ASSESSMENT OF LAND USE LAND COVER CHANGE ANDSOIL PHYSICO-CHEMICAL PROPERTIES IN SEMEN-BENCH DISTRICT, SOUTHWEST ETHIOPIA

M.Sc. THESIS

BY

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ASSESSMENT OF LAND USE LAND COVER CHANGE AND SOIL PHYSICO-CHEMICAL PROPERTIES IN SEMEN-BENCH DISTRICT, SOUTHWEST ETHIOPIA

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I have incorporated the suggestion and modification given during the internal thesis defense and got the approval of my advisors. Hence, I hereby kindly request the Department to allow me to present the findings of my work and submit the thesis.

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We, the thesis advisers have evaluated the content of this thesis and found to be satisfactory, executed according to the approved proposal, written according to the standard and format of the University and is ready to be submitted. Hence, we recommend the thesis to be submitted.

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DEDICATION

I dedicate this thesis manuscript to my parents for their great contribution in my success

STATEMENT OF THE AUTHOR

First I declare that the thesis: Assessment of Land UseLand Cover Change and Soil Physico-Chemical properties in Semen-Bench District**,** Southwest Ethiopia is my own work and all sources of the materials used for this thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for M.Sc. degree in Natural resources Management at the Jimma University and is deposited at the university library to be made available to borrowers under the rule of the library. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma or certificate.

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BIOGRAPHICAL SKETCH

MesfinGubila was born on December 01, 1989 to his father, GubilaKoyesti and his mother, BirtkhunGashabeza , in Indakel*Kebele*, North Bench district of Bench Maji Zone, SNNPR, Ethiopia. He completed his elementary education (1-4) and (5-8) grade in Indakel Elementary School and Temenjizi completed primary school, respectively. Secondary at Mizan high and preparatory school. Upon the successful completion of his preparatory education on February 17, 2009, he joined WolaitaSodo University and graduated with B.Sc. degree in Natural Resources Management from WolaitaSodo University on July 18, 2011.

After his graduation, the author was employed by Semen Bench district Agricultural office and Bench Maji zone Agricultural department. He served the Bench Maji zone for six year until he joined Jimma University, College of Agriculture and Veterinary Medicine on September 2017 to pursue his MSc. degree in Natural Resources Management (Specialization in Watershed management).

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LIST OF ABBREVIATIONS AND ACRONYMS

AF	Agro forestry
ANOVA	Analysis of Variance
AP	Available Phosphors
BD	Bulk Density
CL	Crop land
DEM	Digital Elevation Model
EFAP	Ethiopian Forest Action Program
FAWCDA	Forestry and Wildlife Conservation and Development Authority
GCP	Ground Control Point
GIS	Geographic Information System
HA	Hectare
LULCC	Land Use Land Cover Change
MLC	Maximum Likelihood Classification
RS	Remote Sensing
SBWA	Semen Bench wereda Agricultural and Natural Resources Office
SOM	Soil Organic Matter
SM	Soil Moisture
SNNPR	Southern Nations Nationality and People Regional State
SAS	Statistical Analysis System
SRTM	Shuttle Radar Topography Mission
SW South West	
TN	Total Nitrogen
USGS	United State Geological Survey
UTM	Universal Transverse Mercator

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ABSTRACT

Land use land cover changes have been recognized as the main factors in the process of soil resource degradation in south western Ethiopia. The aim of this study was to determine the land use and land cover change in the year of 1986, 2001and 2018, and to assess soil physico-chemical properties at different land use types in Semen Bench district. The primary data obtain Landsat satellite image (Landsat data): Thematic Mapper (TM) 1986, Enhanced Thematic Mapper Plus (ETM+) 2001 and Thematic Mapper (TM) 2018 obtained from USGS. Soil samples were collected from three land uses, namely forestland, agro forestry and crop land at 0–30cm depth. The satellite image of Landsat TM for 1986,Landsat ETM+for 2001 and LandsatTM for 2018 were analyzed using EARDAS IMAGINE 2015.Supervised classification method using the decision rule of maximum likelihood classifier algorithm was used to classify LULC map. Accuracy assessment in this study was made using the original images and interview with elders who live in the study area for 1986, 2001 and field observation and Google Earth image used for the 2018 study period. Eighteen soil samples were taken at a depth of 0-30cm from three land uses (agro forestry, crop land, and forestlands) of one kebele with six replicationsand one way Analysis of variance (ANOVA) were used to test the difference among land uses. The overall classification accuracy for the period of 1986, 2001 and 2018 was 90%, 87.5% and 90% with kappa coefficient of 0.87, 0.83 and 0.87 respectively. The result of this study indicated the strong agreement as the value is greater than 0.8. LULC change detection of the periods of 1986 to 2018 showed there were changes in several LULC classes. The net change of land cover class from 1986 to 2018 revealed to agro forestry and settlement were consecutively increased by 47.1% and 2.86% while forest land and cropland were decreased by 19.98% and 30.02% respectively. The soil physico-chemical properties result showedthere were significant differences (P <0.05) in between land use types. Soil OC, pH,OM,TN,AK,AP,EC ,CEC, exchangeable base and bulk density) were significantly different (P<0.05). Generally, the result showed land use change has adverse influence on soil physico-chemical properties. Therefore, sustainable conservation of natural forest and integrated soil management system are recommended to maintain forest resources and soil quality.

Keywords: Cropland, Agro-forestry,Forest,Landsat,Soil physical property, soil chemical property

1. INTRODUCTION

1.1 Background

Land use and land cover change (LULCC) is a general term used for the human alteration of Earth's terrestrial surface (Pielke *et al.*, 2011). LULCC are widespread, accelerating, and significant processes driven by human actions. Human activities to obtain food and other essentials goods and services have modified land for thousands of years and likely to continue in the future. The current rates, extents and intensities of LULCC are far greater than ever in history, driving unprecedented changes in ecosystems and environmental processes at local, regional and global scales (Agarwal*et al.*, 2002).

Causes of LULCC at all level are associated with several natural and human induced factors (Rahdary*et al.*, 2008). However, human induced causes are the severe one, which are grouped as direct(proximate) human effect such as agricultural expansion, wood extraction, infrastructure expansion, and indirect (underlying) effects such as demographic, economic, technological, policy , institutional and cultural factors(Geist and Lambin, 2002). According to these authors, the indirect causes are the fundamental forces that activate the direct causes. For instance, increasing the number of population generally results in increasing demand on land for living and agricultural production.In developing countries like Ethiopia the improper land use and land cover change like deforestation, overgrazing, and expansion of agricultural lands has left the land barren, which reduces the biomass (vegetation cover) and results in a decline in soil organic matter content, availability of nutrients and soil moisture (Mao andZeng, 2010). These changes encompass the greatest environmental concerns of human populations including climate change, biodiversity loss and soil resource degradation. Consequently, land use and cover changes could lead to a decreased availability of different goods and services for human, livestock, agricultural production and damage to the environment (Geist and lambin, 2001).

