JIMMA UNIVERSITY

COLLAGE OF SOCIAL SCIENCE AND HUMANITIES DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES.

LAND USE LAND COVER CHANGE DETECTION USING GEOGRAPHICAL INFORMATION SYSTEM AND REMOTE SENSING: CASE STUDY OF SORO DISTRICT, SNN ETHIOPIA.

BY: - Meseret Demeke

THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES JIMMA UNIVERSITY, IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTER OF SINCE GEOGRAPHY AND ENVIRONMENTAL STUDIES SPECIALIZATION IN GIS AND RS

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M.Sc. Thesis

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APPROVED BY BOARD OF EXAMINERS SIGNATURE DATE

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Acronyms

ASTER: Advanced Space borne Thermal Emission and Reflectance Radiometer

CSA: Ethiopian Central Statistics Agency

DEM: Digital Elevation Model

EMA: Ethiopian Mapping Agency

ENVI: Environment for Visualizing Images

ESRI: Environmental Systems Research Institute

EMR: Electromagnetic Radiation

ERDAS Earth Resources Data Analysis System

ETM+: Enhanced Thematic Mapper Plus

TM: Thematic mapper

FAO: Food and Agricultural Organization of United Nations

GIS: Geographic Information Systems

GPS: Global Positioning Systems

SNNPR: Southern Nation Nationality People Republic

LULC: Land use Land Cover Change

SRTM: Shuttle Radar Topography Mission

MoA: Ministry of Agriculture

MWIE: Ministry of Water, Irrigation and Energy

MCE: Multi Criteria Evaluation

PCA: Principal Component Analysis

UTM: Universal Transverse Mercator

USGS: United States Geological Survey

VIS: Vegetation Indices

WOFEDO: Woreda finance Economy and Development

Abstract

Land use/ land cover change has become a central component in current strategies for managing natural resources and monitoring environmental changes. Hence, information about it is essential for the selection, planning and implementation of land use schemes. This project examines the use of GIS and Remote Sensing in mapping Land Use/Land Cover in Soro District between 1987 and 2017 so as to detect and analyze the changes that has taken place in their status between these periods. In order to achieve these, satellite data of Landsat MSS for 1987, TM for 2002 and ETM for 2017 have been obtained and preprocessed using ERDAS Imagine. The Maximum Likelihood Algorithm of Supervised Classification has been used to generate land use and land cover maps. For the accuracy of classified Land Use/Land Cover maps, a confusion matrix was used to derive overall accuracy and results were above the minimum and acceptable threshold level. Post classification comparison change detection method was employed to identify gains and losses between Land Use/Land Cover classes.

The satellite image results show that cultivated land decreased in the first period but increased in the second and the entire study periods. Grassland increased in the first period and decreased in the second period. Wetland is the most converted cover type during the entire study period and forest increased in first study period and decreased in second study period. The impact of this LULC change is more significant on the socioeconomic condition and status of the study area.

Keywords: Soro; Image Classification; GIS; Land Use/Land Cover Change; and Remote Sensing

CHAPTER ONE

1. INTRODUCTION

1.1 Back ground of the study

Land use/land cover change has become a central and important component in current strategies for managing natural resources and monitoring environmental changes(Rawat, 2013).Land use is the intended employment of land management strategy placed on the land cover by human agents or land managers to exploit the land cover and reflects human activities such as industrial zones, residential zones, agricultural fields, grazing, logging and mining among many others(Gete , 2001).

On the other hand, land cover is defined by the attributes of the earth's land surface captured in the distribution of vegetation, water, desert and ice and the immediate subsurface, including biota, soil, topography, surface and groundwater and it also includes those structures created solely by human activities such as mine exposures and settlement(Lambinet al., 2003;Baulies and Szejwach, 1997).

Land use and land cover changes may involve the nature or intensity of change but may also include spatial (forest abatement at village level, or for a large-scale agro industrial plant), and time aspects(Prakasam, 2010).

The conversion of natural land to cropland, pasture, urban area, reservoirs, and other anthropogenic landscapes represents the form of human impact on the environment (Granahanetal., 2005). Roughly 40% of earth's land surface is under agriculture, and 85% has some level of anthropogenic influence(Sanderson et al., 2002). Therefore, large scale land cover change is largely a rural phenomenon, but many of its drivers can be traced to the consumption demands of the swelling urban population (Carr, 2004).

The land use/land cover pattern of a region is an outcome of natural and socio–economic factors and their utilization by man in time and space. Land is becoming a scarce resource due to immense agricultural and demographic pressure(Berhane, 2007). Hence, information on land use/land cover and possibilities for their optimal use is essential for the selection, planning and implementation of land use system to meet the increasing demands for basic human needs and welfare. This information also assists in monitoring the dynamics of land use resulting out of changing demands of increasing population.

In Ethiopia, too, fast population growth and uneven spatial distribution of population have been affecting resource use, leading to its gradual deterioration. Rapid population growth is resulting in increased demands for additional arable land which is surely not adequately available. Population growth leads further to unnecessary natural resource exploitation such as forest clearing both for farming and settlement purposes, short fallow periods, and land fragmentation which has a direct adverse effect on agricultural output(Anderson, 1976).

Land degradation results mainly due to population pressure which leads to intense land use without proper management practices. Over population makes people move towards sensitive areas like highlands. In such areas land use without considering the slope and credibility leads to severe erosion and related problems. The influence of road construction and other comparable disturbances of landscape on erosion and on landslides, and other mass movements on hilly area are well known (Prakasam, 2010).

Most of the population of Ethiopia is settled on the highlands, with the northern and central highlands being the oldest settled regions of the country. These regions are the most exploited and environmentally degraded areas in the entire country. Due to the shortage of arable land, land is continuously utilized year after year, thus giving diminishing yields (Belaye, 2002).

Soro District which is located in the Southern part of the country is one of the exploited and degraded areas of the region. In the past ten and fifteen years the District had been with in a serious problem mostly the south western part. There are observable signs which indicate the existence of land degradation due to over plowing and clearing of forests for different purposes. The rural poor people have been also degrading the natural forest resources to sustain their livelihoods. Because of small landholding size and shortage of land in the District, plowing steep slopes with marginal output is common practice which has led to land and other natural resources degradation. The ability of the land to give production was becoming low and the peoples had started to abandon their land because it becomes incapable of even to grazing. Through the initiation from government, the community started to cover their land by vegetation.

The peoples from Gimbichu Town (the capital town of Soro District) area easily started to grow Eucalyptus and Acacia decurrens trees by hiring land from farmers. Through time the second one i.e. Acacia decurrens was became more preferable because it is functional relatively in a short period of time and rehabilitating ability of soil. Then through process by observing its advantage at both economical and rehabilitation aspect the farmers adopted the system. As a result the spatial and temporal land use/land cover (LULC) in general and the forest coverage of the District in particular is changing.

Change detection is a technique used to determine the change between two or more time periods of a particular object of study. Change detection is an important process in monitoring and managing natural resources and development because it provides quantitative analysis of the spatial distribution in population of interest Arsanjani,(2012).

Gathering information about Land Use/Land Cover changes is fundamental for a better understanding of the relationships and interactions between humans and the natural environment.

RS data have been one of the most important data sources for studies of LULC spatial and temporal changes. In fact, multi-temporal RS datasets, opportunely processed and elaborated, allow to map and identify landscape changes, giving an effective effort to sustainable landscape planning and management (Dewanet al., 2009). In particular, by means of the integration RS and GIS techniques, it is possible to analyze and to classify the changing pattern of LULC during a long time period and, as a result, to understand the changes within the area of interest. The availability of time-series dataset is essential to understand and monitor the change process, in order to characterize and locate the evolution trends at a detailed level.

1.2 Statement of the problem

Land use / land cover (LULC) changes influence climate and weather conditions from local to global scales. They can have impacts by affecting the composition of the atmosphere and the exchange of energy between continents and the atmosphere which can lead to global warming.(Fu, 2000).

Land use /land cover (LULC) changes in Ethiopia is closely linked to the ongoing population growth. More people generally lead to an increasing demand on land for living and for agricultural production. Consequently the pressure on the forest resources themselves increased due to a higher demand on fuel wood and construction timber. The natural regeneration of the land resources is difficult due to high populations of grazing and browsing livestock within the lands (Reusing, 2000 cited in Adugnaw Birhanu,2014).

Lambin et al. (2003) noted that land cover change information is needed regarding what changes occur, where and when they occur, the rate and the social and physical forces that drive those changes. As in the case in many developing countries, most of the population of Ethiopia lives in rural areas and depends directly on land for its livelihood. This rural population is currently growing rapidly and consequently inducing many effects on resource base brought about by the decrease in the area under natural vegetation and its conversion in to other types of land use/ land cover (Woldeamlak and Sterk, 2005).

Soro district has witnessed remarkable LULC change, mainly as a result of deteriorating on agricultural productivity of land. The rural poor people have been also degrading the natural forest resources to sustain their livelihoods. This deterioration of the land is because of the nature of the topography, population size increment, over cultivation and over grazing which enforce the inhabitants to change their land use practice.

The previous researchers made the research on land use land cover change detection activities and they give much concern only for a selected villages.

As stated by Mulugeta (2004) and Lophiso (2010) land use and land cover change have resulted in soil degradation, the removal of topsoil, leading to loss of soil fertility, and the depletion of biodiversity, which in turn leads to irreversible deterioration of natural resources and their study based on simple selected villages not whole district. They also failed to apply geospatial technology to show severity of the problem on the map.

Therefore this study was fill a knowledge gap and provide detail information on land use land cover dynamics, identify the major causes of LULC changes in the study area, and to analyze the dynamics of LULC changes as well as its spatial distribution and Patterns in Soro district by using multi temporal satellite images and GIS technology to assess time serious change of land cover occurred from 1987 to 2017. It identify the major causes of land cover changes by using KII and FGD respondents from study area and these study was give baseline information on land cover change and try to provide recommendations which may contribute to the sustainability of land cover so as to facilitate the local people in the conservation, management and protection of land.

1.3. The Research Questions

The following research questions were designed to guide the study

1. How was the temporal and spatial LULC changes over study area?
2. What are/were the major deriving causes (factors) for LULC?
3. What is/was the extent of impact of LULC change in the livelihood of the communities?

1.4. Objective

1.4.1. General Objective

The main objective of this study is to assess and evaluate land use land cover change of Soro District,Hadiya Zone, SNNP using RS and GIS techniques.

1.4.2. Specific Objectives

- To asses and identify the main driving cause of LULC changes in Soro district
- To examine temporal and spatial distribution of LULC of 19987, 2002 and 2017
- To map the extent of LULC changes over a period of three decades
- To evaluate the effect of LULC changes on livelihood of the communities (societies)

1.5 Limitations of the study

Limitations encountered the researcher while conducting this research are unable to use satellite imageries of high resolution like QuickBird due to its expensiveness. This is ideal for urban features distinction as well as appropriate financial support to purchase the required satellite images. Therefore, the difficulty to discern each land use/land cover category has resulted in misclassification of one land use/land cover into another. In order to overcome this problem, field observations were repeatedly undertook to verify actual land use/land cover which in turn incurred me both time and energy expenditures.

1.6. Scope of the Study

The use of GIS and Remote Sensing technologies to LULC change detection and analysis is a rapidly expanding field. This project was only give how GIS and Remote Sensing can be used as potential analytical tools to detect and analyze LULC change in Hadiya Zone Soro disrict.

1.7. Significances of the Study

The research was conduct to provide a new dimension to LULC change in the study area, to understand how land was used in the past, which types of changes are to be expected in the future, as well as the forces and processes behind the changes, which was produces important information about the effect of unmanageable LULC on biodiversity, climate condition and socio economic status of the study area. Such analysis is of great use to sustainable natural resources management, land use and land resource management, environmentalists, development agents, fund providers, and socio-economic development planners, because it provides accurate information related to LULC changes.

1.8. Organization of the of the study

The research organized into five main chapters. Chapter I Background of the study; introduction, statement of the problem, research questions, objectives, scope, significance of the study and organization of the study. Chapter II Related literature review, Empirical and Conceptual Review Related Literature. Chapter III Methods and Materials, description of a study area, Chapter IV Results and Discussions. Chapter V deals with Summary, Conclusion and Recommendations.

CHAPTER TWO

2. Literature Review

2.1 Land use and land cover

The land use/ land cover change science plan and implementation strategy sought multiple ways to deal with this reality, the first being to distinguish land "use" from land "cover" (Turner et al. Geist,2006). Land cover has been defined by the attributes of the Earth's land surface and immediate subsurface, including biota, soil, topography, surface and groundwater, and human (mainly builtup) structures(Lambinet al. 2003).

According to FAO (2000), "Land cover is the observed biophysical cover on the earth's surface". The same document also defines land use as the arrangements, activities and inputs that people under take on a certain land cover type. According to this definition, land cover corresponds to the physical condition of the ground surface, like forest, grassland, concrete pavement, while land use reflects human activities such as the use of the land such as industrial zones, residential zones, and agricultural fields.

Since humans have controlled fire and domesticated plants and animals, they have cleared forests to wring higher value from the land. About half of the ice-free land surface has been converted or substantially modified by human activities over the last 10,000 years. FAO estimated that tropical regions lost 15.2 million hectares of forests per year during the 1990s. Recent estimates for only the world's humid tropical forests based on a sampling strategy of remote sensing data, revised downward by 23 %(Lambin and Guest, 2003).

2.2. Causes of land use and land cover changes

United States Environmental Protection Agency USEPA, (2004), identified the general causes of land use and land cover changes, which are: (1) natural processes, such as climate and atmospheric changes, wildfire, and pest infestation; (2) direct effects of human activity, such as deforestation and road-building; and (3) indirect effects of human activity, such as water diversion leading to lowering of the water table.

Changes in land use and land cover date to prehistory and are the direct and indirect consequence of human actions to secure essential resources. This may first have occurred with the burning of areas to enhance the availability of wild game and accelerated dramatically with the birth of agriculture, resulting in the extensive clearing or desertification and management of Earth's terrestrial surface that continues today. More recently, industrialization has encouraged the concentration of human populations within urban areas (urbanization) and the depopulation of rural areas, accompanied by the intensification of agriculture in the most productive lands and the abandonment of marginal lands.

All of these causes and their consequences are observable simultaneously around the world today. The question of what factors drive land-use and land-cover change remains largely unanswered (Turner and Meyer, 2001). Recently, human activities and social factors were recognized to have a paramount importance for understanding of land-use and land-cover change. Land use is never static; it constantly changes in response to the dynamic interaction between underlying drivers and proximate causes Lambin and Geist (2002). The conceptual understanding of proximate causes and underlying forces has a crucial importance to identifying the causes of land-use and land-cover changes (Turner and Meyer, 2001).

2.2.1. Human Factors/ Cause

Human-driven land use and land cover change is one of the most important causes for depletion of biodiversity**.** Direct causes of land-use change constitute human activities or immediate actions that originate from intended land use and directly affect land cover. They involve a physical action on land cover. Underlying causes are fundamental forces that underpin the more proximate causes of land-cover change. Human beings have used land and its resource for the sec of meeting their material, social, cultural and spiritual needs; this provide them with the provision of food; clothing; shelter and heat for producing a large variety of goods and service for their its Owen use or market exchange; for moving ground and transporting goods for recreation and leisure; for aesthetic pleasure; for attaining social status and prestige; for spiritual satisfaction and claiming territorial sovereignty. In the past two centuries, the impact of human activities on land has grown (Turner *et al*., 2001).

2.2.2. Natural Cause

The natural events such as weather, flooding, fire, climate fluctuations, and ecosystem dynamics may also initiate modifications upon land cover. However, recently human activities and social factors were recognized to have a paramount importance for understanding of land use and land-cover change. More specifically, it is land clearing for agriculture that has been the most significant process by far and is a process that continues today (Blake and Nicholson, 2004).

Generally, the causes of land use and land cover change can be categorized in to: direct driving forces and underlying driving forces. Direct causes are immediate actions of local people in order to fulfill their needs from the use of the land. These causes include settlements, agricultural expansion, wood extraction, infrastructure expansion recreation and others that change the physical state of land cover (Turner and Meyer, 1994).

2.2.3 Institutional cause

The understanding of institutional causes (i.e. Political, legal, economic, and traditional) and their interaction with individual decision making are important in explaining land use changes. Institutional causes need to be considered at micro and macro levels because the implementation of macro policies is practiced at the local level. Land-use and land-cover changes are influenced significantly when macro policies undermine local policies in that the structure of local and national polices may determine local people’s access to land, capital, technology, and information (Lambin and Geist, 2003).Lack of well-defined policies and weak institutional enforcement may facilitate changes of land use. On the other hand, restoration of land use is possible if there are appropriate land use policies in place. In most developing countries communal (traditional) land holding systems have been shifted to a formal (state) holding system (Lambinet al., 2003). The policy in developing countries of price control on agricultural in-put and out-put and self-sufficiency in food have all influenced land use changes (Turner et al., 1993).

2.3. Land use land cover change and its effects on local, regional and global scales

Thomas (1999), explained the relation between different scale land cover changes that land use and land cover changes occur at all scales, and changes at local scales can have dramatic, cumulative impacts at broader scales. He also discussed that land use and land cover changes are not just of concern at local and regional levels because of its impacts on land management practices, economic health and sustainability, and social processes, but globally as well.

2.3.1. Climate Change

Climate is the interaction of all of the components of the Earth's system and it includes the solar and infrared radiation and sensible and latent heat fluxes that are all impacted by changes in the Earth's surface. The significant role of the land within the climate system should not be surprising. Apart from their role as reservoirs, sinks, and sources of carbon, tropical forests provide numerous additional ecosystem services. Many of these ecosystem services directly or indirectly influence climate. The climate-related ecosystem services that tropical forests provide include the maintenance of elevated soil moisture and surface air humidity, reduced sunlight penetration, weaker near-surface winds and the inhibition of anaerobic soil conditions (Pielke 2002).Land surface is an important part of the climate system. The interaction between land surface and the atmosphere involves multiple processes and feedbacks, all of which may vary simultaneously. It is frequently stressed that the changes of vegetation type can modify the characteristics of the regional atmospheric circulation and the large-scale external moisture fluxes. So that changes in surface energy budgets resulting from land surface change can have a profound influence on the Earth's climate (WMO, 2005).

