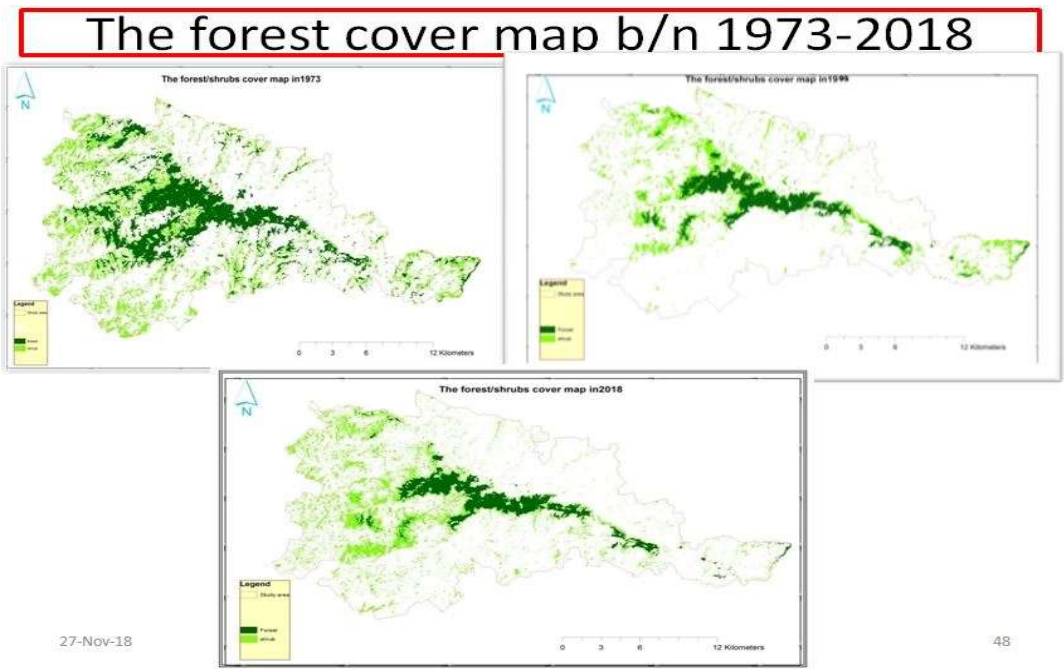


Figure 22 .Forest cover map of 1973,1995 and 2018