LULCC have several undesirable consequences like decline in soil fertility, soil carbon and nitrogen stocks (Lemenih, 2004; Lemenih and Itanna, 2004; Tesfaye*et al*., 2016; Henok*et al*., 2017). Land degradation is a serious problem in Africa, but it is most severe in the densely populated highlands of East Africa (Pender *et al*., 2006) like Ethiopia (McGinley, 2008). Forest cover change in Ethiopia is estimated to be decline from 17 million ha in1955 to 3.4 million ha in 1979, which is about 80% drop with 24 years (Hailemariam*et al.*,2016).In Ethiopia, rapid population growth and environmental factors lead to the conversion of natural forest and grassland into cultivated farmland (Tesfahunegn, 2013) and have contributed to soil degradation and soil loss by deteriorating the soil physical and chemical properties and make the ecosystem more delicate and susceptible to land degradation (Karltun*et al*., 2013). The country's inherently fragile soils, undulating terrain, highly erosive rainfall and the environmentally destructive farming methods that many farmers practice make soil highly vulnerable to soil erosion. The conversion of forest to other land use like agriculture is getting serious, especially in highland area of Ethiopia. These unsustainable LULCC are recognized as the main factors in the process of soil resource degradation (Mulatu, 2014).

For instance, radical losses in soil fertility, soil carbon and nitrogen stocks have been recorded in the first 20–25 yearsafter deforestation in the southern region of Ethiopia (Lemenih*et al*., 2004; Mekuria, 2005; Tesfaye *etal*., 2016). Furthermore, various studies (e.g. Lemenih*et al*., 2004; Lemma*et al.*, 2006; Yimer*et al.*, 2007) showed LULCC have adverse effect on soil physical and chemical properties in Ethiopia. Similar study carried out in south western part of Ethiopia showed land use changes have adverse effect on changes soil physico-chemical properties (Mulatu*et al*., 2014). Kassa *et al*. (2017) also reported loss of soil organic carbon and nitrogen due to the conversion of forest to cropland. Therefore, it can be understood fromthe foregoing studies that it is hardly possible to draw uniform conclusion on the impact of land use andland cover change on physical and chemical properties of soil, which reveals the necessity to conduct studies at local spatial scale. The southwestern highlands of Ethiopia which hold four potential natural vegetation zones (Afromontane rainforest, dry peripheral semi-deciduous Guineo-Congolian forest, transitional rainforest and riverine forest vegetation) (Friis*et al*., 1982; Tadesse, 2007)have forests that provide different environmental contributions like soil fertility sustenance, soil erosion protection and climate change mitigation (Mekuria, 2005; Getachew *et al*., 2010;

Aticho, 2013; Henok*et al.*, 2017). However, the increasing human population and the growing need for expansion of agricultural land have led to deforestation in this area. For instance, the region's coffee-based agro forestry and cereal cultivation have undergone a rapid expansion to forest area owing to the growing demand for food crops ,coffee, spices and the fruit market, driven by the resettlement expansion, commercial investment, land tenure policy, and socio-economic issues (Mekuria, 2005;Dereje, 2007). These and other demands such as expansion for subsistence farming, fuel wood extraction, and timber extraction are major causes for LULCC in the area and have considerable influences on soil physico-chemical properties.

1.2. Statement of the problem

The most significant global challenges in this century relates to management of the transformation of the earth's surface occurring through changes in land use and land cover (Mustard et al., 2004).In Ethiopia, unsuitable agricultural practices, deforestation and overgrazing affect the crop and livestock productivity of the rural poor, hence also their livelihood. These modifications of ecosystem services due to changes in land use/ land cover negatively affect the ability of biophysical systems to support human needs (Solomon, 2005). Forest resources of Ethiopia are concentrated in the southwestern region of the country including Sheka, Keffa and Bench-Maji (Chilalo andWiersum, 2011). These forests are believed to be the origin and primary center of diversity of Arabica coffee where coffee is still grown in the wild and contains a highly diverse gene pool (Aerts*et al.*, 2013). However, research in some part of this area, for instance in Keffa and Sheko,revealed that large portion of natural forest areas has been rapidly declined (Mekuria, 2005; Dereje, 2007). Semen-Bench district is one of the areas in southwestern Ethiopia, which faces high rate of land use and land cover change due the increasing human population and the growing need for expansion of agricultural land. Despite thisfact, little is known about LULCC and its impacts on soil physico-chemical properties in the district. This is due to the lack of study on dynamics of LULCC even though few studies were conducted in some other parts of Southern Ethiopian highlands. Therefore, the aim of this study is to map the LULCC between 1986, 2001 and 2018 and assess the effect of land use types on soil physico-chemicalproperties in the district.

1.3. Objective of the study

1.3.1. General objective

The general objective of this study is to assess the land useland cover change and soil physic-chemical properties in Semen-Bench district, South Western Ethiopia

1.3.2. Specific objectives

1. Toassess land use land cover change inthe study area in the year 1986 to 2018.
2. To assess the effect of land use types on soil physicochemical properties in Semen Bench District.

1.4. Basic research questions

1. Are there land use and land cover changes in the study area between 1986 and 2018?
2. What types of land use and land cover changes were observed in the study area between 1986 and 2018?
3. Have the land use changes influencedthe soil physico-chemical properties in the study area?

1.5. Significance of the study

The aim of this study is to minimize the information gap and develop clear understanding through an in depth on the assessment of the land use land cover changes and its effects in soil physic-chemical properties in the study area. So, this will help to reverse the trend in the area. And it is mainly aimed to determine and map land use and land cover between the years 1986, 2001 and 2018 in the study area, and to compare soil physical and chemical properties among different land uses in the study area. So, the study will provide some information for the coming generation. The result of the study will provide an insight towards the dynamics of land use land cover changes influences on soil physico-chemical properties in semen bench district. Furthermore, policy makers, local development planners, local land managers, NGO and concerned bodies benefit a lot from this research.

1.6. Scope and limitations of the study

The study was conducted only in one Keble in Semen Bench districtdue to finical constraint. Some soil samples were taken and only selected soil physico-chemical properties were analyzed. So, further study will be also needed for the future in the study area.