2.3.2. Global Warming

Global warming is the observed increase in the average temperature of the Earth's atmosphere and oceans in recent decades. The Earth's average near surface atmospheric temperature raised 0.6 ± 0.2 °C in the 20thcentury. The current scientific consensus is that most of the observed warming over the last 50 years is likely to have been attributable to human activities. The primary causes of the human-induced component of warming are the increased amounts of carbon dioxide (CO2) and other greenhouse gases (GHGs). They are released by the burning of fossil fuels, land clearing and agriculture, etc. and lead to an increase in the greenhouse effect.

Human activity is vastly altering the Earth's vegetative cover. Such changes have considerable consequences for the health and resilience of ecosystems and for human welfare. They also contribute to anthropogenic climate change through a variety of processes. These include the growth or degradation of surface vegetation, which produces changes in the global atmospheric concentration of carbon dioxide; and changes in the land surface, which affect regional and global climate by producing changes in the surface energy budgets (Gregg et al. 2003). Land use and land cover changes influence carbon fluxes and greenhouse gas (GHG) emissions that directly alter atmospheric composition and radiative forcing properties. They also change land-surface characteristics and, indirectly, climatic processes. Land use and land cover change is an important factor in determining the vulnerability of ecosystems and landscapes to environmental change (WMO, 2005).

2.3.3. Desertification

Desertification is land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variation and human activities. Furthermore, UNCCD defines land degradation as a reduction or loss, in arid, semi-arid, and dry sub-humid areas, of the biological or economic productivity and complexity of rain-fed cropland, irrigated cropland, or range, pasture, forest, and woodlands resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns, such as: (i) soil erosion caused by wind and/or water; (ii) deterioration of the physical, chemical, and biological or economic properties of soil; and (iii) long-term loss of natural vegetation (WMO, 2005).

2.4 Land Use/Land Cover in Ethiopia

Researches on land use and land cover change in Ethiopia involved in different regions and disciplines depending on the availability of data and tools to perform analysis and their interest. Most of the studies have focused on deforestation, the expansion of cultivated land to land degradation, river catchments and watersheds, urban growth, natural ecosystems and forests as well as the associated consequences.

In general almost all have reached to the conclusion that cultivated land, rural and urban settlements as well as open lands expanded in large amount at the expense of natural vegetation including forest, wooded land and shrub land. Berhanu et al.(1998) has reported that 3.1% of natural forest is lost annually due to shifting cultivation, commercial agriculture, fuel wood collection, urbanization, forest fire, poor utilization and logging .Berhane(2007) has also reported that 693.84ha of forest land is changed in to other land use/land covers annually in Dendi District.

Gete and Hurni(2001) reported an expansion of cultivated land at the expense of natural forest cover between 1957 and 1982 in Dembecha area, north-western Ethiopia. The study also investigated a series trend of land degradation resulted due to the expansion of cultivated land on steep slopes at the expense of natural forests. Aklilu et al.(2007) showed a significant decline in natural vegetation cover, however, there was an increase of plantation in Beressa watershed, in the central highlands of Ethiopia between 1957 and 2000. Eleni et al.(2013) also showed a significant decrease of natural woody vegetation of the Koga catchment since 1950 due to deforestation in spite of an increasing trend in eucalyptus tree plantations after the 1980's. Woldeamlk and Solomon (2013) reported a reduction of natural vegetation cover, but an expansion of open grassland, cultivated areas and settlements in Gish Abay watershed, north-western Ethiopia.

2.5 Soro District land use land cover

The study area has an old history of land use with high erosion damages especially with increasing slopes. As the remnants of the trees depict, the area has once been covered by dense indigenous forests. However, the vegetation cover has been removed partly for cultivation and it has also been replaced by some exotic species such as eucalyptus tree. Between 1974 and 1991, the forest coverage declined to 32% and rapidly went down to 15% between 1991 and 2008. Major reason for this rapid decline of forest coverage was extensive deforestation due to the population growth and expansion of cultivation land. Thus, like other parts of the country, natural vegetation of the area has been influenced by human activities. Like forestland, grassland and wet land is also overgrazed and then gradually changed into farmland. Because of this shortage of grazing field, farmers have owned small numbers of animals. As result, accelerated soil erosion and fertility decline become the main problem of the area once the forest cover was lost, (Kibamo, 2011).

This implies there is a gap in terms of spatial representation in land use and land cover change studies in the country. In order to fill this gap, the present study was carried out in the Soro district in Hadiya Zone, SNNPR Ethiopia. The main objective of this study is to detect and analyze LULC changes in Hadiya Zone Soro district by integrating RS and GIS techniques.

2.6 Impacts of Land Use and Land cover Change

2.6.1. The Impact of Land use and Land Cover Change on Biodiversity

Biodiversity is the web of life that distinguishes planet Earth from the other lifeless spheres in our solar system, if not the universe. There are three different levels of diversity: ecosystem diversity, species diversity, and genetic diversity (*i.e*., diversity within species). Our focus here will be on terrestrial (as opposed to aquatic) ecosystem diversity, and on species diversity within terrestrial ecosystems (Groombridge and Jenkins, 2000).

Species extinction predates the appearance of hominids on the planet, yet there is no doubt that even prehistoric human activities have speeded species loss. Through their use of fire and through hunting, it is thought that early hominids contributed to the extinction of many large terrestrial mammal and bird species (Groombridge and Jenkins). It is really only with the advent of large-scale agriculture, though, that species extinction rates began to rapidly increase. Today, agriculture channels some 40 percent of the planet's net primary productivity to meet human needs. Land use and habitat conversion are, in essence, a zero-sum game: land converted to agriculture to meet global food demand comes from forests, grasslands, and other natural habitats. Today, 1.54 billion ha (or 15.4 km^2.) is in cropland, and 3.47 billion ha is in pastureland, and these are projected to increase 1.89 billion hectares and 4.01 billion ha respectively by 2050. Thus, by 2050 approximately 45 % of the world's land surface will be dedicated, in one way or another, to agriculture. (*Tilma et al., 2001*).

While agriculture sometimes represents a wholesale conversion of land from natural states to crop or pastureland, often the process is a gradual one in which a succession of land uses punches holes in the fabric of nature in ways that can be deleterious to biodiversity. This process is known as forest or habitat fragmentation. Fragmentation can lead to reductions in total genetic variation, dispersal barriers and, for plants, the potential loss of key biotic interactions with pollinators and dispersal agents (Yilma, 2005).

2.6.2. Impact of Land use and Land cover Change on Climate

The land surface is an important part of the climate system. Thus, change in LU/LC also contributes to climate change through a variety of processes locally, regionally and globally. These include the growth or degradation of surface vegetation, which produces changes in the global atmospheric concentration of carbon dioxide; and changes in the land surface, which affect regional and global climate by producing changes in the surface energy budgets. Changes in the land surface have affected local and regional climates (Henderson- Sellers, 1995), and it is increasingly clear that some changes in the land surface can have significant impacts on the climate in distant parts of the Earth. For example, it has been long appreciated that changes in forest cover in the Amazon Basin affect the flux of moisture to the atmosphere, regional convection, and hence regional rainfall. Recently, Sherbinin, (2002) has shown that these changes in forest cover have consequences far beyond the Amazon Basin. Besides, he confirmed that fragmentation of the landscape can affect convective flow regimes and rainfall patterns locally and globally. Land surface changes on the order of 10 km on a side can cause changes in the local pattern of rainfall.

2.6.3 .Land use land cover change on forest

There is roughly 39 million km^2 (29 %) of the world's land surface is under forest cover. The World Resources Institute (1997) estimates that only 26 one-fifth of the world's original forest cover remains, largely in blocks of undisturbed frontier forests in the Brazilian Amazon and boreal areas of Canada and Russia. Vegetation cover and dead plant biomass are known to reduce soil erosion by intercepting and dissipating raindrops and wind energy. Under this situation, lowest erosion rates have been recorded from undisturbed forests, with ranges from 0.004 to 0.5 t/ha per year (Bezuayehu *et al*., 2002). However, once forestland is converted to agriculture, erosion rates increase because of vegetation removal, over-grazing, and continuous cultivation. On the other hand, there is a better understanding that forests burnt in certain parts of the world are important contributors to greenhouse gases and contributing to climate change. Overall these changes affect the livelihoods of societies (FAO, 2001).

In Ethiopia, population pressure is inducing, the clearing of forests for agriculture and other purposes, and the attendant accelerated soil erosion, is gradually destroying the soil resource. This is because natural forests are the main sources of wood for fuel, construction and industry, even though plantation forestry is also increasingly becoming important. In Ethiopia forests may have existed long before history was recorded, but the present day forest cover does not correlate with human population in recorded history, even though environmental problems such as droughts may have also contributed to this phenomenon (Hurni, 1990).

2.6.4. The impact of land use and land cover change on soil erosion

Land-use and land-cover patterns are interrelated with the types and properties of soils. The rate and severity of soil erosion and land degradation partly depends on land use pattern. The problem of soil erosion starts with the removal of land cover (natural vegetation) for various purposes. The relationship between land use and soils is two dimensional i.e. land use affects soils and in reverse soils affect land use. Land-use and land-cover is by far the most important determinant of erosion in the highlands of Ethiopia (Woldeamlak, 2002). The northern and central highlands of Ethiopia are relatively, unstable, compared to the south and south-western highlands. Consequently, the land use and cover pattern in northern and central highlands contribute a lot to soil loss due to erosion (Amare, 1996).

2.6.5. The impact of land use and land cover change on cultivated land.

Land-use and land-cover patterns are interrelated with the types and properties of soils. The rate and severity of soil erosion and land degradation partly depends on land use pattern. The problem of soil erosion starts with the removal of land cover (natural vegetation) for various purposes. The relationship between land use and soils is two dimensional i.e. land use affects soils and in reverse soils affect land use. Land cover characteristics and water cycle have many connections. The type of land cover, obviously, can affect both rate of infiltration and runoff amount by following the coming of precipitation (Hougton, 1995). According to Turner et al. (2001), both surface and ground water flows are significantly affected by type of land cover.

2.6.6 The impact of land-use and land-cover change on grazing land

The land use systems in Eastern Africa are severely affected by forms of land degradation such as over cultivation, overgrazing, deforestation and others. Places where vertisol is common, like most parts of Ethiopia, are suffering from overgrazing with shrub invasion and soil erosion (Girma et. al, 2002). Because of the increasing intensity of grazing, shrubs and perennial grasses may change into annual grasses and bare land. Heavily grazed plots result in poor quality of physical and even chemical properties of soils. High soil compaction that leads to low infiltration rate is clearly observed in heavily grazed plots than less grazed plots. (Girma, et.al 2002)

Ethiopia is rich in different types of climax grasslands because of the variation in topography including variations in elevation, types of soil and climate. The share of livestock population to Ethiopia's agricultural gross domestic product (GDP), total GDP and income from farming products is about 30-35, 13-16 and 85 percent, respectively (Befekadu and Brehanu, 2000). This contribution may be adversely affected by the reduction of traditional grazing areas for various purposes. The expansion of cultivated land at the expense of bush lands, natural pasture and forest, caused by ever increasing human population, has strongly affected the number of livestock and the quality of the products. In addition, shrinking of grazing land would force the livestock to move into upper slopes and roadsides. This in turn induces overgrazing and soil erosion in different parts of the country (Hoekstra et al. 1990).

Land use and land cover changes result from various natural and human factors within social, economic and political contexts. Hence, the local human activities expressing the drivers can be determined by measuring the rates and types of changes and analyzing other relevant sources of data like demographic profiles, household characteristics and policies related to land resources administration. To achieve this, it is crucially important to consider multiple sources of information and to acquire temporal, spatial and other non-spatial forms of data.

2.7 Overview of Remote Sensing and GIS

Planners and resource managers need a reliable mechanism to assess the consequence of the changes resulted by the stress imposed natural resource by detecting, monitoring and analyzing land use changes quickly and efficiently. The conventional method of environmental data collection and analysis are not efficient in delivering the necessary information in a timely and 18 cost effectively fashion. Hence viewing the Earth from space has become essential to comprehend the cumulative influence of human activities on its natural resource base. Remote sensing technology however can play a vital ro\le in providing accurate and reliable information with cost effective and lesser time compared to other methods.

Remote sensing refers the technique of obtaining information about an object or feature through the analysis of data acquired by a device that is not in contact with the object or feature under investigation (Lillesand and Kifer, 2002). Remote sensing has helped in the development of various environmental management methodologies, providing the following advantages when compared to conventional ground based methods (Roy, 2005): Synoptic view: Remote sensing facilitates the study of various features of earth’s surface and the spatial relationship between features, · Accessibility: Remote sensing makes it possible to gather information about areas that are not accessible for ground surveys, like mountainous areas or foreign lands and Time: Since information about a large area can be gathered quickly, these techniques save time and effort.

Some of the application of remote sensing technology in mapping and studding LU/ LC dynamics are: map and classify vegetation (forest), assess the spatial arrangement of land cover and vegetation types, provide information for extrapolating field observations, allow analysis of time-series images used to analyze landscape's history, report and analyze results of inventories including inputs to Geographical Information System (GIS), provide a basis for model building. Remote sensing and Geographic Information Systems (GIS) are providing new tools for advanced ecosystem management. The collection of remotely sensed data facilitates the synoptic analyses of earth-system function, pattern and change at local, regional and global scales over time. Such data also provide a vital link between intensive, localized ecological research and the regional, national, and international conservation and management of environment (Wilkie and Finn 1996).

2.8 RS and GIS Techniques in LU/LC Mapping and Change Detection.

2.8.1 Application of Remote Sensing For Land Use and Land Cover Change.

There is significant variation between various sensor instruments' capability and wealth of information captured and also the applicability depends on the objective of the intended study. There is also clear variation in the spatial and 14 spectral properties of satellite images acquired by different versions of a particular sensor instrument. Landsat instruments can be taken as a good example of showing continuous improvement in radiometric and spectral property of images enabling better understanding of land resources. Since 1972, the Landsat satellites have provided repetitive, synoptic, global coverage of high-resolution multispectral imagery. Their long history and reliability have made them a popular source for documenting changes in land cover and use over time (Turner et al., 2001) and their evolution is further marked by the launch of Landsat 7 by the US government in 1999. Multispectral Scanner (MSS) data from the U.S. Geological Survey's (USGS) EROS Data Center (EDC) has provided a historical record of the Earth's land surface from the early 1970s to the early 1990s. The MSS and TM sensors primarily detected reflected radiation from the Earth's surface in the visible and IR wavelengths, but the TM sensor provides more radiometric information than the MSS sensor.

Remote sensing is the science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device that is not in physical contact with the object, area, or phenomenon under investigation (Lillesand and Kiefer, 2000). This is done by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information.

Advantages of remote sensing are:

- Provides data of large areas
- Provides data of very remote and inaccessible regions
- Able to obtain imagery of any area over a continuous period of time through which the

- any anthropogenic or natural changes in the landscape can be analyzed
- Relatively inexpensive when compared to employing a team of surveyors
- Easy and rapid collection of data
- Rapid production of maps for interpretation

Disadvantages of remote sensing are:

- The interpretation of imagery requires a certain skill level
- Needs cross verification with ground (field) survey data
- Data from multiple sources may create confusion
- Objects can be misclassified or confused
- Distortions may occur in an image due to the relative motion of sensor and source
- Expensive to build and operate!!!!
- Measurement uncertainty can be large
- resolution is often coarse
- need to understand measurement uncertainties
- need to have some knowledge of the phenomena you are sampling

http://iosrjournals.org/iosr-jhss/papers/Vol20-issue3/Version-3/F020334348.pdf

2.8.2 Land use/Cover Classification

Land cover/use is one of the most important and typical application of remote sensing data. Land cover corresponds to the physical conditions of the ground surface, for example, forest, grassland, concrete pavement etc., while land use reflects human activities such as the use of the land, for example, industrial zones, residential zones, agricultural fields etc (Donald *et.al*, 2005).

According to Anderson (1976) one of the prime prerequisites for better use of land is information on existing land use patterns and changes in land use through time. Knowledge of the present distribution and area of such agricultural, recreational, and urban lands, as well as information on their changing proportions, is needed by legislators, planners, and State and local governmental officials to determine better land use policy, to project transportation and utility demand, to identify future development pressure points and areas, and to implement effective plans for regional development.

2.8.3 Image classification

Image classification according to (Lillesand and kiefer, 2000), is the process of creating thematic maps from satellite imagery. A thematic map is an information representation of an image that shows the spatial distribution of particular theme.

Image preprocessing: The raw data which was received from imaging sensors mounted on Satellite platforms, remotely sensed data generally could contain flaws, deficiencies or errors due to the perspective of the sensor optics, the motion of the scanning system, the motion of the platform (altitude and velocity), the train relief or the curvature and rotation of the Earth Some of them might be radiometric distortions, geometric distortion and noise. So, before using the data for specific analysis, the data were checked and errors were removed. Such errors were corrected by using preprocessing techniques like radiometric correction, geometric correction and noise removal, which were applied on the raw image (Lillesand and Kiefer 2004).

Image Enhancement: Image enhancement is used to increase the details of the image by assigning maximum and minimum brightness values to maximum and minimum display values, and it is done on pixel values. This makes visual interpretation easier and assists the human analyst. The visual interpretability of images enhanced by using histogram equalization stretch (Lillesand and Kiefer, 2000).

According to Lillesand and Kiefer,(2000), there are two main spectrally oriented classifications procedures for land cover mapping: unsupervised and supervised.

Unsupervised classification is more computer-automated. It enables user to satisfy some parameters that the computer uses to uncover statically patterns that are inherent in the data. These patterns are simply clusters of pixels with similar spectral characteristics. In some cases, it may be more important to identify group of pixels with similar spectral characteristics than it is to sort pixels into recognizable categories.

In **supervised classification** the image analyst supervises the pixel categorization process by specifying, to the computer algorithm, numerical descriptors of the various land cover types present in a scene. To do this, representative sample sites of known cover type, called training areas are used to create the parametric signatures of each class. Each pixel in the data set is then compared numerically to each category in the interpretation key and labeled with the name of the category it ‘looks like most like.