2. LITERATURE REVIEW

2.1. Over view of land use land cover change in general

Land-use refers the way in which humans exploit the land cover, whereas land cover is a biophysical characteristic which refers to the cover of the surface of the earth (Lambin et al., 2003). Land-use/cover change is a dynamic process driven mainly by anthropogenic activities and natural phenomena (Lambin et al., 2001; 2003).

One of the most significant global challenges in this century relates to management of the transformation of the earth's surface occurring through changes in land use and land cover (Mustard et al., 2004).

In sub-Saharan Africa, a combination of population's growth and land degradation increases the vulnerability of people to both economic and environmental change (Millennium Ecosystem Assessment, 2005)

One of a serious problem in Africa is land degradation, but it is most severe in the densely populated highlands of EastAfrica (Pender *et al*., 2006). The Ethiopian highlands are among the most densely populated agricultural areas in Africa (McGinley, 2008).Ethiopia has experienced recorded anthropogenic interference on ecosystems through land use change for four to five decades (Hailu, 2000).

2.2. Assessment of land use land cover change in Ethiopia

The harmful rate of forest land and grass land cover change show that there was deforestation and conversion of land use land cover. Number of research reports from different parts of the country revealed the forest land and grass land were converted to farm and bare lands for instance; about 115 ha of forest land were changed to other lands per year in HayelomTabias, Northern Ethiopia. Sebhatleab (2014) reported that from 1973 to 2010 in Desa'a forest the overall rate of forest cover change was around 110 ha per year. Comparable studies in the southern part of Ethiopia indicate that the overall forest conversion was 87 ha/year (Aklilu, 2010). In most areas of the country anthropogenic activity was the major factor for forest resource degradation (Gebreegziabher 1999; Shiferaw 2011). The change from forest land to agricultural land is increasing from time to time and the conversion from forest land to agricultural land is 426 ha, 2612 ha and 3038 ha from 1987-2001, 2001-2015 and 1987-2015 respectively. Study conducted in Arsi Zone Dera District also revealed that considerable reduction of natural forest and shrubs, while expansion of agricultural land were observed between 1985 and 2011 with most significant expansion of agricultural lands due to the clearance of the forest to obtain more land for agricultural production and fuel wood for cooking and lightning(Gashaw et al.,2014).Conversely, inAmeleke watershedGebrekidan et al.,(2014) where shrubs were expanding from 2000 to 2006 and simultaneous to this, an increase of shrub land cover was found in Afar range lands from 1972 to 2007.Studies in south western parts of Ethiopia specifically at kaffa zone showed that about 55% of forest covers were lost between 1987-2015. The main drivers are: growing demand for forest products like fuel, construction wood, fodder, etc. Change of forest land to agricultural land, shifting cultivation, urbanization, etc., additionally increasing population, resulting in tangible human and animal population above the carrying capacity of the land also has a great impact on forest resource. Since land use/ land cover patterns are interrelated with the types and properties of soils. The rate and severity of soil erosion and land degradation partly depend on land use pattern. The problem of soil erosion starts with the removal of land cover for various purpose (Solomon, 2005). The land use affects the soils. The land use/ land cover is by distant most significant determinants of erosion in the highlands of Ethiopia (Bewket, 2002). Among others the one factor that affect the productivity of the land are land use type.

Land use/ land cover change have an impacts on grazing land since it is affected by forms of land degradation such as over cultivation, over grazing, deforestation and others. According to Tamirie (1997), about 60 million hectares of land for grazing were reduced to less than 55 million due to its conversion in to other land use/ land cover. An important factor contributing to the decline in fodder resources is the ever increasing human population, which resulted in an increase in cropland at the expense of traditional grazing areas such as bush lands, natural pasture and forests which have been aggravated since recently (Kahsay, 2004).It is important to understand effects of spatial and temporal changes of land use/ land cover and demographic structure of their effects on landscape pattern that affect the grazing land (Amin *et al.*, 2011).

2.3.Land Use Land Cover Change in the Southwestern Ethiopia

The forest cover of the highland plateau in the SW was quiet high until recent years, when compared to other parts of the country. The change in forest cover during the last 30 years is the most severe anthropogenic catastrophe that the country has seen. Reusing (1998) estimated that the closed high forest of SW Ethiopia dropped from a 40% cover between 1971 and 1975 to only 18% by 1997, which is a loss of 60% (Gole et al. 2002). As Woldemariam and Fetene (2007) studied at Sheka Zone, Masha and Anderach weredas, conversion of natural forest to agriculture by smallholder farmers to large-scale coffee and tea plantations are the major driver of land use change. The process of forestland allocation for investments in plantation still continues without any environmental impact assessment, and the impact on the livelihood of the people. Similar to Sheka zone, Benchi Maji is under the problem of conversion of natural forest to plantation of coffee, and rice and sesame in large scale as well as mango and rubber in minor scale. A lot of farmers have also got forest-plots for coffee plantation establishment. Such changes to plantation are permanent conversion of forestlands for other uses, as compared to conversion to agriculture (shifting cultivation). Besides the impact of such changes on the environment and biodiversity, there is a growing conflict on forest resources, violations of traditional tenure rights and taboos, cultural changes and changes in traditional forest resource management practices (Woldemariam and Fetene,2007).

2.4. Causes of land use land cover change

Land use/ land cover changes are caused by human-induced activities and Growth, socio-economic factors, deterioration of vegetation cover, agricultural activities government policies, and environmental factors (Gol *et al.*, 2010). Although natural processes may contribute to changes in land use/ land cover, human activities and social factors were recognized to have a paramount importance for understanding of land use/ land cover change

(Geist and Lambin, 2002). Different human driving forces, mediated by the socio-economic setting and influenced by the existing environmental conditions, lead to an intended land use of an existing land cover, through the manipulation of the biophysical conditions of the land (Turner *et al*., 1993).

Other important determinants of changes in land use/ land cover include several types of policy such as human settlement and land tenure policy. Humans have been altering the earth's surface to produce food through agricultural activities for centuries. In the last few decades, conversion of grass, wood and forest lands into cropland and pasture has risen dramatically in the tropics (Houghton, 1994).

Land use is constantly changes in response to the dynamic interaction between underlying drivers and proximate causes (Geist and Lambin, 2002). The driving forces of LULC change are generally subdivided into two groups: proximate causes and underlying causes. Proximate causes are the activities and actions of local people that directly affect land use in order to fulfill their needs from the use of the land. E.g. agricultural expansion, forest product extraction, infrastructure expansion and others that change the physical state of land cover. Melese (2002) explains the tropical deforestation in terms of immediate causation by multiple factors rather than single variables. Also he points out that agricultural expansion as the most prominent proximate cause, which is coupled with wood extraction and infrastructure expansion.

However, underlying causes are often external and beyond the control of local communities and are fundamental socio-economic and political processes that push proximate causes into immediate action on land use/ land cover including demographic, economic, technological, institutional and cultural factors (Melese, 2002; Geist and Lambin, 2002).

In Ethiopia, the main land use/ land cover changes are the conversion of vegetation cover to arable lands. Moreover, the major driving forces behind such pervasive LULC changes are identified as high population pressure, followed by land clearance for agricultural expansion, the lack of an appropriate land use plan and poor management practices (Gol *et al*., 2002). Large scale plantations of coffee and tea are also under the major causes of land use change in the southwestern part of the country (Woldemariam and Fetene, 2007).

In Ethiopia, population pressure is one of the underlying causes, and induces the clearing of forests for agriculture and other purposes; the attendant accelerated soil erosion is gradually destroying the soil resource (Hurni, 1990).Although forests may have existed in Ethiopia long before recorded history, the present day forest cover does not correlate with the historical human population, even though environmental problems such as drought, may also have contributed to this phenomenon.

Furthermore, the other problems regarding forest cover in Ethiopia is the use of biomass energy sources. One obvious causes of land use/ land cover change, particularly of deforestation is increasing for fuel wood (Solomon, 2005). As population increases household energy consumption also increases. For the poor in rural areas, it is not only a source of energy but a means of income generation too. In Ethiopia, 85 percent of household energy consumption is derived from forest products (EFAP, 1994).

Vegetation cover and dead plant biomass are also used to reduce soil erosion by intercepting and dissipating raindrops and wind energy (Kahsay, 2004). However, once forestland is converted to agriculture, erosion rates increase because of vegetation removal, over-grazing, and continuous cultivation. Generally, the overall these land use/ land cover changes has an impact on the vegetation cover.

2.5. Consequence of land use land covers change

Land use/ land cover change also has impacts on local and regional climate and water resources (Solomon, 2005). The LULCC also affect runoff, evapo-transpiration and surface erosion in a watershed (Esyase, 2010). The destruction of vegetation cover affects rainfall amount. For example, tree canopy and leaf litter can help reduce the impact of raindrops on the ground, hence reduce soil erosion, while roots hold the soil in place and also absorb water. In the absence of vegetative cover, soil erosion will result and there is low productivity.

A massive removal of forest in the Amazon has led to a decrease in evaporation and precipitation in the region (Turner *et al*., 1995). LULC changes also, especially vegetation cover, affect water and energy balances (Houghton, 1995). According to Turner *et al.* (1995), certain land use types have significant impacts beyond the proportion of their spatial extent.

Land use/ land cover characteristics and water cycle have many connections. The type of land cover, obviously, can affect both rate of infiltration and run off amount by following the coming precipitation (Houghton, 1995).

In the past 50 years, the construction of dams and reservoirs has become important part of human induced land cover changes. Impacts of land cover changes that occur due to artificial water body are beyond their proportion of aerial extent. The type of land cover, obviously, can affect both rate of infiltration and runoff amount. According to Turner *et al.* (1995), both surface and ground water flows are significantly affected by type of land cover. Low level vegetative cover could also affect infiltration and could lead to reduced ground water levels and therefore the base flow of streams (Dagnachew*et al*., 2003).

2.6. Application of geographic information system and remote sensing in land use change monitoring

The remote nature of remote sensing technology allow us to make observations, take measurements (i.e. measuring the reflected and/or emitted electromagnetic energy from the earth's features), and produce images of phenomena that are beyond the limits of our own senses and capabilities. Remote sensing launch of the first civilian remote sensing satellite in the late July 1972 that covered the way for the modern remote sensing applications in many fields including natural resources management (Lillesand*et al.*, 2014).

Satellite remote sensing provides a large amount of data at different spatial, spectral, and temporal resolutions by using the appropriate combination of bands to bring out the natural and man-made features that is most pertinent to a certain project for detecting changes. The data obtained from satellites imagery used for a wide array of change related application areas such as vegetation and ecosystem dynamics, hazard monitoring, Hydrology, land use and land cover change, and so on. Satellite image data enable direct observation of the land surface at repetitive intervals and therefore allow mapping of the extent and monitoring and assessment. Remote sensing at various scales plays a major role in spatio-temporal earth surface monitoring (Neteler*et al.*, 2004).

The most useful characteristic of remote sensing in land use and land cover change detection is the multi spectral and temporal resolution of the data. That is, images are obtained in different portions of the electromagnetic spectrum and the same area isimaged with a specified periodic time interval. The advantage of using remote sensing in Land use/land cover is that information from the same area could be easily obtained at different times and this is important in change detection applications. Furthermore, remote sensing can provide the required data in short time with a reasonable accuracy (Billah*et al.*, 2004) and has an important contribution to make in documenting the actual Change in land use/land cover on regional and global scales from the mid-1970s (Lambin*et al.*, 2003). The investigation system of land use pattern use pattern changes plays an important role in forecasting land cover changes and for formulating local development strategies. Nowadays ,technology of remote sensing in combination with GIS have given rise to the arrival of more precise and geographically referenced data on land use and land cover, which are the best for the determination of land use /land cover change(Codjoe, 2007).

2.7. Effects of Land Use Types on Soil Properties

Land use and land cover changes have negative impact on soil resources. Land use changes, mainly shift from natural ecosystems into managed agro ecosystems, and subsequent deterioration in quality of soil resources have become common phenomena in Ethiopia. As reported by many experts, the loss original forest has caused soil erosion by wind and water erosion. This forest cover changes affects major soil physical properties (color, texture, bulk density, and water holding capacity and chemical properties (soil organic carbon, soil organic matter, pH, electrical conductivity, available phosphorus, total nitrogen, cation exchange capacity, and concentration of different nutrients in the soil (Verma and Jayakumar, 2012) Moreover, impacts on organic matter (OM) pools and fluxes typically result in negative impacts on soil resources such as impact on soil erosion rates, aggregate formation, biological activity, and drainage. These also have profound effects on OM accumulation and CO_2 evolution. Moreover, conversion of natural ecosystem such as forest and pasture lands to croplands resulted in declined level of OM (Emiru and Gebrekidan, 2013).

Land use change such as deforestation and expansion of agricultural lands has also resulted in a decline in soil organic matter content, availability of nutrients and soil moisture (Mao and Zeng 2010). The reductions in OM content decreases the moisture holding capacity and nutrient availability, increase in bulk density, which affects the aggregate stability of the soil and the movement of water and nutrients through it. Moreover, increase in bulk affects biological activities in the soil (Gardner *et al*., 1999).