2.8.4 Accuracy of image classification

Accuracy is essentially measure of how many ground truth pixel was classified correctly. when land cover map was developing from satellite image errors were happened, so we need to keep in mind how accurate they are, and whether that level of accuracy is sufficient for the ways we want to use the map information (Awotwi, 2009) based on the 30 meters DEM resolution of the Land sat data used to create map, it is important to keep in mind that the map will be most accurate for viewing geographic pattern over large areas. The result of an accuracy assessment provides us with overall accuracy of the map based on an average of the accuracy for each class in the map.

$$\text{Overall accuracy} = \frac{\text{Number of pixel correctly classified}}{\text{Total number of pixel}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

Kappa is used to measure the agreement of accuracy between the remote sensing derived classification map and the reference data as indicated by the major diagonals and the chance agreement which is indicated by the row and column totals. The Kappa factor is given by the Equation 2, (Jensen 2003).

$$\text{Kappa (K)} = \frac{P0 - pe}{1\text{-}Pe} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

Where Po = the proportion of correctly classified cases

Pe = the proportion of correctly classified cases expected by chance

Producer accuracy gives how well a certain area can be classified. User accuracy is when the total number of pixels that were actually classified in that category (row total) the result is a measure of commission error. The user accuracy or reliability is the probability that a pixel classified on the map actually represent that category on the ground, (Jensen 2003).

2.8.5 Post Classification Approaches

Post classification approach is based on the use of supervised classification approaches (requiring an a priori knowledge of data classes), and it is based on texture features. The extraction of texture features cannot be done at pixel level, because the texture is defined on a set of pixels (Hichamet al., 2007). This method is the most simple and obvious change detection based on the comparison of independently classified images(Singh, 1989). Maps of changes can be produced by the researcher which shows a complete matrix of changes from times $t_1$to time t_2. Based on this matrix, if the corresponding pixels have the same category label, the pixel has not been changed, or else the pixel has been changed (Xuet al., 2009).

2.8.6 Geographic Information System

Maps have been used for thousands of years, but it is only within the last few decades that the technology has existed to combine maps with computer graphics and databases to create GIS. Many GIS databases consist of sets of information called layers. Each layer represents a particular type of geographic data. For example, one layer may include information on the streets in an area. Another layer may contain information on the soil in that area, while another records elevation. The GIS can combine these layers into one image, showing how the streets, soil, and elevation relate to one another.

A GIS database can include as many as hundred layers. This capability of GIS makes it a very useful tool in the analysis of land use changes. Layers for land use change analysis can be datasets obtained at different periods, different classes of land use at the same period, drivers of land use change etc. The applications of a GIS are vast and continue to grow. By using a GIS, scientists can research changes in the environment; engineers can design road systems; electrical companies can manage their complex networks of power lines; governments can track the uses of land, make policies to guide the use of land for a sustainable environment; fire and police departments can plan emergency routes. The GIS technology is employed to assist decision-makers by indicating various alternatives in development and conservation planning and by modeling the potential outcomes of a series of scenarios. It should be noted that any task begins and ends with the real world. Data are collected about the real world. After the data are analyzed, information is compiled for decision-makers. Based on this information, actions are taken and plans implemented in the real world.

Advantages and Disadvantages of GIS

GIS (geographic information system) is used in conservation research. How has it changed collecting and analyzing data for scientist? What are the advantages and disadvantages of using GIS?

There are several *advantages* and *disadvantages* of using GIS in conservation research. It leds to better time management as finding locations is almost instant. But that is only if the signal can be found. Collection of data is quicker with GIS and location is more accurate. With more data better predictions and analysis can be made. Also with the less timely amount to collect data certain things can be cataloged to create a database to refer to in the future. Because GIS is relatively new, integrating GIS data with traditional maps is difficult. Also funding for GIS is needed because it is more costly. Few are worried that GIS will be too heavily relied on and there will be a loss of knowledge of geography (which I believe is already seen in personal GPS).

http://apollo.lsc.vsc.edu/classes/remote/lecture_notes/measurements/disadv_remote.html

CHAPTER THREE

3 Materials and Methodology

3.1 Description of Study Area

3.1.1 Location

Soro is one of the 10 Districts in Hadiya Zone which is located at $7^0$30'-7^0 43 North and $37^0$35'-38^0 05' East. It is situated in the southern-tip of the zone and bordered by Gombora District in the North; Oromiya Region (Omo River) and Yem Special. District in the West; Dawro Zone, Kambeta (KAT) Zone, and Duna District in South and Southeast; Lemo District and again Kembata Timbaro Zone in the Northeast and East. The total land area of the district is 58,061he which comprises of 30 rural villages. The administrative center for Soro District is Gimbichu Town; which is 264 km far from Addis Ababa (the capital city of Ethiopia) and 200 km far from Hawasa the SNNP capital. Source(WOFEDO).

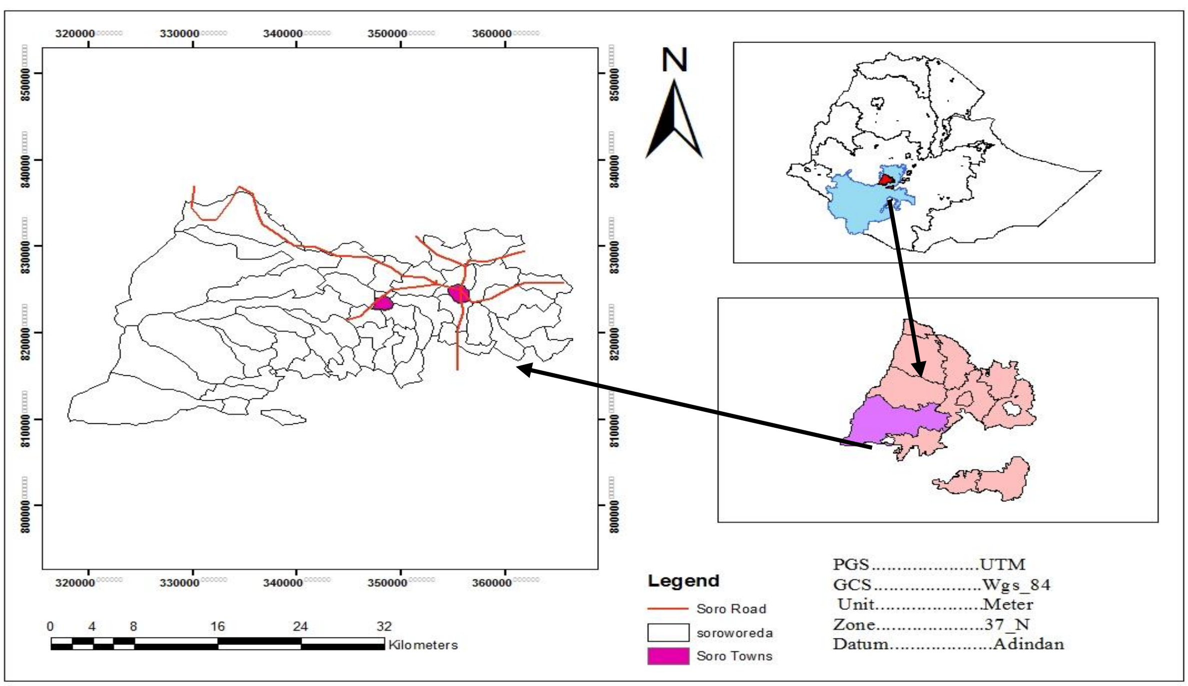


Figure 2: Location map of the study

3.1.2 Demography and Socio-economic Setting

The total population of the district in 2008 E.C was about 196,693; with 98,229 males and 98,464 females. The population density of the area is about 338 persons per s km^2. According to the Soro District Finance Office and Population and Housing annual report, the population for the year 2009/10 was 217,452. Male Populations account about 108,271 (49.8%) and females were about 109,181(50.2%). About 95.9% of population of Soro district was involved in agriculture and reside in rural areas experiencing declining food security (Kibemo, 2011).

The livelihood of the people in the district depends mainly on mixed farming (crop livestock production). Dominantly growing crops in the study area include wheat, tef, sorghum, bean and pea, barley, maize, potato and Enset. None of these crops could be grown without chemical fertilizer application since natural fertilizer of the soil is insufficient, except Inset. Enset is the staple food in the area and almost always grown for consumption source (District Agricultural department/offices, 2008).

3.1.4 Rainfall and Water Resource

Soro district is a typical of the moist temperate agro-ecological zone (8%temparate, 55%weyna-dega and 37% kola). The mean annual total rainfall is about 1260mm and has two rainy seasons, Belg and winter. Belg is the short rainy season and lasts between March and May. The Winter season, which is the longest rainy season, lasts between June and September. More than 75% of the total rain falls during this season and the highest rainfall occurs in July and August. Rain that occurs during the winter season is very intensive and, hence, the severity of soil erosion is high during these two months. Most of the crop production also takes place during the winter season. Even though there were some variations with respect to cessation, amount and distribution, the belg rains were by large favorable in most areas of the district. For example, onset of the rain was timely in almost all Belg producing villages of the district and most districts of the Hadiya zone (kibemo, 2011).

3.1.5 Bio-Physical Conditions

Topographically the study area is characterized by steep slopes, moderately gentle lands and flat plains in certain areas. The altitude of the district ranges from 1454 to 2850m above sea level, (Soro District Agricultural and Rural Development Office, 2010).

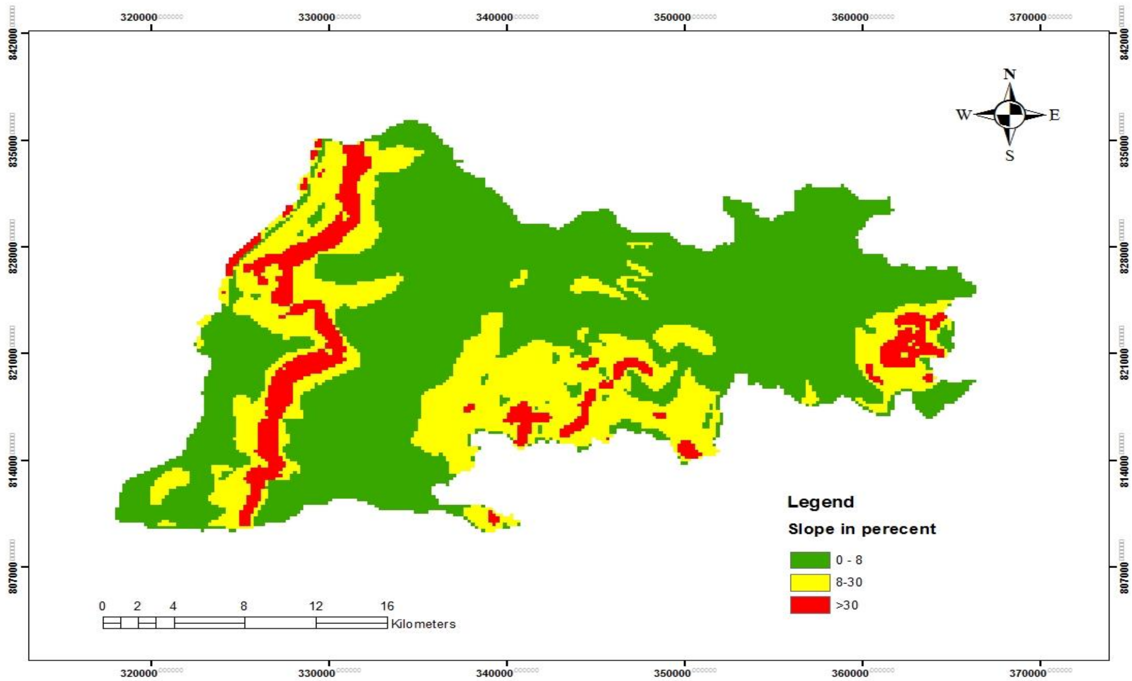


Figure 2: Slope Map of Soro District (Source: Generated from DEM)

3.1.6 Soro district Land Cover and Soil Types

The study area has an old history of land use with high erosion damages especially with increasing slopes. As the remnants of the trees depict, the area has once been covered by dense indigenous forests. However, the vegetation cover has been removed partly for cultivation and it has also been replaced by some exotic species such as eucalyptus tree. Between 1974 and 1991, the forest coverage declined to 32% and rapidly went down to 15% between 1991 and 2008. Major reason for this rapid decline of forest coverage was extensive deforestation due to the population growth and expansion of cultivation land. Thus, like other parts of the country, natural vegetation of the area has been influenced by human activities. Like -forestland - grassland and bush land is also overgrazed and then gradually changed into farmland. Because of this shortage of grazing field, farmers have owned small numbers of animals. As result, accelerated soil erosion and fertility decline become the main problem of the area once the forest cover was lost, (Kibamo, 2011).

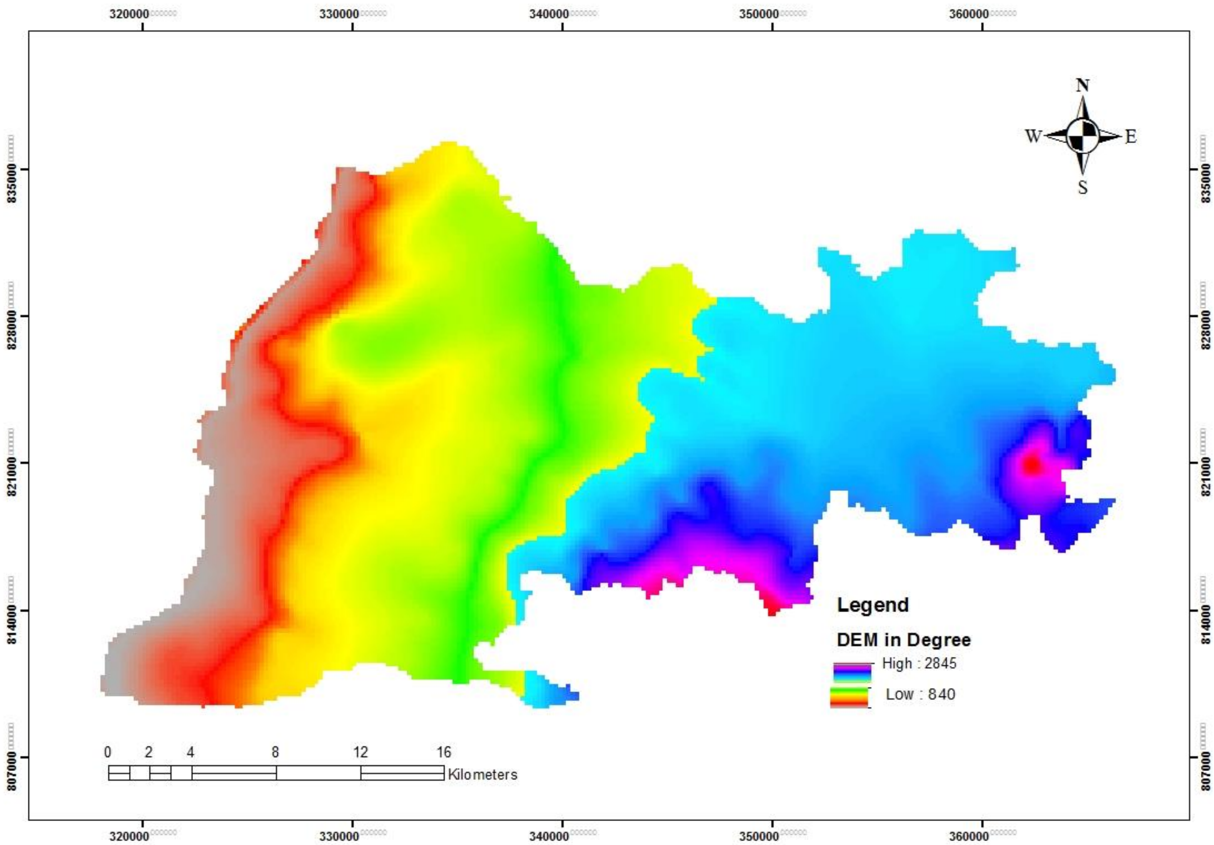


Figure 3: Dem Map of Soro District

3.2 Research Design

This study involved primary and secondary data collection techniques. Landsat satellite images of the study area were acquired for three periods; 1987, 2002 and 2017. Satellite imageries were used to classify the land use/land cover of the study area at different periods. This includes a computer based analysis of the data using GIS techniques and field observation to obtain the necessary information required for the study. These images were obtained from United States Geological Survey (USGS). The images were extracted to Tiff formats for processing and the detail of image properties are summarized in below. The images were acquired from the period January – February, as this is a clear sky season in the region, reducing atmospheric and radiometric problems. Images were composed in different ways in order to identify surface features in the study area. True color composite usually known by RGB 321 combination where band 3 reflects red color, band 2 reflects green and band 1 reflects blue color. Another composite called “false color composite" which uses an RGB combination of 432. In this band combination band 4 represents the NIR infrared, band 3 belongs to red and band 2 to green. This combination gives better visualization in identifying vegetation which looks red in 432 combinations. Figure 6 illustrates maps of the study area generated using the false color combination.

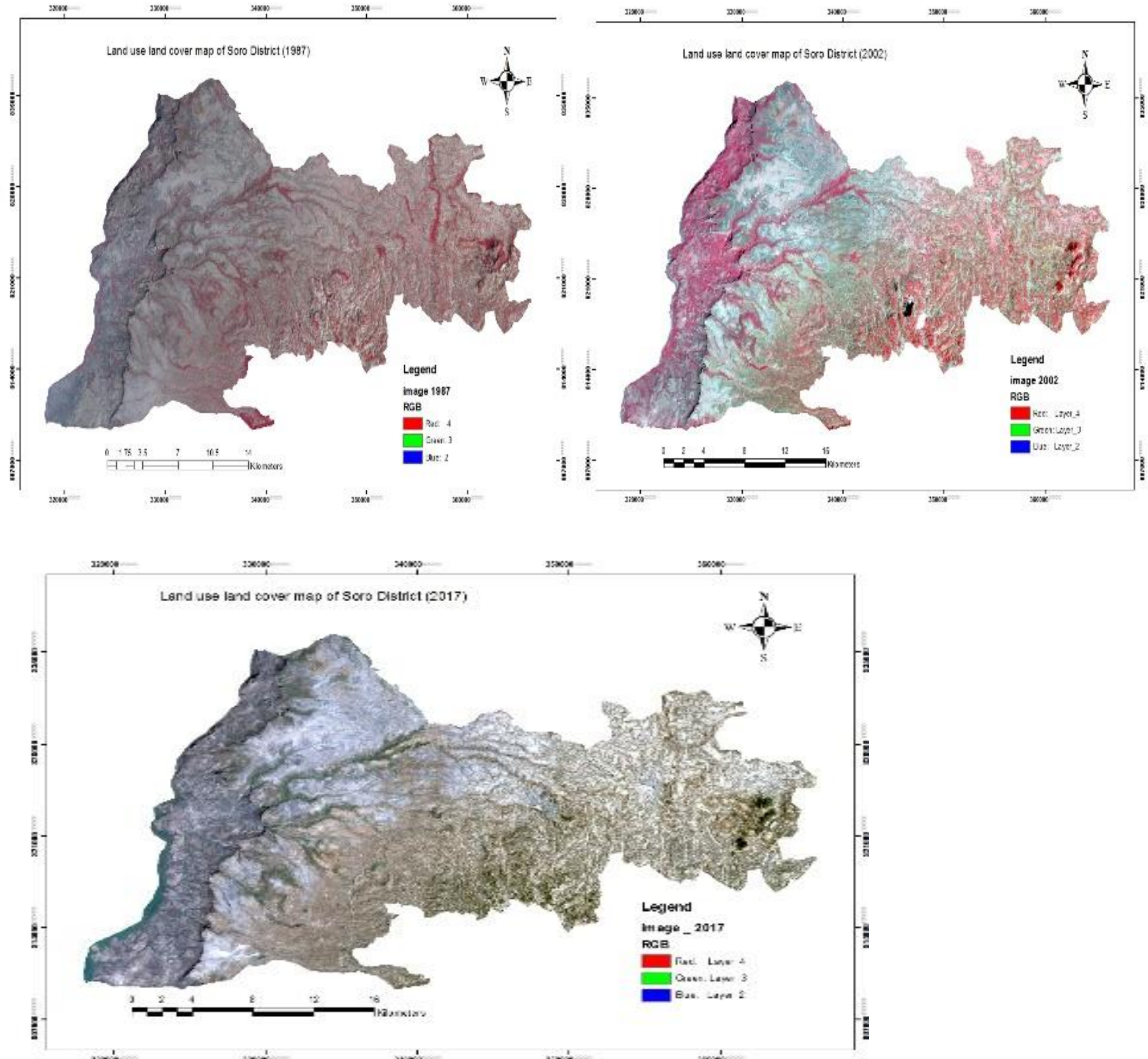


Figure 4: False Color Composite **of** 1987 (left), 2002(right) and 2017 (bottom)

3.3 Source of Data

To detect changes LULC remotely sensed imageries were utilized at different period intervals: three satellite imageries.

Table 3: Data Source Characteristics

No	Data Type	Sensor	Path/Raw	Resolution	Source
1	Landsat Image	MSS	169/55	60m by 60m	USGS
2	Landsat Image	TM	169/55	30m by 30m	USGS
3	Landsat Image	ETM	169/55	30m by 30m	USGS

In this study the investigator used both primary and secondary data sources in order to collect necessary information to this study.

Primary source: primary data was collected through survey by GPS, Key Informant Interview (KII), Focus Group Discussion (FGD) and personal observation.

Secondary source: To add supportive concepts and findings from the primary data, secondary data such as review of related literature, research reports, project reports, seminar papers, and report and official documents were collected.

3.4 Tools of Data Collection

The methods of data collection depend on the nature, the objective, and the method of data analysis and the scope of the study. The availability of data, finance, time, personal and other facility also influence the selection of method to be used for the study. The main instruments of primary data collection were GPS, different software, key informant interviews and focus group discussion was tools used in collecting primary data.

3.4.1. GPS

Geographic Position System (GPS) was used to collect geographic coordinate values in (UTM, Lat-Long). The geographic coordinate values were used as ground control points (GCP) to locate field photographs on satellite image for supervised classification and identify market access. The field photographs were used as signature of land cover class which helps as region of interest in supervised image classification.

3.4.2. Software

Different software's were used effectively to conduct the research. ArcGIS 10.3 – This was also used to compliment the display and processing of the data.

ERDAS Imagine 2014 – this was used for displaying and subsequent processing and enhancement of the image. It was also used for the carrying out of the study area from the whole scene imagery using administrative boundary data. The land LULC classes were also developed using this software.

3.4.3. Key informant interviews

This method is useful in all phases of development activities identification, planning, implementation, and evaluation. For example, it can provide information on the setting for a planned activity that might influence project design. Or, it could reveal why intended beneficiaries aren't using services offered by a project (USAID, 1996).

Accordingly 15 key informants were selected purposely to collect data about causes of land cover change and related problems in the study area.

Then, key informant interview as one of data collection methods was carried out with knowledgeable and experience rich experts from the agriculture and rural development office, natural resource experts, development agents, NGOs and forestry sites from district selected purposively as to generate relevant information.

In this study the investigator used semi-structure interview because of its flexibility and to make clear any time when there is ambiguity. Key informants were selected for interview to collect qualitative data. It was conduct in face to face approach.

Table 2 Sample respondents for interview

No	Respondents	Number of interviewer
1	agriculture and rural development office	6
2	Natural resource expertise	4
3	Development agents	3
4	NGOs agent	2
	Total	15

Source: Field Survey, 2017

3.4.4. Focus Group Discussions

The focus group discussion (FGD) is a rapid assessment, semi-structured data gathering method in which a purposively selected set of participants gather to discuss issues and concerns based on a list of key themes drawn up by the researcher/facilitator (Kumar 1987).

The choice of participants depends on the topic of the focus group. Often, the people who are included are those knowledgeable about the topic but at the same time, it is also wise to gather the views of certain groups in the target population. The optimal number of participants is 8 -10 (Morgan, 1988).

Focus group discussion (FGD) was conducted in the selected five villages of the study area, and in each villages one focus group discussion had been conducted. Each focus group discussion was composed of 8-10 individuals who were selected based on the (Morgan, 1988) and following parameters such as, age groups, sex and socio economic status .The participants of focus group discussion were elders, village administration, model farmers and longtime environmentalist and 40 informants were selected purposively from the District.

A checklist of questions were used to guide the discussions which availed information that could not be picked by using primary data sources. Such information included interested questions to capture the historical trends over time with regards to land cover dynamics including forest cover change, wet land, shrub grass land and agricultural land expansions. It also intended to obtain information on institutional arrangements regulating land use, population dynamics and community awareness about the land use.

Table 3 Sample respondent for focus group discussion

No	Respondents	Number of participant
1	Community elders	12
2	Village Administration	6
3	Model farmers	14
4	Long time Environmentalist	8
	Total	40

Source: Field Survey, 2017

3.4.5. Field observation

The observation acted as a cross checking mechanism for the extent of during the field observation in the study area. The researcher observed the forest cover, wet land, shrub grass land and cultivated land .The researcher used check list during field observation. Then field visits to site was carried out to obtain ground control points using Garmin GPS 72 H tool for data collection.

3.5 Development of a Classification Scheme

Based on the prior knowledge of the study area and a brief reconnaissance survey with additional information from elders, a classification scheme is developed for the study area as fallow:

Table 4 Description of each land use class

Landover classes	Description of each land use class
Cultivated land	Areas allotted to rain fed crop production, mostly of cereals in subsistence farming
Forests	Areas covered by trees forming closed or nearly closed canopies; predominant species like Juniperus procera.
Shrub grass land	Land covered by small trees, bushes, and shrubs, in some cases mixed with grasses; less dense than forests or areas with a cover of shrubs and short trees mixed with grasses
Wet land	Represents most plains areas with frequent flooding event during the rainy season and water table is at, near, or above the land surface for a significant part of most years

3.6 Methods of Data Analysis

The main methods of data analysis were adopted in this study.

3.6.1 Pre Classification

Land use classification is the extraction of differentiated classes of land cover and land use categories from remotely sensed data. Pre-field image processing was done using false colour composite of bands 4, 3, and 2 in RGB (Red Green and Blue) band combination by using ERDAS Imagine 2014 software. This is because vegetation cover reflects more at infrared region than visible band. At true colour composite only green band was reflected and the other bands was absorbed for photosynthesis by chlorophyll. Since the acquired satellite image was already geo-referenced, there is no need of geo referencing of the acquired satellite image. Then the original satellite image was subset by using ERDAS Imagine 2014 to fit the digitized study area that was delineated based on the watersheds.

3.6.2 Classification

Classification of a satellite image can be done either by supervised or unsupervised procedures. A supervised approach relies on the prior specification of training areas, in which major land cover types are delimited manually as a key for electronically classifying the image. In contrast, no such visual interpretation is involved in an unsupervised method. It uses automated methods to cluster reflectance values in order to derive a required number of land classes and their associated spectral signatures. This was supplemented by a number of field visits that made it possible to establish the main land use land cover types. The classification of changed area may be performed according to any desired decision rule like maximum likelihood, minimum distance and decision trees. For this study a supervised classification scheme with maximum likelihood classifier decision rule was used by following three stages, assigning training sites, classification and outputs.

3.6. 3 Post Classification

Post-classification change detection technique, performed in Arc GIS 10.3 was employed by the study. This approach is generally considered the most obvious approach to change detection (Liu and Zhou, 2004). It requires the comparison of independently classified images of the same study area acquired over two different time periods(Serra et al., 2003).

By properly coding the classification results for times 1987, 2002 and 2017, the analysis were produced a change map showing a complete matrix of changes (e.g., change from wetland to cultivated land and shrub grassland to forest). The principal advantage of post classification comparison lies in the fact that the two dates of imagery are separately classified; there by minimizing the problem of radiometric calibration between dates (Copping, 2004). If the same type of satellite imagery for two different periods of time that are necessary to achieve a particular objective set in a project is lacking and two completely different but similar or comparable satellite data are available, this approach can be effectively used because classification is done independently. This is the case for most projects that examine change over a longer duration between two time periods and one type of remotely sensed data is not available for both dates. The important issue to be considered in this study is the spatial resolution of two different Landsat images (e.g., 60m MSS data and 30m TM data). For these reasons, the researcher employed the post-classification change detection approach.

Majority Analysis: Classified data often manifest a salt-and-pepper appearance due to the inherent spectral variability encountered by a classifier (Lilles and & Kiefer, 1994) and it is often desirable to smooth the classified output to show only the dominant (presumably the correct) classification. Moreover, classified images often suffer from a lack of spatial coherency (speckle or holes in classified areas). Low pass filtering could be used to smooth these images, but the class information would be contaminated by adjacent class codes.

Class Statistics Analysis: This is another post classification technique, which helps to know what percent, and area coverage of each land use land cover has for each period.

Accuracy Assessment: The other crucial post classification technique is the accuracy assessment by which the overall accuracy of satellite image classification as compared with the actual condition could be compared. Finally image differencing between two produced maps in order to detect change was made. Normally, the map from t1 is compared with the map produced at time t2, and a complete matrix of categorical change was obtained. The simple approach consists of comparing the properly coded results of two separate classifications. So that, the comparisons based on three satellite images based classified maps, 1987, 2002 and 2017 were made. The first comparison was between 1987 and 2002; and the second comparison was between 2002 and 2017 maps. Based on the comparison by using spatial statistics the land use land cover change was detected. Also the direction of change was analyzed by change detection statistics and presented in change detection matrix (Table9,10 and Table 11).

3.6.4 Calculation of the area in hectare and percent of the resulting LULC

These method was used for identifying change in the land use types. The comparison of the LULC statistics assisted in identifying the percentage change, trend and rate of change between 1987 and 2017. In achieving this, the first task was to develop a table showing the area in hectares and the percentage change for each year (1987, 2002 and 2017) measured against each LULC type. Percentage change to determine the trend of change can be calculated by dividing observed change by sum of changes multiplied by 100.

$$\text{Percentage change (trend)} = \frac{\text{observed change}}{\text{Sum of change}} \ldots\ldots\ldots\ldots (3.0)$$

In obtaining annual rate of change, the percentage change observed in the study period is divided by the number of years in the study period i.e. 1987– 2002 (15years) and 2002 – 2017(15 years).

In this study, a total test samples of 120 for image 1987, 105 for image 2002 and 140 for image 2017 were randomly selected respectively from the original images of 1987and 2002 and Google earth for the images 2017. In addition for 1987 and 2002 images some of the sample points were supported by local area elders as “what was there at what time” and for 2017 visual observations was carried out. The researcher has examined the test sample plots and assigned a class value to each. The accuracy assessment was conducted for each classification result. Thus, agreement and disagreement of the analysis is evaluated by using an error matrix and mathematical equation .

Socio – economic data of both quantitative and qualitative dates were obtained from field survey by using FGD, KII, Digital camera and field observation was analyzed through descriptive statistics (using tables, percentages, pie charts and figures). Key informant interview was prepared to identify the causes of land cover change in the study area. Both close and open ended questions were designed and distributed for the key informants and the data was analyzed through descriptive statistics.

Generally, the method followed in this study is presented (Figure 7) It shows the steps followed beginning from the acquisition data and classification of satellite images of the study area to the extraction of the required information and output.

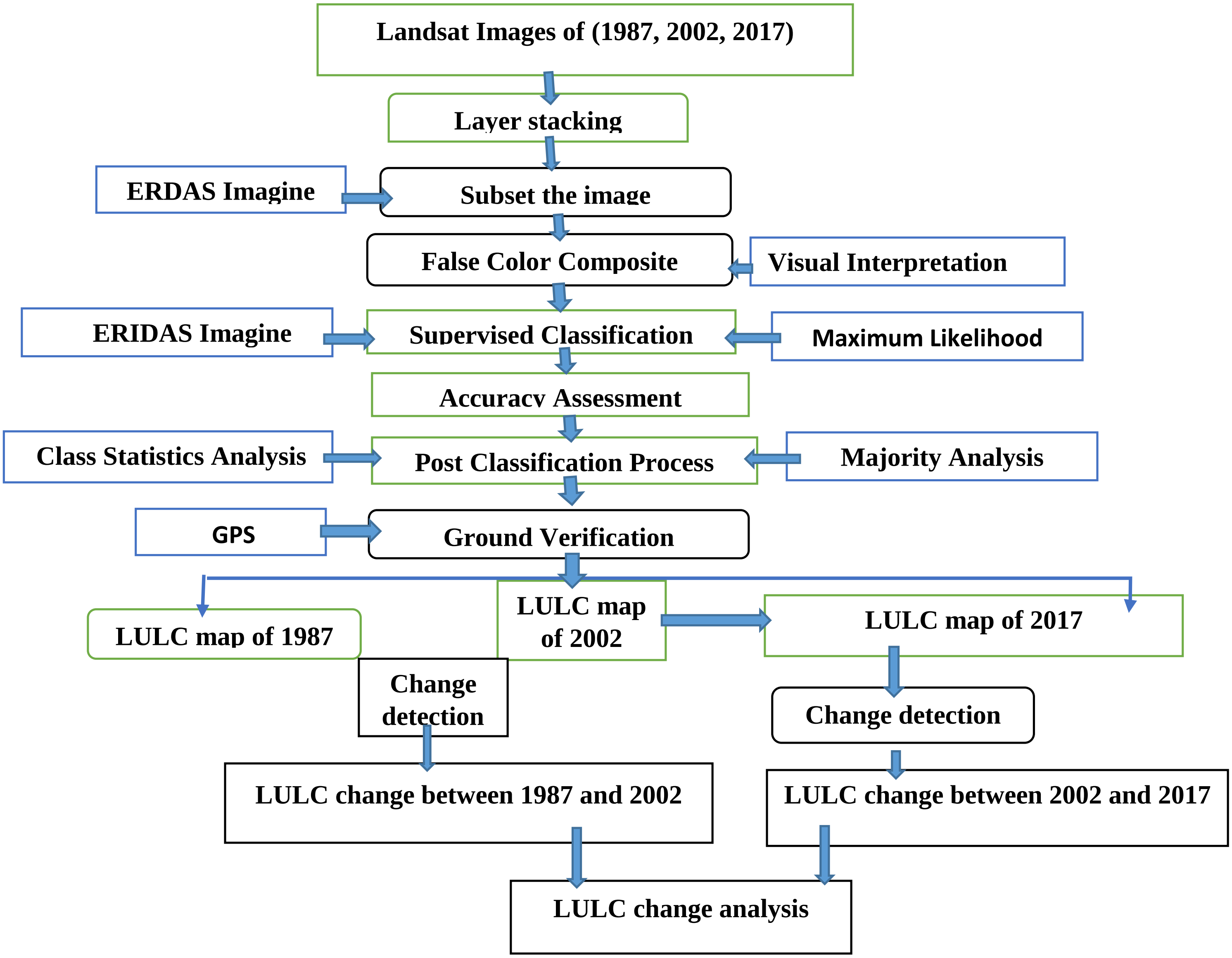


Figure 5: Flowchart of Research Procedure

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4. INTRODUCTION

Change detection, one of the post-classification activities. The most common approach for monitoring the LULC change since it provides more useful information between the initial and final LULC types in a complete matrix of change direction (Campbell, 2002). The classification and quantification of images of the study area over the study periods was necessary in the detection of changes of different LULC categories. The static land use land cover distribution for each study year (1987,2002, and 2017) as derived from the maps are presented in the table below.

4.2 LULC mapping

Using the application of image classification methods, four major land use and land cover types were identified. These include forest, wet land, shrub grass land and cultivated land based on the characteristics of Landsat satellite images of the year 1987, 2002 and 2017.