Also, intensive farming and mismanagement of the deforested areas brought environmental problems and soil impacts such as soil erosion, acidification, soil compaction and pollution (Lal, R., 2004). These problems have many interlink effects that can appear through the reduction of chemical and physical qualities of the soil resources (Kirchhoff *et al*., 2017).

According to Nega and Heluf (2009), deforestation and continuous cultivation in Ethiopia has resulted in increment of bulk density, deterioration of OM and reduction in cation exchange capacity (CEC). Moreover, Mulatu (2014) reported that conversion of forest to other land use like agriculture's are main factors in the process of soil resource degradation in Ethiopia. The anthropogenic changes in land use have altered the characteristics of the Earth's surface, leading to changes in soil physico-chemical properties such as soil fertility, soil erosion sensitivity and content of soil moisture (Abad *et al*., 2014). These changes may be caused by soil compaction that reduces soil volume and consequently lowers soil productivity and environmental quality (Abad *et al*., 2014). Deferent Researchers showed that linkage between land uses and soil properties, particularly in relation to soil nutrients and carbon sequestrations (Agbede, 2010; EmiruandHeluf, 2013).

Inappropriate land use and cultivation in degraded lands might reduce the productive quality of soil and the services of habitat components. Consequently, the harsh deterioration of the quality can result to a permanent degradation of the land productivity, and increase in land degradation and increase the costs of agriculture to maintain soil fertility (Abera and Belachew, 2011; Mojiri*et al.*, 2011). Haile*et al.* (2014) also showed that chemical properties such as OC, TN, available P and pH significantly changed in response to land use and management.

Land use changes have several undesirable consequences like decline in soil fertility, soil carbon and nitrogen stocks (Lemenih, 2004; Lemenih and Itanna, 2004; Tesfaye*et al.*, 2016; Henok *et al.*, 2017). For instance, radical losses in soil fertility, soil carbon and nitrogen stocks have been recorded in the first 20–25 years after deforestation in the southern region of Ethiopia (Lemenih *et al.*, 2004; Mekuria, 2005; Tesfaye*et al.*, 2016). However, some studies show that the extent of soil quality, soil organic carbon and nitrogen stocks varies with native vegetation, climate, soil type, management practice, land use history and time since conversion (Craswell and Lefroy, 2001; Lemenih, 2004;). Furthermore, the soil fertility, soil organic carbon and nitrogen stocks' decline (owing to land use changes) was not restricted to the surface but comparative changes were proportionally high in the subsoil (Don *et al.*, 2011; Lemenih, 2004). As it mentioned the above indicated that land use change has adverse effects on soil physical, biological and chemical properties and other ecosystem services provided by soil ecosystem. So, to leave some cover and appropriate land use during carrying out activity should be significant to reduce the impact land use and land cover change on soil properties.

2.7.1. Assessment of land use types on soil physical properties

The physical properties of Soil were significantly influenced by different land use types. Results revealed that soil bulk density (BD), gravimetric soil moisture content, soil porosity and proportion of sand, silt and clay contents were significantly different under different land use types(Bahilu*et al.*,2016). According to Sebhatleab(2012)in northern Ethiopia carried out the same study showed that soil textural classes, sand, silt and clay, were significantly affected by change in the LULC. The significant interaction of the LULC with elevation and depth affect textural composition. Separately from the LULC difference the two elevations and depths show a difference in textural composition for each LULC. The significant difference for the sand and silt percentages of bare land with the other LULC at the upper elevation was reduced at the lower elevation. Soil bulk density is an important indicator of soil physical properties, and it affects soil fertility and crop productivity. Bulk density showed a significant variation between the LULC classes. Parallel studies reported that bulk density was significantly affected by the type of LULC and depth (Gol, 2009). Land uses could decrease the soil bulk density, especially in the soil after agricultural cultivation, which might be due to the increase of soil organic matter after cultivation (Liu *et al.*, 2010).

There was also a change in bulk density among cultivate, pasture and natural forest soils. The continuous cultivation should increase in bulk density and disruption of pores. Long term continuous cultivation of the natural forest soils resulted in change in soils in physical characteristics (Mhawish, 2015).Deforestation should be seriously changes soil physical properties. Mechanical land clearing methods have caused soil compaction because of the action of the machine tracks including back and forth movement in the process of stamp removal, the removal of root mat, and a highly porous material. The effect of compaction degrades soil physical properties which lead to increase in bulk density, although bulk density is often related directly to root growth and crop yield (Mhawish, 2015). The value of bulk density was high in the cultivated and fallow land. This could be attributed to continuous cultivation and trampling effect of livestock since fallow and cultivated land in the northern Ethiopia were used for intensive livestock grazing during the dry season. The findings are in agreement with (Lemenih *et al*., 2005 ; Ayanna*et al*.,2013) who reported progressive increase in bulk density due to deforestation and continuous cultivation in the surface layers because of the decline in the soil organic matter content and compaction from the tillage. The high bulk density in the cultivated and grazing land is the result of constant shallow depth cultivation and too much dry season livestock trampling.

2.7.2 Assessment of land use types on chemical property of soil

Land use change can have negative or positive effects on soil quality. Conversion of forest land to other land use affects soil chemical properties. For example, dynamics in soil pH, CEC and exchangeable cations are important indicators of soil qualities of deferent land uses (Saha and Kukal, 2015).Soil pH affects the process of other nutrient transformations, solubility, or plant availability of many plant essential nutrients (McKie, 2014). It also affects the quantity, activity, and types of microorganisms in soils which in turn influence decomposition of organic materials (Barua and Haque,25 2013). Therefore, soil pH is one of the several soil quality indicators that give useful information on soil dynamics and nutrient availability and how the soil resource is functioning (McKie, 2014). Different study result indicate that cultivated land has the lowest OM, TN, CEC, pH, Ca and Mg contents compared to forestland and grazing land.

Potassium (K) is the third most abundant exchangeable cation in most productive soils. Itsconcentration in the soil can be affected by various factors. According to Wakeneand Heluf(2001), the variation in the distribution of K depends on the mineral present, particles size distribution, and degree of weathering. The greater the proportion of clay mineral high in K, the greater will be the potential K availability in soils. Al-Zubaidi*et al*. (2008) reported that exchangeable K values for some Lebanese soils, varying in clay mineralogy, range between 0.12 – 1.47 cmol(+)/kg (47 – 573 mg/kg). Soil K is mostly a mineral form and the daily K needs of plants are little affected by organic associated K, except for exchangeable K adsorbed on OM. Normally, losses of K by leaching appear to be more serious on soils with low activity clays than soils with high activity clays, and K from fertilizer application move deeply (Ajiboye and Ogunwale, 2008).