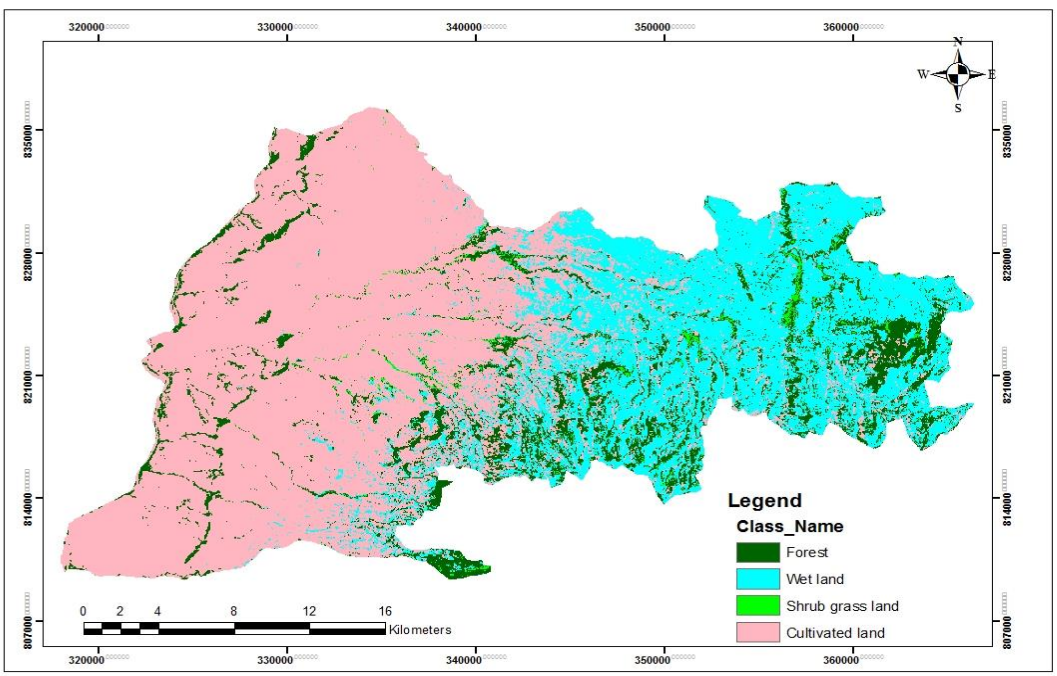


Figure 6: LULC map of Soro District, Hadiya Zone for 1987

The major land use/land cover classes of 1987 include agricultural land, wet land, forest and, shrub grass land. As indicated in (Figure 6) the greatest share of LULC from all classes was cultivated land, which covered an area of 34,478.85 ha, contributes (48.83%) of the total area. Wet land and shrub grass land an aerial size of 18,291 ha (26%) and 9,701.19 ha (13.73 %) respectively. Whereas the aerial coverage of forest is 8,135.55 ha (11.52%) from the total area of the district. This shows that 51.25% of the total area of the district was covered by shrub grass, forest and wet land in 1987 and the remaining 48.75% was covered by agricultural land.

This finding agrees with that of Gete and Hurni (2001) and Solomon (2005), who indicated an increase of cultivated land in Anjeni area and Headstream of Abay Watershed respectively, both in northwest Ethiopia. On the other hand, it differs from Woldeamlak's report (2002), which showed a decrease of this land cover type and increase forest land in Chemoga watershed, between 1957 and 1998.

Table 4: Interpretation result of map Soro district in 1987

	Period 1987	
Land use/Land cover class	Area in ha	Percent
Cultivated land	34,478 .85	48.83
Wet land	18,291.78	26
Forest	8,135.55	11.52
Shrub grass land	9,701.19	13.73
Total	70,607	100

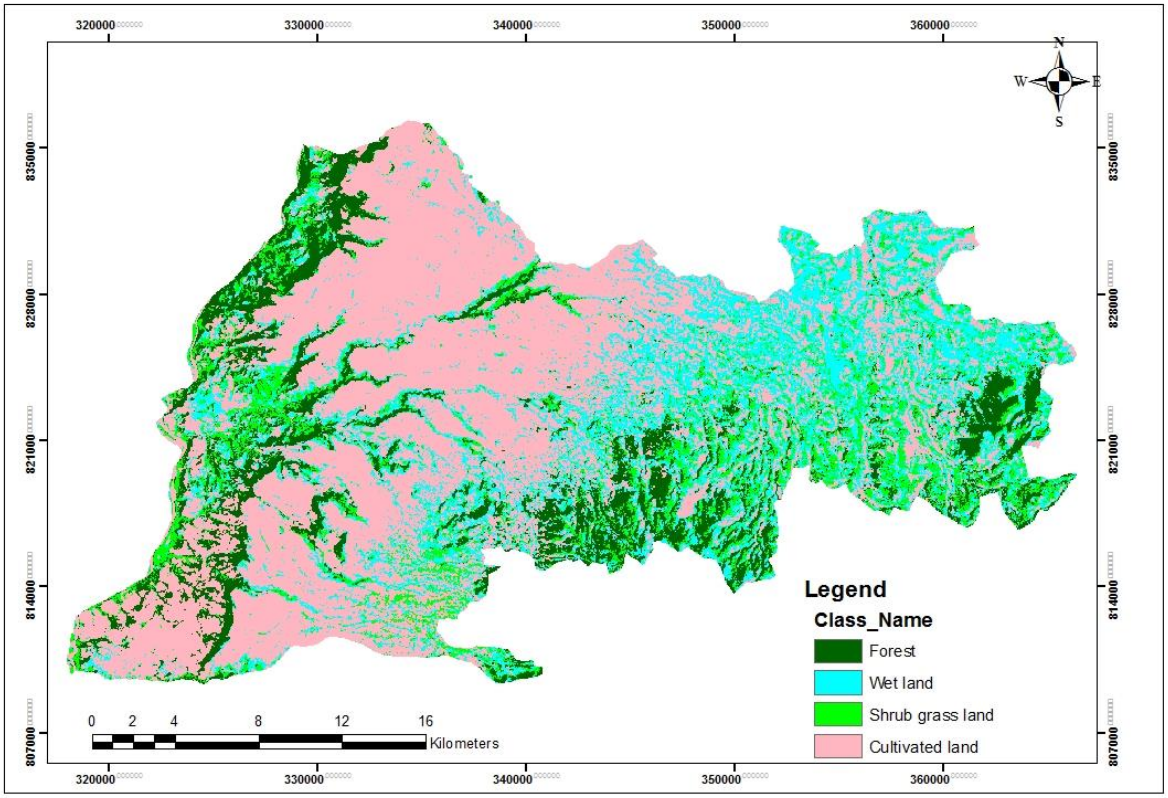


Figure 7: LULC map of Soro District, Hadiya Zone for 2002

Where as in the case of 2002 the major land use/land cover classes were forest, cultivated land, wet land and shrub land. As indicated in (Figure 7) the greatest share of land use/land cover from all classes is Cultivated land, which covers an area of 49,905 ha (56.56%). Cultivated land and wet land cover an aerial size of 19,536 ha (27.6 %) and 7,648 ha (10.8 %) respectively. The least aerial coverage is shrub grass land, which has only 3,517.5 ha (5 %) from the total area of the district. This finding agrees with that of Woldeamlak's report (2002), who indicated an increase of forest land in Chemoga watershed, between 1957 and 1998.

Table 5: Interpretation result of map soro district in 2002.

	Period 2002	
Land use/Land cover class	Area in ha	Percent
Cultivated land	19,536.12	27.66
Wet land	7,648.1	10.83
Forest	39,905	56.51
Shrub grass land	3,517.5	5
Total	70,607	100

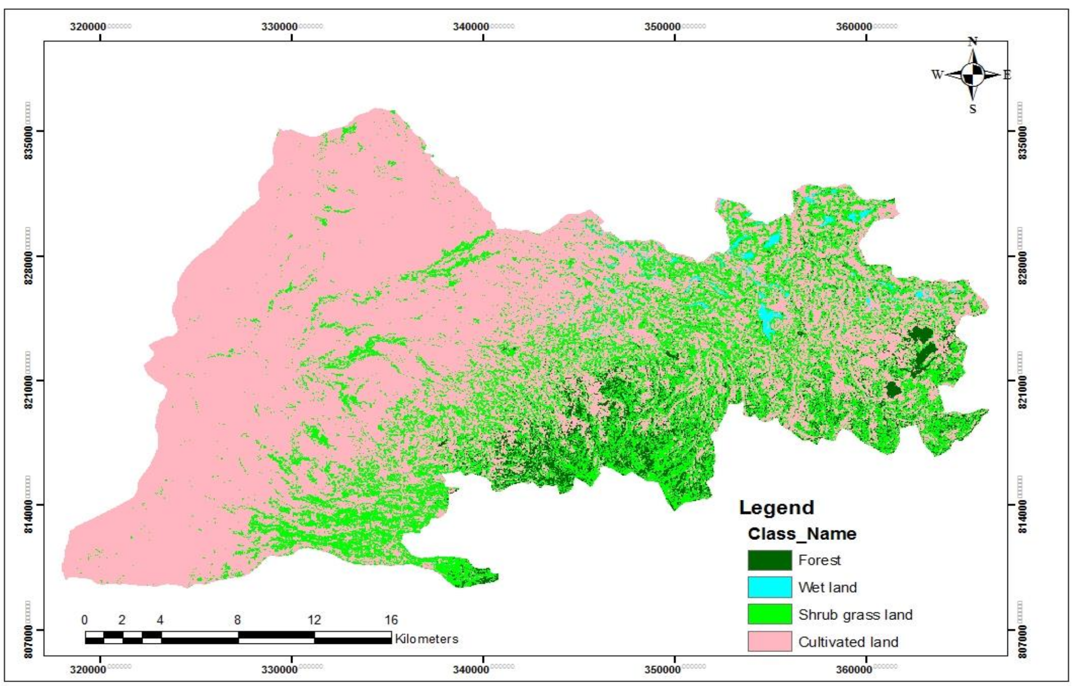
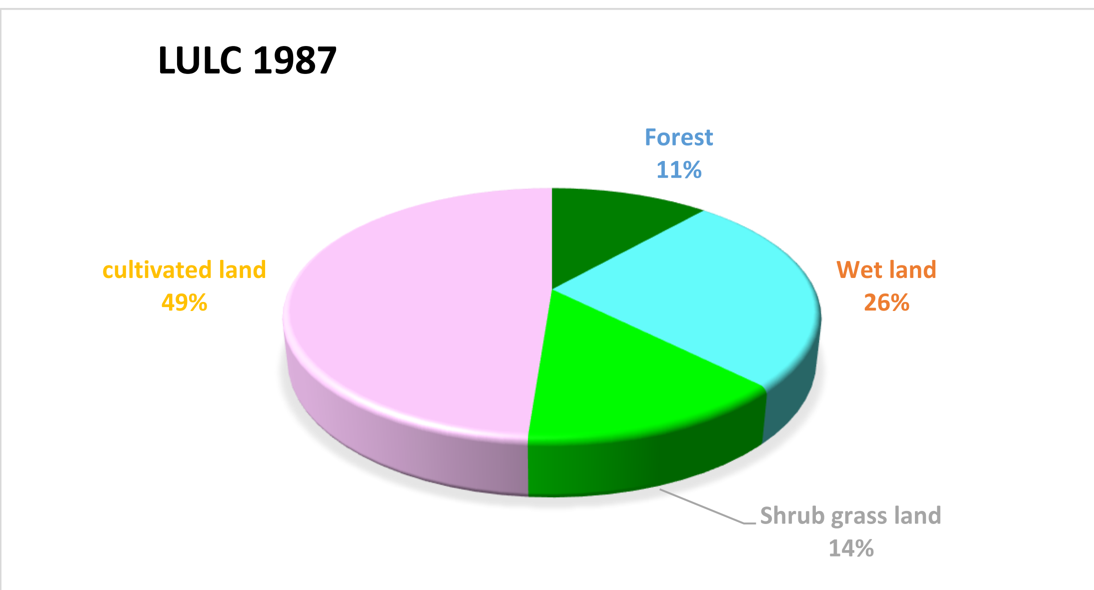


Figure 8: LULC map of Soro District, Hadiya Zone for 2017

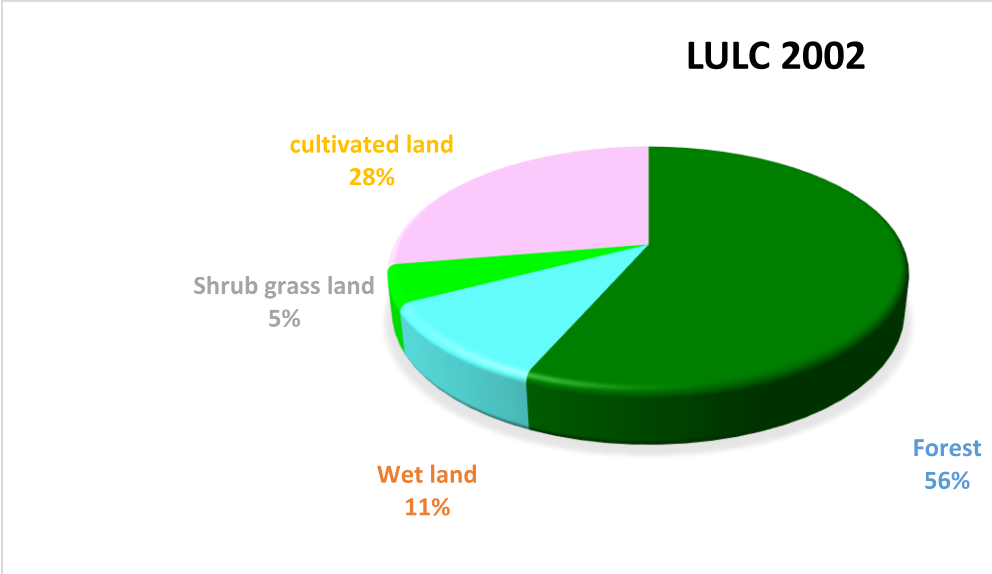
During 2017 the major land use/land cover classes include cultivated land, shrub grass land, forest land and wet land but all the land use classes have different aerial coverage from the previous time. As indicated in (Figure 8) the greatest share of land use/ land cover from all classes is cultivated land, which covers 45,385.74 ha (64.27%) almost above half of the total area of the district. Shrub grass land and forest covers 5,641.92 ha (8%) and 18,704.97 ha (26.5%) respectively. The least area is covered by wet land, which is 874.44 ha (1.23%) from the total size of the district. The cultivated land is cover largest area in 2017 which depicts conversion of other land cover classes to cultivated land. This finding agrees with that of Mamo (2009) who indicated the greatest share of land use/ land cover from all classes is cultivated land in Kacebira district, Kmbata zone, southern Ethiopia.

Table 6: Interpretation result of map Soro district in 2017

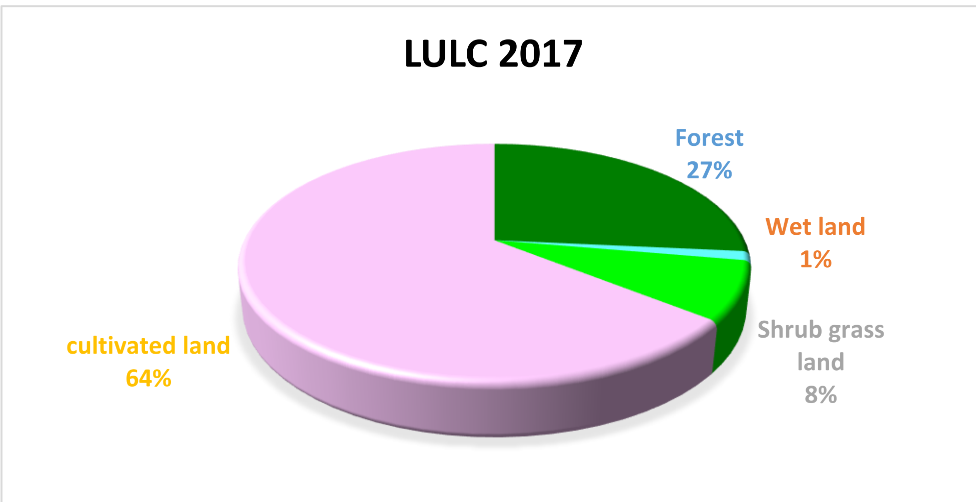
	Period 2017	
Land use/Land cover class	Area in Ha	Percent
Cultivated land	45,385.74	64.27
Wet land	874.44	1.23
Forest	18,704.97	26.49
Shrub grass land	56,41.92	8
Total	70,607	100



Graphical Representation of LULC Classes for the Study Year1987



Graphical Representation of LULC Classes for the Study Year2002



Graphical Representation of LULC Classes for the Study Year 2017

Forest land increased in 2017 compared to 1987 the reason is an attempt to recover the lost forest cover through afforestation program was practiced in the area during the second study period. As a result the coverage of forest increased between 2002 and 2017 (the second study period) and on the whole entire period 1987 and 2017 (three decades under study) the major change on forest between 1987 and 2017 has been basically characterized by introduction of Acacia decurrens and increasing of Eucalyptus trees Asmamaw,(2013). This can partly be attributed to the change in state policy in 1997 to rights of disposal of individually owned trees and to the increase in seedling availability. Two agricultural centers were established and started provision of different seedling without any cost and with little charge on some of them. Of the many seedlings provided at a time Acacia decurrens have gotten a wide acceptance Amare, (2013).This is because of its match with the degraded soil, high growth rate, wanted for charcoal production and the ability revive the fertility of soil. After cutting the Acacia decurrens trees farmers plow this land and they are obtaining good crop products.

4.3 User's Accuracy

Results of user's accuracy in this study showed that in 1987 the maximum class accuracy was 91.3%, which was wet land where correctly classified and the minimum was shrub grass land class with an accuracy of 84.61% as presented in table 7 below. In 2002, the class accuracies range from 78.9% to 91.4% where as in the period 2017, it ranges from 84.61% to 92.3% as indicated in tables 8 and 9 respectively. The lowest values of class accuracies were misclassified due to spectral property similarities among other land cover classes.

As shown in tables 7 ,8 and 9, the user's accuracy was lowest for shrub grass land as some of the shrub grass land areas were misclassified as forest , cultivated land and wet land. Moreover, the time of image acquisition has a great role for such misclassification problems. Since the images obtained during the dry season where most irrigation activities were carried out in the study area, other land cover classes appears agriculture and vice versa (Mesfin, 2009).

As indicated in the classification scheme cultivated land, grassland, wetland and forest area are the major LULC classes for the study periods. The classified images were acquired, when crop harvesting had already started, and farmlands appear bare and grasslands look relatively bright in their color. Regarding vegetation, there were relatively undisturbed areas that had been serving as a home for some wild animals with varying levels of density, ground cover and disturbance. Some of these forests have been sources of wood for house construction, household energy and farm implements (Bireda, 2015).