Exchangeable sodium (Na) alters soil physical and chemical properties mainly by inducing swelling and dispersion of clay and organic particles resulting in restricting water permeability and air movement and crust formation and nutritional disorders (Sposito, 1989). Moreover, it also adversely affects the population, composition and activity of beneficial soil microorganisms directly through its toxicity effects and indirectly by adversely affecting soil physical and as well as chemical properties. In general, high exchangeable Na in soils causes soil sodicity which affects soil fertility and productivity. Lowest possible level could be taken as an opportunity because Na concentration is not recommendable to high level as it deteriorates soil structure and make the soil liable for soil erosion and devoid of beneficial organisms (Taye and Yifru, 2010).

Soil organic matter is lowest as caused by land use changes, cropping pattern and frequency, removal of crop residues, faster decomposition and oxidation process as well as soil erosion on cultivated lands (Adugna, and Abegaz, 2016).The presence of high soil organic carbon and nitrogen stocks in the forest and agro forestry can be explained by a continuous leaf defoliation from trees and shrubs.

Various leguminous trees species *Albizia gummifera* J.F.Gmel.c.A.Sm.,*Millettia ferruginea Hochst baker,Sesbaniasesban* L Merr and *Leucaenaleucocephala* Lam.de Wit) could constitute the lion's share for the high soil organic and nitrogen stocks (in forest and agro forestry).

The carbon and nitrogen fixed in the tissue of leguminous treescontribute lotto to surfaceand subsurface soil inthe form ofdetritusupon seasonal defoliation andsenescence. These results correspond with the findings of Mohammed and Bekele (2014) and Lal (2001), who evidenced high soil carbon stocks in the native forest and (coffee-based) agroforestry compared to the arable land. Despite the fact that the estimated organic carbon loss could vary depending on the time of land use conversion, the organic carbon loss due to the conversion of forest to cropland as well as agro forestry to cropland were yet considered as a rapid decline. The topsoil organic carbon loss related to the conversion of both forest and agro forestryto cropland are in the same range to the carbon loss by converting the semi-arid Acacia woodland to cropland (2.4 Mg ha^{-1})(Lemenih and Itanna, 2004). The estimated carbon dioxide emission through the conversion to cropland is big enough to contribute to the atmospheric greenhouse gas effect.According to Adugna and Abegaz (2015) the content of SOM was the highest in forest lands (9.04%) and the lowest in cultivated land (4.59%) while in grazing land (7.31%) is in between, and the deference's are statistically significant ($P < 0.05$, Table 3). The percentage changes in SOM are higher in cultivated land (−49%) than the change in grazing land (−19%) compared to forestland. Higher content of OM in the forest land attributed to the role played by plants; soil macro fauna (worms, large insects, etc.); soil microflora (bacteria, fungi, protozoa, algae, etc.); and microbial biomass. Leaves fromplants fall to the soil surface and dead macrofauna, microflora, and microbial biomass in the soil decompose and form organic matter of soils of forest land. Living soil organisms also decompose leaves and mix them with the upper part of the soil. On grazing lands, grassroots were fibrous nearthe soil surface and easily decompose, and adding organic matter. On the other hand, lower content of SOM on cultivated land may be attributed to accelerated rates of erosion and decomposition, because these processes were most active on cultivated lands than forest and grazing lands.

Available phosphorus (P) is an essential element classified as a macronutrient because of the relatively large amounts of P required by plants. Although P is essential for plant growth, mismanagement of soil P can pose a threat to water quality. Changeability of the level of available P is related to land use, altitude, slope position and other characteristics, such as clay and calcium carbonate content. Several study shown that soil devoted to crop production lost far more P to steams than do those covered by relatively untouched forest or natural grass land. The traditional slash burning resulted in large transformations of un-available phosphorus in soil into mineral forms readily available to plants. Shortly after forest conversion to cultivated land, readily extractable inorganic phosphorus concentrations generally was raised in pasture and in soils cultivated with field crops Awotoye*et al*., (2013) as cited in Mhawish (2015)).Available phosphorus in the top soil increased after few years of continuous cultivation. Cultivation largely decreased the phosphorus sorption capacity of soils, and those reduced phosphorus availability to plants. Weathered soil minerals, organic fertilizer and inorganic fertilizer are important pools of soil P (Abegaz and van Keulen, 2009). Thus, the fact that soils in the forest land has higher AP than the grazing land may be attributed to two reasons. Firstly, even though, in forestland, a pool of available P could be removed by trees, there is a probability of P return through litter fall to soil surface (Asmamaw and Mohammed, 2013; Fu*et al*., 2011). Secondly, microbes which are abundant in the litter layers of the forest may quickly add high proportion of P pool under forest cover. On the other hand, a higher AP in cultivated land than grazing land may be attributed to three reasons. Firstly, applied cattle dung on cultivated field may increase level of P concentration in this land use, while cattle dung has been collected from grazing land. Secondly, frequent application of inorganic P-fertilizer on the cultivated fields may provide a considerable amount of inorganic P pool to the soil of cultivated field. Thirdly, a higher P release as a result of higher weathering process on cultivated land than on grazing land may provide higher amount of P to the soil of cultivated land. Fantaw*et al*., (2007) also reported similar findings.

3. MATERIALS AND METHOD

3.1. Description of the Study Area

3.1.1.Location

The study was conducted in Semen- Bench district of Bench Maji Zone, in South Nation Nationalities and Peoples Regional States (SNNPR), Ethiopia (Fig . 1).The study district is bordered by Keffa zone in east, Sheka zone and Sheko in north, Shay-Bench in South and Debub-Bench district in west. The study area is located in Bench Maji zone, between $35^0$31’35.09’’ degree and $35^0$43’42.64’’ degreeE longitude and $6^0$54’56.79” degree and $7^0$12’31.25’’ degree N latitude. The altitudes of the district range from1153 to 2696 m a.s.l and the slope ranges from 13.42%to 131.69% as it calculated from digital elevation model. The outcropping lithology comprises Tertiary basalt traps and rhyolites (Henok*et al*., 2017).