Table 7: Confusion matrix for LULC map of the Soro District, Hadiya Zone in 1987

Class name	Forest	Wet land	Shrub grass land	Cultivated land	Corrected classify	Total	User accuracy
Forest	27	0	4	0	27	31	87.096%
Wet land	0	21	0	2	21	23	91.3%
Shrub grassland	3	0	23	0	23	26	84.61%
Cultivated land	0	5	0	35	35	40	87.5%
Total	30	26	27	37	106	120	
Producer accuracy %	90	80.76	85.2	94.6			
Over all accuracy %			88.33				
Kappa statics			83.1				

Table 8: Confusion matrix for LULC map of the Soro Dstrict, Hadiya Zone in 2002

Class name	Forest	Wet land	Shrub grass land	Cultivated land	Corrected classify	Total	User accuracy
Forest	26	0	3	1	26	30	86.66%
Wet land	0	18	1	2	18	21	85.7%
Shrub grassland	3	1	15	0	15	19	78.9%
Cultivated land	0	3	0	32	32	35	91.4%
Total	29	22	19	35	91	105	
Producer accuracy%	89.6	81.2	78.94	91.4			
Overall accuracy%			86.6				
Kappa statics			81.86%				

Table 9: Confusion matrix for LULC map of the Soro District, Hadiya Zone in 2017

Class name	Forest	Wet land	Shrub grass land	Cultivated land	Corrected classify	Total	User accuracy
Forest	35	1	4	1	35	41	85.36%
Wet land	0	28	0	3	28	31	90.32%
Shrub grassland	2	1	22	1	22	26	84.61%
Cultivated land	1	2	0	39	39	42	92.3%
Total	38	32	26	44	124	140	
Producer accuracy%	92.1	87.5	84.6	88.63			
Overall accuracy%			88.57				
Kappa statics		84.56%					

4.5 Overall Accuracy

It is computed by dividing the total number of correctly classified pixels (i.e., the sum of the elements along the major diagonal) by the total number of reference pixels. It shows an overall result of the tabular error matrix.

Over all accuracy classification of the Landsat image (supervised classification) of the year 1987 was found to be 88.33% and the overall Kappa Statistics was found to be 0.831 (Table 7). Similarly, for Landsat image (supervised classification) of the year 2002, it was found to be

86.6% with Kappa Statistics of 0.8186 (table 8) and for Landsat image (supervised classification) of the year 2017 was found to be 88.57 % with kappa statics was found to be 0.8456 (Table 9).

The 1987 supervised classification with an overall accuracy of 88.33% was achieved with a Kappa coefficient (kappa) of 0.8318. This value implies a strong agreement with good accuracy, and is often multiplied by 100 to give a percentage measure of classification accuracy.

Applying the methods of Congalton and Green (2009) the above results represent strong agreement between the ground truth and the classified classes. In general, the maps met the minimum accuracy requirements to be used for the subsequent post-classification operations such as change detection(Anderson et al., 1976).

Therefore, the Kappa value of 0.8318 represents a probable 83% better accuracy than if the classification resulted from a random assignment. The Kappa result of 2002 and 2017 classified images are 0.8186 and 0.8456 respectively, which implies as the results are acceptable.

4.6. LU/LC Change Detection for 1987 to 2002

As indicated in the methodology part of this research paper, the change detection was made based on the classified maps of 1987, 2002 and 2017.

The change detection tables presented below are change matrices that depict what are changed to what. The column of the table represents the initial stage 1987 or 2002 and the row represents the final stage 2002 or 2017. The diagonal values of the table depict the unchanged values, which are found in both times images. Unlike the diagonal values the class change tells the total changed image areas of each LU/LC of the initial stages. Whereas the class total value of the column indicates the initial stage image total area of each LU/LC classes whereas the row total represents the final stage area of LU/LC classes.

LU/LC changes in all the land use types are not static; there is a significant LU/LC change observed in the area. The automated digital LU/LC change between the time periods of 1987 and 2002 and 2002 and 2017 is presented in the tables respectively.

Forest

The pattern of change for forest cover showed increase between 1987 and 2002 (first period). In 1987 the area under forest cover was 8,135.55 ha (11.6%) of the study area which increased to 39,914.42 ha (56.9%) in 2002 (Table 9) . The annual increase of forest cover was 2,660ha. From blow table 9 in 1987, 0.32% was converted into cultivated land, 4% into grassland, and 0.72% in to wet land and the remained 95% of the original area in the same category.The finding, it differs from Tesfa Worku Meshesha report (2016), which showed a decrease of forest land during 1984 and 2015 in the Beressa Watershed Northern Central Highland of Ethiopia.

Wet land

Wet land of the Soro district was located in the flat area around the Jajura village. It was one of the most disturbed land use type by human-induced LULC dynamic. As a result, the land use type showed continuous decline throughout the study period. During the initial study period, the wetland covered 26.62% (18,291.77 ha) of the total area of the district (Table 9). However, its size is reduced by 10.87% (7,648 ha) between 1987 and 2002.

The change detection matrix showed that about 17.4% (3,173 ha), 9.1% (1,682.3 ha) and 41 % (7,538.67 ha) was shifted to cultivated, shrub grass land and forest land respectively from 1987 to 2002 (Table 10).

Among the four LULC types, this is the most converted cover type during the entire study period. Wetland destruction and alteration has been and is still seen as an advanced mode of development, even at the government level (Abebe and Gaheb, 2003).

Shrub Grassland

In 1987, this category had the smallest areal proportion next to forest it is covered only 9,710.25 ha and 13.74% from the district. Its pattern of change showed a drastic decreased by 3,517 ha in the first study period which means from 1987 - 2002.

According to Table 10 conversion matrix for the year 1987 - 2002, 8,187.5 ha (84%) shrub grass land was transformed into forest. By the same period, 442 ha (4.5%) of shrub grass land was changed into cultivated land and 316 ha (3.2%) was changed in to wet land.

Cultivated Land

Agriculture has been the greatest force of land transformation on this planet. Nearly a third of the Earth's land surface is currently being used for growing crops or grazing cattle. Much of this agricultural land has been created at the expense of natural forests, grasslands, and wetlands that provide valuable habitats for species and valuable services for humankind(Millennium

Ecosystem Assessment, 2003). Cultivated land constituted 34,478.75 ha (48%), 19,535 ha (26.6%) in the years 1987 and 2002. In this period, cultivated land decreased by 19,535 ha (26.6%).

From 1987 – 2002, over 10.1% of each LULC types were changed into cultivated land. In the same period, about 46% of cultivated land remained unchanged and 54% was converted into forest, wet land and shrub grass land.

Table 10:Post-classification Matrix of Study Area between 1987 and 2002

	Forest		Wet land		Shrub grass land		Cultivated land		Total	
	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%
Forest	7728.75	11	59.22	0.08	321.48	0.45	26.1	0.036	8135.55	11.56
Wet land	7538.67	11	5897.8	8.4	1682.3	2.4	3173	4.5	18,291.77	26.62
Shrub grassland	8187.5	11.6	316.3	0.44	763.83	1.08	442.62	0.62	9,710.25	13.74
Cultivate land	16459.5	23.3	13,74.85	1.95	750	1.02	15,894.4	22.51	34478.75	48.83
Total	39914.42	56.9	7,648	10.87	3517	5	19535	26.6	70607	100

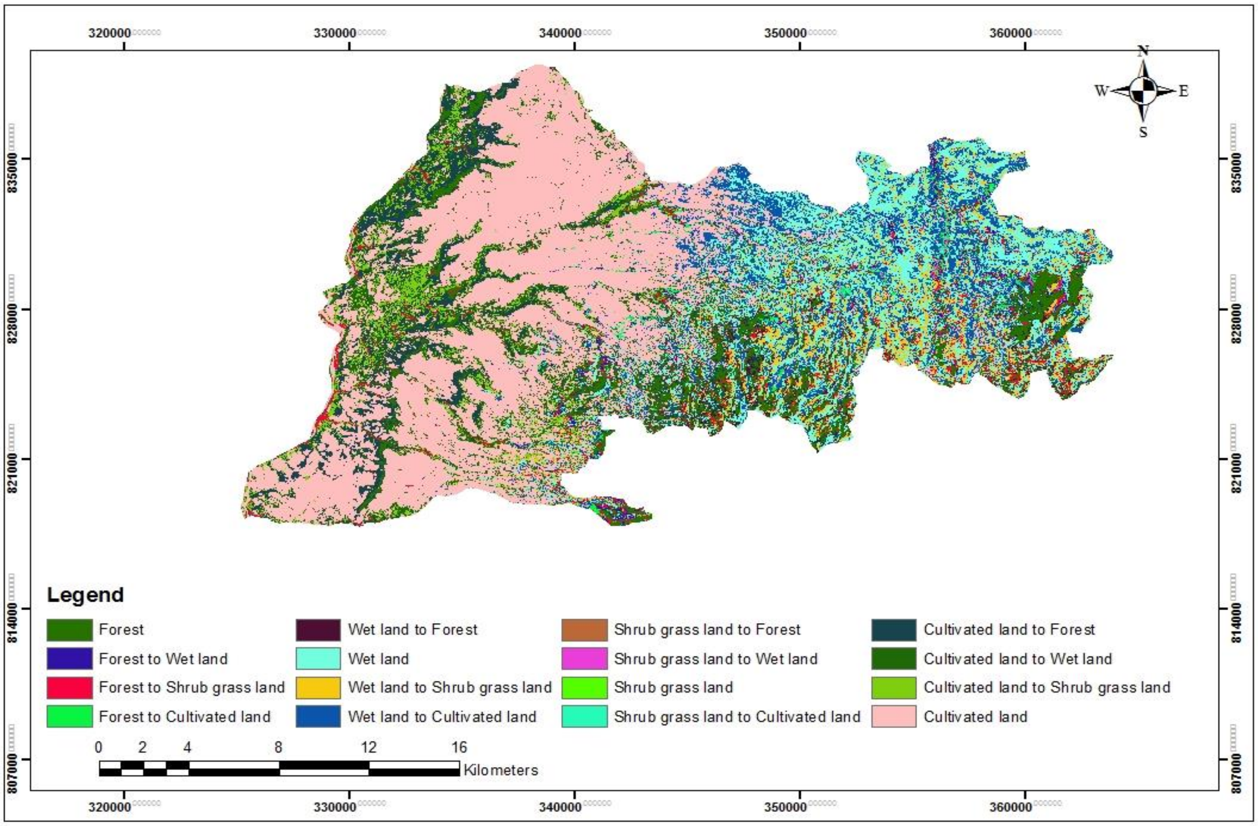


Figure 9: LULC change map of the Soro District, Hadiya Zone between 1987 and 2002

4.7 LU/LC Change Detection for 2002 to 2017

Forest

The pattern of change for forest cover showed a decrease between 2002 and 2017 (second period). In 1987 the area under forest cover was 8,135.55 ha (11.6%) of the study area) which increased to 39,905.37 ha (56%) in 2002 (Table 10) . Of the total forest area in 2002 was 39,905.37 ha and decreased to 18,704.4 ha (26.4 %) in fifteen years difference or in 2017. The annual decrease of forest cover was 1,247 ha. From (Table11) in 2002, 52.2% was converted into cultivated land, 7.7% into shrub grassland and 0.2% in to wet land and the remained 40% of the original area in the same category.

Wet land

The area under wetland was about 7,648 ha (10.76%) in 2002 but it was diminished to 874.45 ha (1.17%) in 2017 (Table 10). Between 2002 and 2017 4,705.38 ha (61.5%) wet land was transformed into cultivated land. By the same period, 1,431 ha (18.7%) of wetland was changed into shrub grass land and 795 ha (10.4%) was changed in to forest while 716 ha (9.4%) was unchanged.

Shrub grass land

In 2002, this category had the smallest areal proportion and it is covered only 3,517.5 ha (5%) from the district. But in 2017 it was increased by 3,517.5 ha to 5,641.92 ha (7.9%) from total district.

According to (Table 11) conversion matrix for the year 2002 - 2017, 3,517 ha (34.6%) shrub grass land was transformed into forest. By the same period, 1,389 ha (40%) of shrub grass land was changed into cultivated land and 9.12 ha (0.27%) was changed in to wet land

Cultivated land

Cultivated land covered 19,535.5 ha (27%), 45,385.52 ha (64%) in the years 2002and 2017. In this period, cultivated land increased by 45,385.52 ha (64%) in fifteen years interval.

In the 2002, about 94% of cultivated land remained unchanged and 6% was converted into forest, wet land and shrub grass land. In 2017 the cultivated land was increased from 19,535.5 ha to 25,850 ha (130%). The annual increase of cultivated land was 1,723 ha.

The result of this finding particularly the same finding of Shiferaw(2011) indicated that in his study it has been increased by 256 ha/year between 1972 and 1985. Different study elsewhere made by Gashaw et al. (2014), and Dessie and Kleman (2007), indicated that the size of cultivated land area have been intensively expanded at the expense of forest cover, bare land and grazing land without significant conservation measure.

Table 11:Post-classification Matrix of Study Area between 2002 and 2017

	Forest		Wet land		Shrub grass land		Cultivate land		Total	
	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%
Forest	15919.92	22.5	79.38	0.022	3079.26	4.36	20826.81	29.5	39,905.37	56.38
Wet land	795.06	1.12	716.05	1.04	1431.63	2	4705.38	6.6	7648	10.76
Shrub grassland	1219.6	1.72	9.72	0.013	898.83	1.27	1389.33	1.96	3517.5	4.96
Cultivate Land	770.4	1.09	69.3	0.098	232.2	0.32	18,464	26.15	19,535.5	27.65
Total	18704.4	26.5	874.45	1.17	5641.92	7.95	45385.52	64.2	70607	100

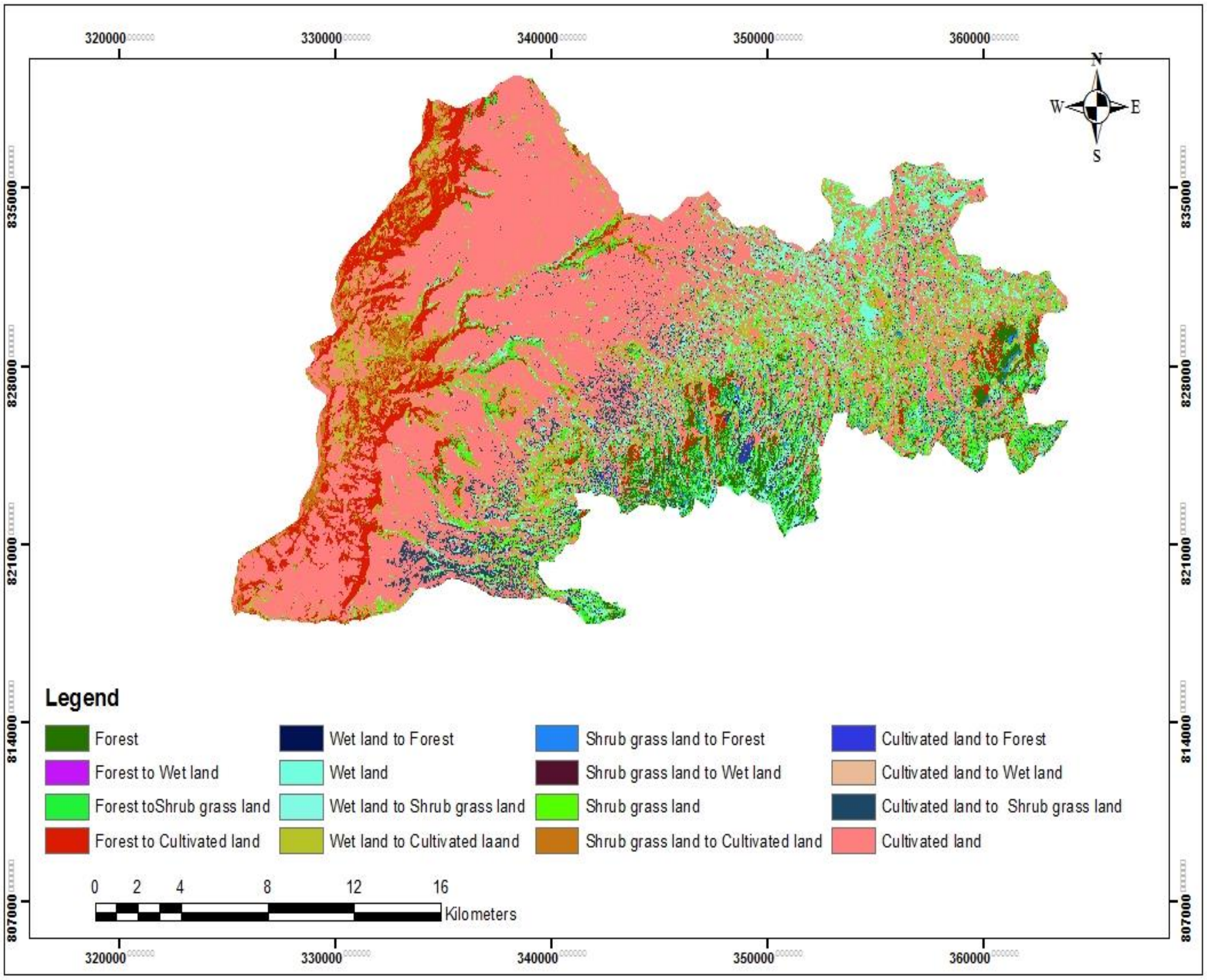


Figure 10: LULC Change map of the Soro District, Hadiya Zone between 2002 and 2017

4.8 LU/LC Change Detection for 1987 to 2017

Forest

The increase of forest in the first periods between 1987 and 2002 around by 8,135.6 ha (11.6%) to 39,905.37 ha (56.38) because the shrinkage of natural forest coverage attributable to regenerated and increased household and community level tree planting. The decrease of forest between 2002 and 2017 around by 39,905.37 ha (56.38%) to 18,704.4 ha (26.4 %) even though too small, given the increase in expansion of agricultural land and increase in population number, it is contradicted from the expectations. Therefore, over the 30 year time period in between 1987 and 2017 the share has increased by 8,135.6 ha (11.6%) to 18,704 ha (26.5%). On the basis of key informants of interview various major reasons have been positively contributed for the increase of share of forest coverage such afforestation, private and community level tree plantation ofsesbania susban, tree Lucerneand eucalyptus trees.

From blow (Table.12) in 1987, 32.2% was converted into cultivated land, 4.4% into shrub grassland and 0.05% in to wet land and the remained 63.4% of the original area in the same category.

In district level large amount of forest is found in Kosha, Shonkola, Danotora, Banara and Hangada this areas were protected by Shonkola World vision project from 1992 - 2007. After 2010 the project was leave the district. Now, these forests especially Shonkola forest and Kosha forest have controlled by Wachamo University from 2012 - 2017. Even if it is difficult to avoid deforestation of natural forests totally in the area, recently the concerned government bodies in collaboration with the local community are trying to protect.

An attempt to recover the lost forest cover through afforestation program was practiced in the area during the second study period before leaving the shonkola world vision project from 2002– 2014. As a result the coverage of forest increased between 1987 and 2002 (the first study period) and decreased in 2002 to 2017. While it is increased whole entire period 1987 to 2017 (three decades under study).

This finding agrees with that of Solomon (2005), who indicated an increase of forest cover in Headstream of Abay, in northwest Ethiopia.

Wet land

The coverage of wet land was decrease from 1987 to 2017 by 18,291.8 ha to 163.4 ha in the third study period which is presented in blow (table 12).

In the same period also, greater part of wetland 9,237 ha (50.5%) was changed into cultivated land. According to (Bireda, 2015) the conversion of most wetlands to cultivated land because wetlands have the capacity to grow crops without irrigation in winter season . The major crops which are cultivated on wetland areas of the Soro district are potato, wheat and maize. This LULC type is found around the plain areas of the landscape, which is more preferable for farming. About a 4,322.4 ha (23.6%) of the wetland was changed in to grassland between 1987 and 2017. Consequently, during the entire period, the area under wetland shrank by around 18,128 ha

(98.93%) with an average conversion rate of 604 ha/yr. The area changed from other categories into wetland was too small compared to land conversion from wetland to the other cover types. The area under wetland was about 18,291.8 ha (10.76%) in 1987 but it was diminished to 163.4 ha in 2017 (Table 12).

Shrub grass land

In 1987, this category had covered by 9,710.25 ha and 13.74% from the district but in 2017 it was decreased to 5,641.46 ha (8%). Its pattern of change showed a drastic decreased by 4,060 ha (41%) in the third study period which means from 1987 - 2017.

According to (Table 12) conversion matrix for the year 1987 - 2017, 4,460 ha (46%) shrub grass land was transformed into forest. By the same period, 4,627.8 ha (47.7%) of shrub grass land was changed into cultivated land and 23 ha (0.23%) was changed in to wet land. Also the finding agrees with Woldeamlak's report (2002), which showed a decrease of this shrub grass land in Chemoga watershed, between 1957 and 1998.

Cultivated land

Cultivated land constituted 49 %, 26% and 64% in the years 1987, 2002 and 2017, respectively (Table 10,11 and 12) From 1987_ 2017 , cultivated land increased by 34,478.6 ha (57.8%) to 45,385.5 ha (73.6%) in the third period (Table 12). In 30 years period, a transformation of cultivated land by 28,889 ha (84%) was observed no change but forest, wet land and shrub grass land area which shared 14%, 0.16% and 1.08% respectively.

According to Alelign Dessalew (2009) the greatest share of land use/ land cover from all classes is cultivated land from 1972- 2003 a case of Borena District in north centeral Ethiopia so my finding is agrees with him.

Table 42:Post-classification Matrix of Study Area between 1987 and 2017

	Forest		Wet land		Shrub grass land		Cultivate land		Total	
	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%
Forest	5142.96	7.3	4.14	0.005	356.76	0.50	2631.7	3.72	8135.6	11.52
Wet land	3941.2	5.6	790.8	1.12	4322.4	6.12	9237	13	18,291.8	25.92
Shrub grassland	4460	6.3	23.49	0.033	589.7	0.85	4627.8	6.5	9701	13.73
Cultivate Land	5160	7.3	55.98	0.079	373	0.52	28,889	49.9	34,478.6	57.8
Total	18,704	26.5	163.4	1.23	5641.46	8	45385.5	73.3	70607	100

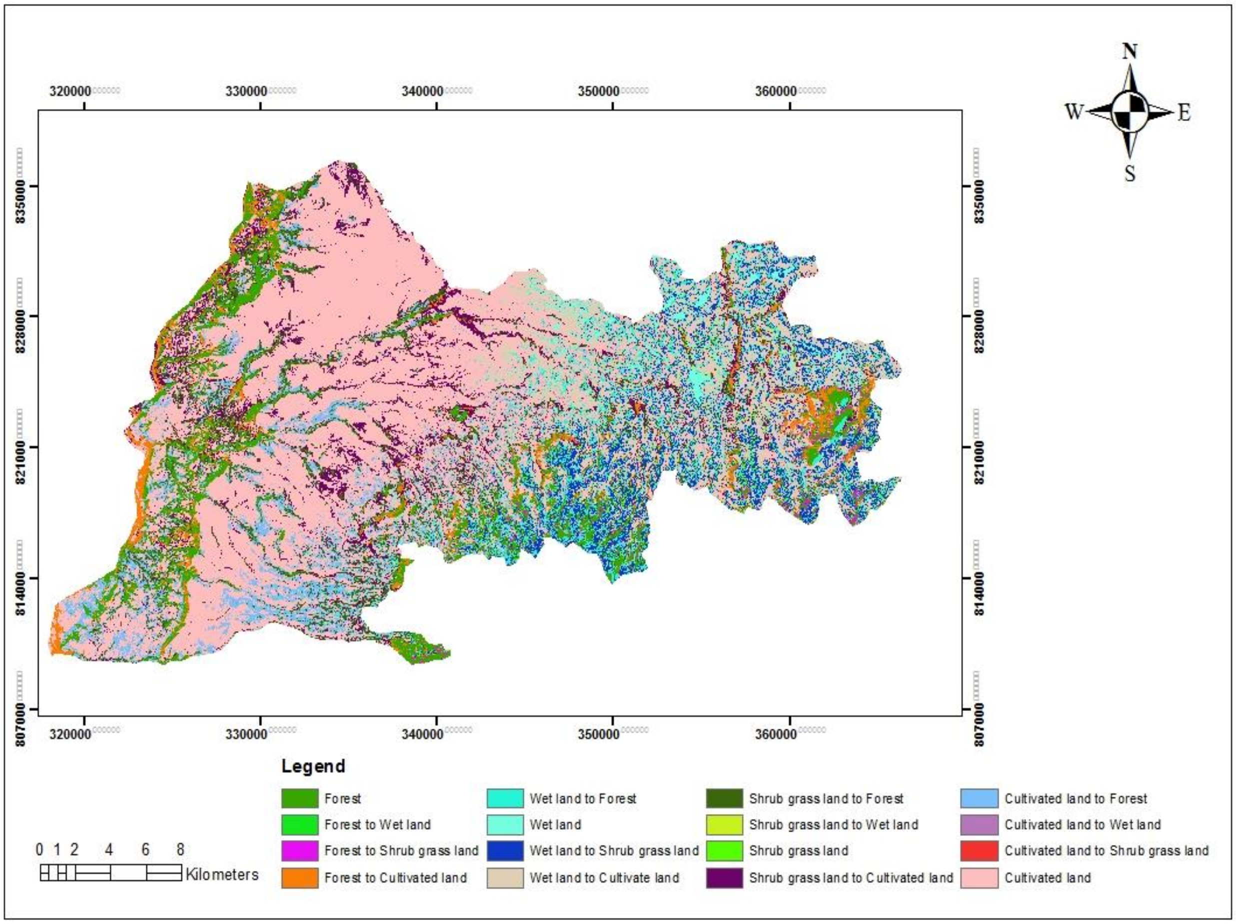
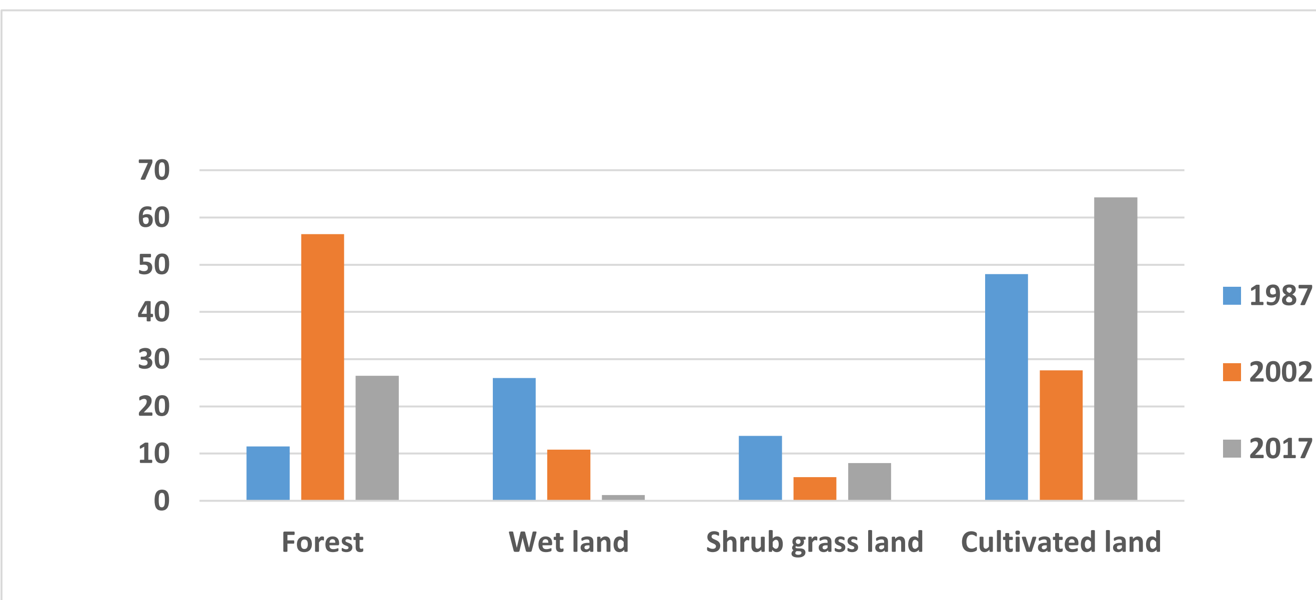


Figure 11 LULC Change map of the Soro District, Hadiya Zone between 1987 and 2017



Rate of land use land cover changes

Table 13:Summary of Magnitude and Rates of Change in LULC of the Study Area between 1987 - 2002 and 2002 - 2017.

	Year			Rate of change (he/year) and **%Δ**					
	1987	2002	2017	1987-2002	%Δ	2002-2017	%Δ	1987-2017	%Δ
Forest	8,135	39,905	18,704	+2,118	+32	-1,413.6	-3.12	+10,569	+14
Wet land	18,291	7,648	874.4	-709	-16	-451	-58	-17,417	-0.31
Shrub grassland	9,701	3,517	5,641.2	-412	-2.4	-270.7	-10.7	-4,060	-3.8
Cultivated land	34,478	19,536	45,385	-996	-3.77	+727	-15	+10,907	+8.8

From above Table.13 we observed that wetland, cultivated land and shrub grass land decreased by 709 ha/year, 412 ha/ year and 996 ha/year in the period of 1987 to 2002 and forest increased by 2,118 ha/year .This is because of the productive nature of wetlands for farming, the farmers were use the shrub grass land area for plant trees in the village level and degraded the land cover by soil erosion in Shonkola and surrounding villages. Subsequently, grassland, forest land and wet land decreased by 270.7 ha/year, 1,413.6 ha/year and 451 ha/year respectively from 2002 - 2017.Between 2002 to 2017 cultivated land increased by 727 ha /year.

4.9 Causes and impacts of land use land cover change in Soro district

4.9.1 Population pressure

Table 14 cause of land use land cover change

No	Cause for LULC change	Number of participant	Percent
1	Population growth	8	20%
2	Lack of proper management	10	25%
3	Deforestation	12	30%
4	Forest cover change	10	25%

Total	40	100%

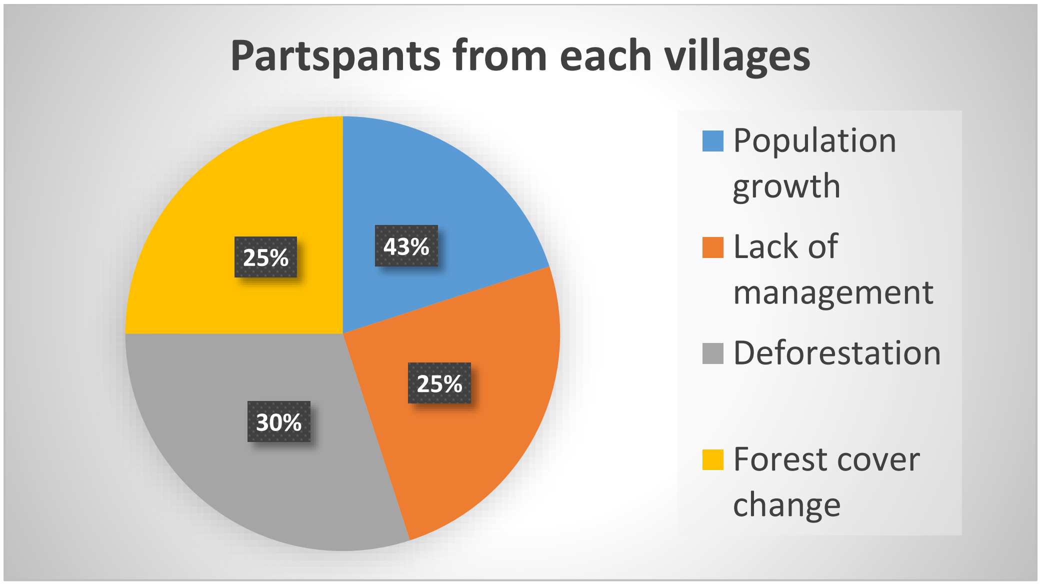


Figure 12 parts pants from each villages

According to respondents' response on the status of land compared to 30 years before, all of therespondents reported that has become scarce. The respondents also asked to justify their reason and accordingly table 14 indicates that about 43 percent of the respondents reported that population increase is the main cause for land scarcity. Lack of off (non) farm activities, an increased land degradation followed by drop in soil fertility were recorded as causes of land scarcity. Land redistribution which was reported by about 25% of the respondents could have accentuated land fragmentation.

According to data obtained from key informant interview growth and increasing land scarcity, which is the effect of the former, as the factor of the first order of importance of land use change in the district. Fast population growth and the consequent high pressure on resources are expected to have an adverse effect on the existing natural resources of the area.

Respondents were asked to identify the causes of this land use land cover change, according to Table 14, 43 percent of the respondents confirmed that population increase is the cause for the change followed by improved access to basic physical and social infrastructures.

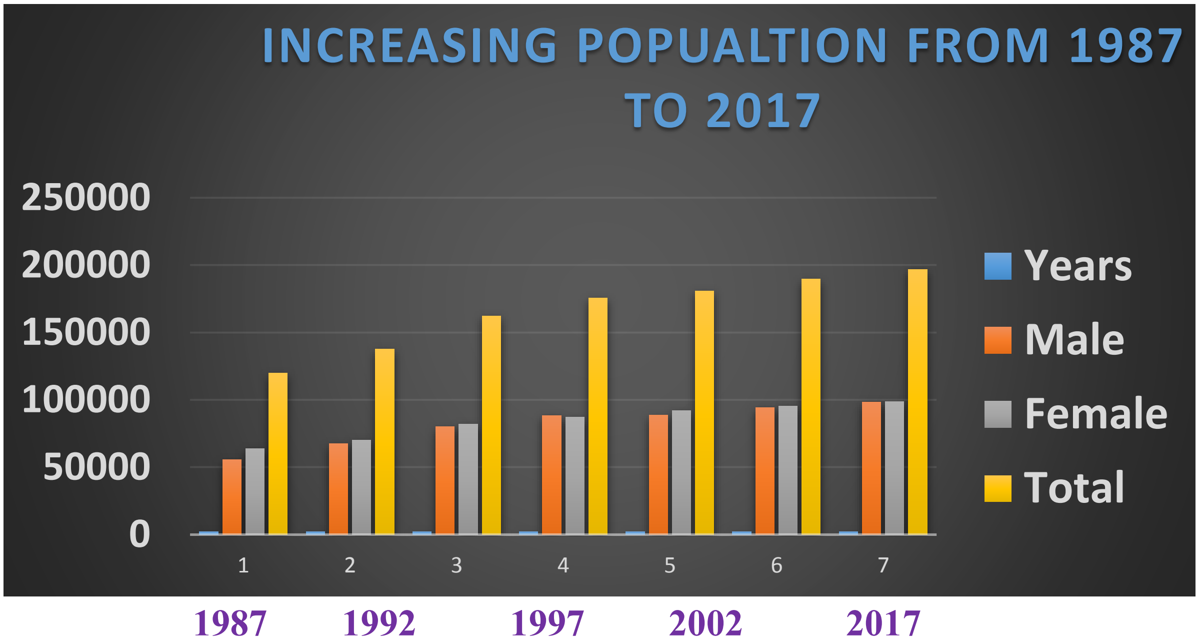


Figure 13 population from 1987 to 2017 Source: (District Finance and Economy Office)

4.9.2 Biodiversity loss

According to data obtained from the focus group, due to absence of clear forest tenure system the forest trees of the district were indiscriminately destroyed. In many parts of the district the indigenous trees are replaced by exotic trees like eucalyptus. As it was explained by the key informants, the decline of forest cover caused a decline in the number of wild animals. In some cases animals such as tiger, lion and antelope which were commonly found in the district before 30 years ago disappeared. Thus the conversion of forest land to other type of land use caused numerous negative impacts on the ecosystem as well as the livelihood of the society in the study area. According to Teshale Refera (2015) the major impact of the decline of forest in the study area results shortage of firewood, increase soil erosion and flooding in the surrounding areas. In addition to his finding the decline of forest in the study area results loss of plant and grass species. Due to decline of forest, increased runoff and reduces infiltration of water which contribute to flooding problems in the surrounding areas. Generally the decline of forest cover caused a decline in the number of wild animals.

4.9.3 Effect of Land use land cover change

4.9.3.1 Soil erosion

Respondents were asked to identify the environmental problems which are common in their localities following the land use/land cover change. According to Table 15, 50 percent of the sample household heads were replied that deforestation is the common effect followed by 45 percent respondents understanding that the effect is soil erosion.

Table 15 Effect of Land use land cover change

Effect of land use/land cover change	Number	Percent
Soil erosion	25	45
Degradation of water shade	12	21
Deforestation	28	50
Forest cover change	19	35
Total	55	100%

Source: Field Survey, 2017

The persistent deforestation happened in the district for decades due to different human activities especially for crop production together with the rugged landscape has exposed the study district to soil erosion. According to the information obtained from the DAs' (Development Agents) of the study area, upper slope and of the middle slopes are seriously affected by soil erosion. The explanation given was that much of the uplands and the escarpments were characterized by different human induced practices such as the clearing of natural vegetation for different uses, cultivation of steep slopes, in appropriate farming system and absence of soil conservation and soil fertility management methods. As a result, they lose much of their soil through water runoff.