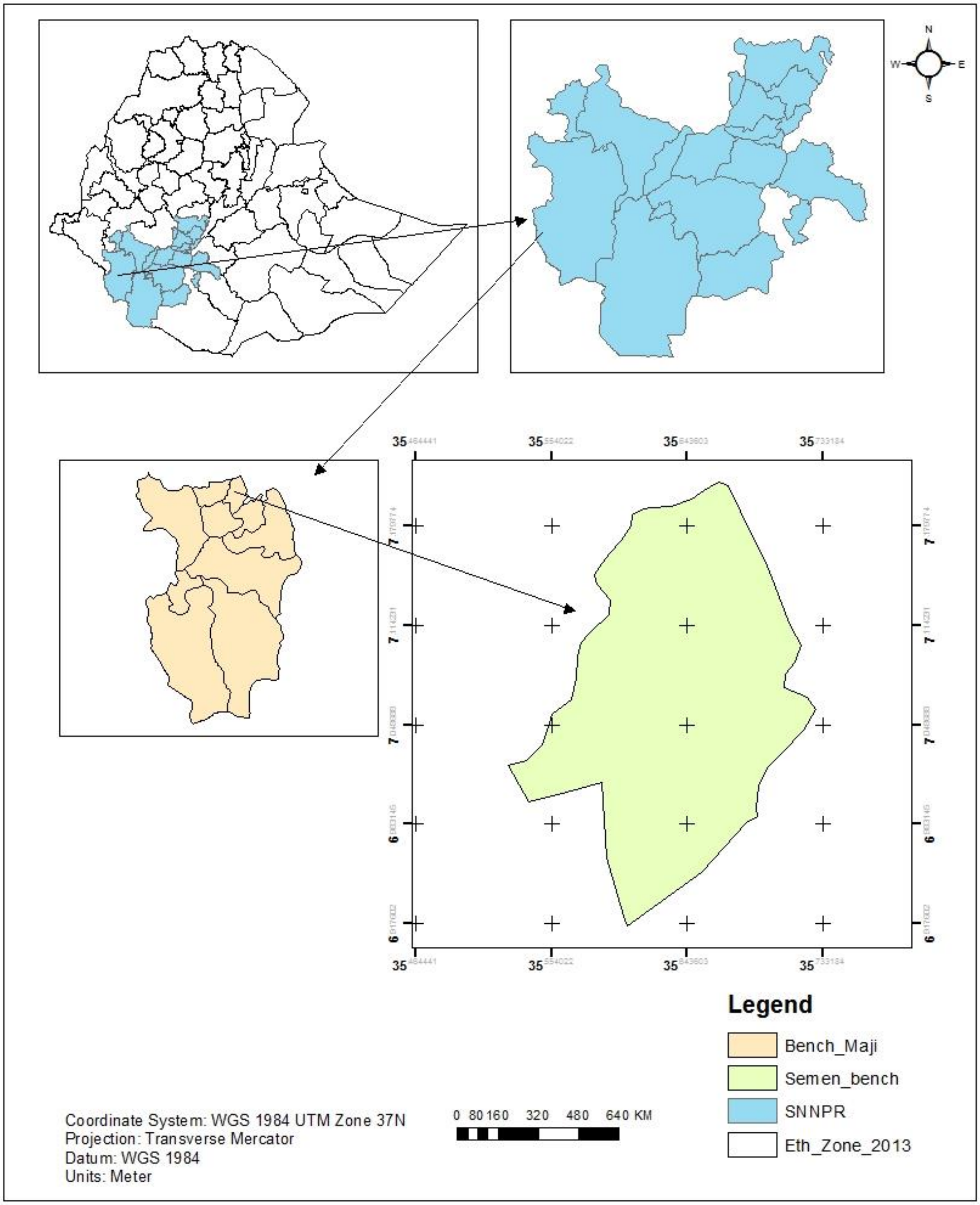


Figure 1. Map of the study area

3.1.2 Climaticcondition

The annual rainfall pattern is unimodal with a rainy season from mid-March to mid-November. The average annual rainfall in MizanTeferi (1440 m.a.s.l.) is 1780 ± 270 mm/year and the annual reference evapo-transpiration amounts to 1259 ± 12 mm/year while the average air temperature ranges from 13 to 27°C (Henok*et al*., 2017).

3.1.3. Type of soil

Leptosols are dominant soil type on crests, while Nitisols are dominant on the hill slopes (lower, middle and upper parts), to which Alisols and Cambisols are associated locally (Dewitte*et al*., 2013). Fluvisols are found in the flat valley bottoms, where meandering rivers occur.

3.1.4. Vegetation cover

The type of vegetation in the study area are *Aningeria adolfifriederici, Engl., Crotmacrostachyus, exsDelile, Hagenia abyssinica willd ferruginea., Millettia ferruginea Hochst. Baker. Polysciasfulva Hiern. Harms, Albizia gummifera J.F.Gmel.C.A.Sm.,ridelia micrantha,Hochst.Baill., integrated with lower canopy trees like Grewia ferruginea Hochst. exA. Rich, Vernonia amygdalina Delile, Cyathea manniana Hook and Solanecio, mannii Hook F.C. Jeffrey* (Henok *et al*., 2017).

3.1.5. Population and land use system

The total population of Semen Bench district is 130,000 from which 77,260 and 52760 was female and male respectively (BOFED SNNPR, 2012).The type of land use in the study area is two which are open filed farmland and agro forestry. According to (Henok*et al*.,2017), the agro forestry land of the district is composed of Coffee arabica L., as main cash crop integrated with food crops such as false banana (*EnseteventricosumWelw. Cheesman*), banana (*Musa sapientum* L.), taro (*Colocasiaesculenta* L. *Schott*) and spices like korarima (*Aframomumcorrorima Braun*). Moreover, various fruit trees such as mango (*Mangiferaindica* L.), avocado (*Perseaamericana Mill.*), papaya (*Carica papaya* L.) and orange (*Citrus sinensis* L. *Osbeck*) are also part of the farming system. Furthermore, native trees like *AlbiziagummiferaJ.F.Gmel. C.A.Sm., Cordia africana Lam.,* *MillettiaferrugineaHochst.Baker*, *PolysciasfulvaHiern*. Harms are kept for shade, fodder, firewood, medicinal value and soil fertility maintenance. On the other hand, on the cropland, cereal crops like maize (*Zea mays L.*) are integrated with root vegetables like taro and park trees (Henok*et al*., 2017).

3.2. Method of Data Collection

3.2.1. Source of data

The primary data obtain Landsat satellite image (Landsat data): Thematic Mapper (TM) 1986, Enhanced Thematic Mapper Plus (ETM+) 2001 and Thematic Mapper (TM) 2018 obtained from USGS with 30 X 30m resolution. Soil samples were collected from three land uses, namely forestland, agro forestry and crop land at 0–30cm depth.