Field observation in such areas recorded sheet erosion as well as numerous gullies that originated from the escarpment running down ward to the lower positions of the watershed .In the lower positions of gentle slopes, the gullies tend to narrow and become shallower because of the sedimentation process of the materials transported from upper slopes. However, the accumulation of sediments and its water logging nature especially during rainy season as well as soil depletion due to repeated cultivation were common agricultural problems in the low-lying areas of the study area.

4.9.3.2 Forest cover change

Table 16 Forest cover change

Effect of land use/land cover change	Number	Percent
Deforestation	36	65
Degradation of water shade	8	14
Soil erosion	11	20
Total	55	100%

Respondents were asked to identify the environmental problems which are common in their localities following the land use/land cover change. According to Table 16, 65 percent of the sample household heads were replied that deforestation is the common effect followed by 20 percent respondents understanding that the effect is soil erosion and 14 percent degradation of water shade.

The rate and decline of forest depend on land use pattern. According to data obtained from the key informants forest cover in the study area decline from time to time. According to them the main driving causes of the decline of forests in the area are, deforestation, fire wood, cutting trees to fulfill the demand of constructional materials, settlement expansion and income generation are directly or indirectly related to population growth. As result, accelerated soil erosion and fertility decline become the main problem of the area once the forest cover was lost, (Kibamo, 2011).

Figure 14 Photo graph shows that forest changed into cultivated land by deforestation

4.9.3.3 Agricultural land expansion

As discussed in the previous sections, the agro ecological condition of the district is convenient for agriculture. Due to this, crop production and livestock rearing is the basic economic activity in the district. Most of the farmers rear livestock and want to maintain large number with little care for their quality. According to the informants, the larger number of cattle population in a given family is both a source of wealth and status. Indeed, this mental attitude is not limited to the study area and is prevalent throughout Ethiopia**.**

Table 13 indicated that there is an increasing trend of cultivated land from 1987 to 2017. The implication of increased cultivated land interims of aerial coverage means other land cover/land use units have been converted into cultivated lands. For instance, between 1987 and 2017, about 2,631 ha forest cover, 9,237 ha wet land and 4,627 ha shrub grass land is changed into cultivated land. In addition to this, according to the views of respondents, the expansion of various types of agricultural activities is the major sources of forest cover change in the study area. Therefore, the presence of peasants with their various types of agricultural activities (both crop production and livestock rearing) inside and along the margin of the districts forest cover land is considered to be the major factor for LULC change in the study area.

4.9.3.4 Fire wood and charcoal production

In the rural areas fire wood (collected from the nearby forest areas) and cow dung are the two most important sources of energy. According to the informants over the recent years fire wood is commercialized as its demand has increased particularly in those areas which are devoid of trees in the district. Moreover, as the agricultural officers identified fire wood and charcoal productions are the major causes of forest cover change. Hence, the increasing demand of forest products, in the form of fire wood and charcoal within and outside the district has been causes of deforestation in Soro district.

4.9.3.5 Cutting trees for constructional materials

The demand of forest products for the construction of house and fence has been aggravated the destruction of forest in Soro district. From the respondent's point of view, it was evident that cutting trees to fulfill the demand of constructional material is considered to be the causes of deforestation in the district. Field observation data also indicated that woody biomass was found to be the most important house construction material in the district specially for making doors and windows.

Figure 15: Natural forest in Shonkola village (Source; on Field Survey, 2017)

4.9.4 Impact of decline of forest

Forest loss affecting, the livelihood and the environment particularly the rural people in Ethiopia different ways including shortage of firewood, shortages of non-timber forest products and accelerated soil erosion which affects agricultural productivity. The decline of forest has a significant impact on various functions such as production, biomass, biological habitat filtration and sources of row materials (FAO, 2001).

According to data obtained from the key informants, the major impact of the decline of forest in the study area results shortage of firewood, increase soil erosion and flooding in the surrounding areas. In addition to this the focus group discussion confirmed that decline of forest in the study area results loss of plant and grass species. Due to decline of forest, increased runoff and reduces infiltration of water which contribute to flooding problems in the surrounding areas. Similarly, Kibamo (2010) reported that decline of forest products reduced the availability of fuel wood, construction materials, wild food and increase soil erosion.

Therefore, the finding obtained from the key informants and the focus group discussion indicate that shortage of firewood, increased soil erosion and flooding are the major impact of the of forest in the study area. Generally, different types of land use and land cover change in the study area accelerate the destruction of forests which reduced the availability of fire wood, increased soil erosion, reduction of portable water and loss of bio-diversity.

4.9.4.1 Land Degradation with soil erosion

Land degradation is one of the major causes of low and in many places declining agricultural productivity and continuing food security and rural poverty in Ethiopia (IFPRI, 2005). One of the major environmental problems in the study area is land degradation in the form of soil erosion, destruction of vegetation and destroying the forest in the around shonkola villages.

According to data obtained from the respondents the major factors accelerated land degradation in the study area population pressure illegal housing and expansion of small towns. These demands aggravate the destruction of forest which is found the surrounding area, the conversion of agricultural land in to shrub grass land area. In addition to this high population growth increase the demand of construction of housing along the marginal land which reserved for green areas aggravate land degradation in the study area. Similarly, studies indicated by (Temesgen et al, 2014) land degradation in Ethiopia mainly caused by population increase and unwise use of natural resources.

Therefore, the finding indicates that the major factors that aggravate land degradation are high population pressure, illegal housing and uncontrolled management of government officials.

4.9.4.2 LULC Changes

Table 17 LULC Changes

Land use land cover class	Increased	Percent	Decreased	Percent	No change	Percent
Change in cultivated land	22	40	5	9	7	12
Change in forest land	10	18	6	10	3	5
Change in shrub grass land	7	12	2	3	1	2
Change in wet land	16	29	4	7	5	9
Total	55	100	30	29	16	28

Source: Field Survey (2017)

When we compare this result with satellite image analysis, the trend of change is similar with forest land, grassland and wet land. Regarding the cultivated land area 40% of the respondents replied that cultivated land is increased while 9% believed decreased. This could be related with their understanding of personal cultivated land holding size decline

Similar studies in Hadiya zone Shashogo district and other surrounding villages also identified deforestation and over harvesting of tree as major deriving factor for causing significant pressure on natural resources and LULC (Kibamo, 2011and Lophiso Shamebo, 2010).

4.9.5 Socio-Economic Impact of Land Use Land Cover Change

Land use an essential impute for food production and housing. Thus, land use is the backbone of agricultural economics and provides substantial economic and social benefits. Land use change is necessarily and essential for economic development and social progress (Gete and Hurni, 2001).

Key informants said that land use and land cover change that is the deforestation of forest and expansion of small village towns results many socio-economic impacts on the neighboring agricultural society. According to data obtained from the focus group the major socio-economic impacts of land use and land cover change are loss of agricultural and grazing land which results loss of income gained from farm land and animal rearing. In general the growing population and increasing socio-economic needs in the study area creates pressure on land use and land cover change. This pressure results in loss of agricultural and grazing land.

4.9.6 Significance of planting of trees

In order to address the problem of soil degradation, biomass scarcity and loss of biodiversity, restoration of degraded land planting of trees play vital role to maintain the ecosystem of the study area. The information obtained from the key informants confirmed that planting of trees are important in the study area particularly in Shonkola Mountain and its surrounding areas to maintain soil erosion, biodiversity and regulating local climate. According to data obtained from the focus group discussion maximize vegetation covers also important to prevent erosion, reduced nutrient removal and reduced the speed and the volume of flow over the soil. Similarly, UNCCD (2004) revealed that forest and tree covers combat land degradation and desertification by stabilizing soils, reducing water and wind erosion.

Therefore, planting of trees can contribute to poverty reduction, making the people less vulnerable to the impact of land degradation. According to data obtained from the key informants and the focus group discussion the major actors participating in planting of trees in the study area are the communities, the government and local non-governmental organization because to protect the environment from destruction it requires a collective participation of different stakeholders.

4.9.7 Community Participation in Conservation

Community participation on conservation activities has positive effect on sense of ownership and the communities' commitment for effective protection and sustainable management of resources. The key informants replied that the communities are actively participating in soil and water conservation activities in Shonkola and Kosha degraded area. They also assured that community participation in soil and water conservation activities in the study area enable to restore severely degraded land along the study area and its surroundings. In addition to this, they said that soil and water conservation activities help to protect and recover vegetation in Shonkola Mountain and surrounding areas.

The focus group discussion also replied that participation of local communities in soil and water conservation activities since the last ten years was very high. According to them participation of local communities in conservation practices play vital role in protecting the environment and sustain the service of ecosystem. Generally, community participation is one of the major factors that determine conservation activities. Therefore, the involvement of local communities in conservation activities enables them to feel more sense of responsibility to protect the surrounding natural resource and helps to protect the various biodiversity and natural resources in the study areas

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

LULC changes have wide range of consequences at spatial and temporal scales. Because of these effects and influences it has become one of the major problems for environmental change as well as natural resource management. Identifying the complex interaction between changes and its drivers over space and time is important to predict future developments, set decision making mechanisms and construct alternative scenarios.

This study has been conducted by integrating GIS and Remote Sensing. In order to detect and analyze changes in land cover classes, these techniques were implemented. In the first section, satellite data for the study periods of 1987, 2002 and 2017 and Remote Sensing techniques were applied to generate LULC maps through a maximum likelihood supervised image classification algorithm. The accuracy assessment and change detection processes has also been done. The overall accuracy of land use and land cover maps generated in this study had got an acceptable value of above the minimum threshold.

From the remote sensing of image classification result, the district showed significant change in the LULC over the last three decades. The changes are largely caused by increased population growth and land degradation. According to (Tekle 2000), land use land cove is caused by increased population growth, land degradation and deforestation in the case study of Doyogane, SNNPR. It is true to Soro district where rapidly growing of population brought shortage of land, removal of forest cover, soil erosion and land degradation. From the observed changes expansion of cultivated land and Shrub land areas can be taken as something positive. In the study period the study area was covered by four LULC categories namely cultivated land, grassland, wetland and forest.

The finding of this study indicates that forest land increased in the study periods from 1987 – 2002 and decreased from 2002 – 2017.Wet land decreased in all study periods and shrub land area decreased during 1987 -2002 and increased 2002 – 2017. Cultivated land decreased in the first study period and increased in the second study period.

From the observed changes wetlands are the most converted cover type during the entire study period. According to Bireda, (2015) The conversion of most wetlands to cultivated land because wetlands have the capacity to grow crops without irrigation in winter season. Also this LULC type is found around the plain areas of the landscape, which is more preferable for farming.

The key informant interview conducted that population growth is the major cause for land use/ land cover change and this factor is also supported from the analysis that land scarcity was happening in the study area following the growth of population. Deforestation and soil erosion were identified as the major effects of the change in the study area according to the key informant interview conducted. According to farmers, this decline in soil fertility, soil erosion caused by deforestation and intensive cultivation of steeper slopes has resulted in a decline in agricultural production and productivity. These forced farmers to put more land under cultivation in order to maximize their agricultural produce.

As a result, wetlands which were used as grazing land became converted to agricultural land. This has also its own impact on the loss of habitats of aquatic animals .Land improvement measures were being carried out in the study area which will improve the situation in land use/land cover changes .According to data obtained from the elders the district the expansion of this LULC type is due to decrement on the productivity of forest land which opened or cleared the way for the agriculture and home consumption. The socioeconomic condition of the study area community had largely affected by the changes on this LULC type. According to (Netsanet Deneke, 2007) the major change was happened on dense forest due to various economic activities, which decrease the forest density. The effects of human activities are immediate and often radical, while the natural effects take a relatively longer period of time. The difference in increase by households and land cover change indicates the pressure on land cover change and related biodiversity.

5.2 Recommendations

Based on the findings of this study, the following recommendations are forwarded for policy implications and future research directions:

- The use of high resolution imageries such as IKONOS and Quick Bird are important in generating good quality of LULC maps. Because it is difficult to map small parcels of LULC like urban areas in 1987 and 2017 study periods and high resolution imagery provide better information by mapping these areas. .
- There should be an appropriate land use planning and policy with impact studies and scenarios, in order to use a given land with its maximum output.
- Population increase has played a major role on LULC change and there should be strong family planning awareness creation campaigns with adequate health services from the zonal and administrative health extension services (offices).
- I recommend integration of socio-economic data, land policy scenarios, biophysical parameters and demographic variables when predicting future LULC patterns.
- Therefore, the local managers and responsible sectors in the study area (Soro district) should give emphasis in participation of the local communities in conservation activities and decision making.

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APPENDEX-I

JIMMA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

COLLEGE OF SOCIL SCIENCES AND HUMANITIES

SCHOOL OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

SPECIALIZATION ON GIS AND REMOTE SENSING

Dear respondents the main objectives of these interview is to assess the dynamics of land use land cover in Soro district. I hope that the research outcomes contribute to the betterment of land use practices in the study area. Please note you that the response you give will not have any negative impact on you and your family. What is needed is the response you give to the issues raised. Just feel and respond and explain only what you think is correct.

Thank you for your cooperation

Yours faithfully

Questionnaires for Key Informant Interviews

Name of informants______________________________

Age___________

Sex___________

Educational status________________

Occupation ______________________

1. Following the land use/land cover change, which environmental problems are very common in your area?

1. Soil erosion 3. Deforestation

2. Degradation of watersheds 4. Increased waste land

5. Other, Specify ---

2. If your choice for question number 1 is soil erosion, what are the major causes?

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3. If your choice for question number 1 is deforestation, what are the major causes?

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4. What are the causes for land use/land cover change in your area?

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5. What look like forest cover age of the area compared with the past?

A. Decline

B. Increasing

C. No change

5.1. If your answer is decline what are the main causes of the decline of forest overage in your area.

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5.2. If your answer is increasing what are the main causes of the increasing of forest coverage in your area?

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6. What are the impact of land and land cover change on the surrounding environment?

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7. What are the socio-economic impact of land use and land cover change in your area?

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7. 1. What factors have contributed to the changing land use land cover change in your locality?

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8. What are the environmental problems related to the development in your village?

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9. Do you think that is necessary to plant tree in this area?

Yes___ No___

____

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9.1 If your answer is yes what kind of plant species you opt to commonly plant in this area?

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10. What are some of the problems of land use land cover change that are connected with environment such as.

- Loss plant density and diversity
- Soil erosion
- Water scarcity

11. Which conditions are aggravated the problem land degradation?

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APPENDEX -II

To be completed by elderly and focus group participants

The principal objective of this questionnaire is to explore the extent to which human beings, through their socio-demographic characteristics have influenced the land use/land cover in Soro district. The study is conveyed for academic purpose. Hence, the responses from respondents are confidential and cannot be traced to the persons who provided them.

Thank you in advance for your cooperation.

1. Is there any change in your area with regard to cultivated land, forest, shrub grass land and wet land use pattern over the past 30 years? If any please indicate them accordingly. A change in:-

A) Forest cover

B) Shrub grass land

C) Cultivated land

D) Wet land

2. What are the major reasons/causes for all these changes?

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3. Do the individuals or the community actively participating in the conservation activities?

Appendix III   Ground Control Pointsfor Image Interpretation and Classification

LULC	x_coordinate	y_coordinate	LULC	x_coordinate	y_coordinate
Forest	362945	823455	cultivated land	361424	819420
Forest	362458	823604	cultivated land	361621	819278
Forest	362458	823752	cultivated land	361664	819279
Forest	362775	822651	cultivated land	361765	819283
Forest	362775	829429	cultivated land	361919	819286
Forest	363230	819838	cultivated land	361994	819234
Forest	363237	819911	cultivated land	353045	828584
Forest	363379	820267	cultivated land	359577	830063
Forest	363405	820638	cultivated land	357757	829610
Forest	363404	820641	cultivated land	351866	826044
Forest	363404	820640	cultivated land	349564	825846
Forest	363471	820932	cultivated land	354037	826057
Forest	363487	821184	cultivated land	338929	817953
Forest	363286	821153	cultivated land	362419	821607
Forest	363151	821167	cultivated land	362397	821543
Forest	363105	821220	cultivated land	362387	821437
Forest	362990	821242	cultivated land	362709	821454
Forest	362817	821360	cultivated land	362724	821456
Forest	362753	821432	cultivated land	362787	821415
Forest	362593	821456	cultivated land	362825	821383
Forest	362572	821534	cultivated land	362892	821274
Forest	362507	821604	cultivated land	363164	821220
Forest	362490	821727	cultivated land	363061	819034
Forest	362530	821730	cultivated land	363052	819146
Forest	362414	821681	cultivated land	362873	819310
Forest	362419	821607	cultivated land	362782	819362
Forest	362397	821543	cultivated land	359850	825734
Forest	361382	819557	cultivated land	359850	830310
Forest	361409	819497	cultivated land	349842	825734
Forest	361430	819461	cultivated land	360343	825057
wet land	349834	820251	cultivated land	362765	825668
wet land	349980	820264	cultivated land	362815	825886
wet land	350284	820899	cultivated land	364626	825936
wet land	348406	821134	cultivated land	361055	826288
wet land	347704	819404	cultivated land	351991	820119
wet land	347651	819624	cultivated land	351409	819947
wet land	367658	812996	shrub grass land	336393	831276
wet land	347519	820000	shrub grass land	334964	830959

wet land	348009	817605	shrub grass land	336155	828260
wet land	350377	817605	shrub grass land	338616	829965
wet land	351898	817103	shrub grass land	336314	833340
wet land	351356	817380	shrub grass land	328297	834578
wet land	351514	818095	shrub grass land	365498	818225
wet land	354676	819047	shrub grass land	364577	823456
wet land	345799	815444	shrub grass land	326467	811355
wet land	345849	815890	shrub grass land	338140	822340
wet land	347089	816785	shrub grass land	339013	823737
wet land	347609	818225	shrub grass land	342585	826218
wet land	348112	819599	shrub grass land	344331	828260
wet land	354516	823220	shrub grass land	330599	828499
wet land	357467	821209	shrub grass land	329487	832447
wet land	347678	820405	shrub grass land	354948	824497
wet land	346855	821309	shrub grass land	354562	824798
wet land	347207	818845	shrub grass land	355283	825033
wet land	345933	818627	shrub grass land	355551	825134
wet land	346016	817152	shrub grass land	356842	825905
wet land	345949	816180	shrub grass land	356825	827399
wet land	345564	82635	shrub grass land	358820	824798
wet land	345681	815576	shrub grass land	359239	825419
			shrub grass land	359859	827011