3.2.2.Image pre processing

LULC maps of the study area was generated from 30 X 30m resolution Landsat Thematic Mapper , Land sat(ETM^+) and Land sat(TM) Satellite Imagery of 1986,2001 and 2018 were downloaded from USGS.Satellite image is row data with a full of errors and will not be directly employed for features classification.Pre-processing involves two major processes: geometric correction and haze correction. Haze reduction used to remove aerosols, noise and molecule in the atmosphere. Geometric corrections were correcting for geometric distortions due to sensor-Earth geometry variations, and conversion of the data to real world coordinates (e.g. latitude and longitude) on the Earth's surface. Pre-processing aims to correct distorted data in order to create more faithful representation of the original scene, this typically involves the initial processing of raw image data to correct for geometric distortions.

3.2.2.1. Image layer stacking and Image subseting

During layer stacking, Band from band 1 to 5 and 7 for TM 1986 and ETM+ 2001 and band 2 to 7 for TM 2018 Bands were considered for laystack. A number of irrelevant parts of the image can be removed and the image region of interest is focused. Taking out the project area from the whole part of the image is important to reduce the size of the image file to include only the area of interest (AOI). This is not only eliminates the extraneous data in the image. But it speeds up processing due to smaller amount of data to process.

3.2.2.2. Image enhancement

Image enhancement is the system applied to image data in order to make more effectively display or record the data for subsequent visual interpretation. Normally, image enhancement involves techniques for increasing the visual distinction between features in the scene (Billah and Rahman, 2004).The main purpose of image enhancement is to improve the interpretability of information in images for human viewers, or to provide better input for other automated image processing techniques.In this research the false color composite image made using Land sat 8 bands 5-4-3(R-G-B), Land-sat 5 TM bands 4-3-2 (R-G-B) and Land sat 7 ETM+ 4-3-2 (R-G-B)) were found to be best for the identification of major land cover classes in the study area

3.2.3. Image classification technique

In remote sensing, Image classification is the task of extracting information classes from a multiband raster image or extracting information based on the reflectance of the object and it serves specific aims; which is converting image data into thematic data. Digital image classification techniques assemble pixels to represent LU/LC classes. Image classification uses the reflectance statistics for individual pixels. Pixels were grouped based on the reflectance properties of pixels called clusters. The users identify the number of clusters to generate and which bands to use. With this information, the image classification software generates clusters. In this research supervised classification techniques is used.

3.2.2.1. Supervised classification

Supervised classification is the techniques most often used for the quantitative analysis of RS image data depending on their reflectance properties. It uses the spectral signature obtained from training samples to classify an image. Image classification toolbar, can easily create training samples to represent classes. With supervised classification, it can be identified sample of information classes (any land-cover type) of interest in the image. The supervised classification image of each year involves pixel categorizations by taking training area for each class of LU/LC.Areas in digital images were marked as signature of individual identity and the field truth verification was adapted to represent LU/LC class (Coppin and Bauer, 1996).Using Multispectral Band from band 1 to 5 and 7 for TM 1986 and ETM+ 2001 andband 2 to 7 for TM 2018 Bands of the preprocessed images the land-use/ land-cover pattern mapped was by supervised classification with the likelihood classification algorithm of ERDAS Imagine 2015 software. In supervised classification, with the help of image processing techniques, the user specified type of the land-use land-cover classes. The four major classes studied in Semen Bench district were forest Land, crop land, settlement and agro forestry.

3.2.2.2. Maximum Likelihood classification

Maximum likelihood classification (MLC) is one of the most known methods of classification in remote sensing, in which a pixel with the MLC is classified into the matching classes/categories. It is a statistical decision measure to assist in the classification of overlapping signatures; pixels are assigned to the class (categories) of the highest probability. It was considered more accurate than parallelepiped classification. However, it is slower to extract computations. The MLC classification tool considers both the variances of the class signatures when assigning each cell to one of the classless represented in the signature file.

3.2.4. Accuracy assessment technique

Accuracy assessment is a universal term for comparing the classification to geographical data that are understood to be true, in order to determine the accuracy of the classification process. To assess the accuracy of the LULC maps, field collected data has been compared against the classified images. The major cover types within the study area are forest, agro forestry, cropland and settlement. For each of the classified cover type's random sample points were established. Then, each random sample point visited in the field and the real cover typeswere confirmed (recorded as reference data). Using hand held Global Positioning System (GPS) field survey was conducted in the study area and about 50 points identified. The field survey and Google Earth were used as a ground for evaluation the LU/LC classification accuracy. The final output of classification accuracy was calculated for the years 1986, 2001, 2018 Land-use/Land-cover Map.

3.2.5. Change Detection analysis

Accomplishing classification of each land use/land cover classes, land use land cover change detection was developed by comparing the two successive periods of image. By comparing the two sets of imagery data , the statistically summary of the areas covered by each land cover types and change among different land cover classes that helps to know what percent, and area coverage of each land use land cover has for each period were computed.

Land use and land cover change detection method used in this study was post classification comparison and multi-date composite image change detection. This method is widely used and easy to understand. The advantage of this method includes the detailed from-to information that can be extracted. Change detection was done for 1986 -2001, 2001 – 2018 and the third 1986-2018 to get the from-to information of changes in land use land cover and specially to see the rate of the settlement, cropland, forest land and agro forestry coverage of study area. Change statistics was computed by comparing values of area of one data set with the corresponding value of the second data set in each period. The values were presented in terms of hector and percentage. Quantification of the rate of change has been applied to generate information about the land use and land cover change of the study area.

The rate of change for each land use land cover was calculated using the following formula (Abebe,2017).

$$Rate\ of\ change(\%) = (\frac{X - Y}{Y}) \times 100$$

Where, X= final area of land use land cover

Y= initial area of land use/land cover

$$Annual\ rate\ of\ change = \frac{\%\ obaserved}{Rate\ of\ time\ interval}$$

Using the rate of change between the three periods, the rate of change per annum was also computed by dividing it with the year difference between the two periods. The relationship between LULC distribution and changes in each category was extracted in Arc GIS by combing images. Cross tabulation is a means to determine quantities of conversions from a particular land cover to another land cover category at a later date (Doygun *et al.*, 2008). Images from the year 1986 were taken due it was the earlier available images for the study area. Also there was high expansion coffee, fruits and spices by the project of Bench ruraldevelopment (BRDP)in the year 1986-2001 and at that time more than ten thousand hectares of land should be planted by coffee. Therefore, it can be understood that these years indicate important points in the dynamics of LULCC in the area. Accordingly, satellite images that captured in the month of January were taken. This time is chosen to acquired satellite images due to the atmosphere is cloud free during January as a result satellite images can be cloud free for land use/land cover interpretation.

Table 1. Characteristics of Landsat images used in the study area

No	Sensor type	Acquisition date	Source	Spatial resolution	Cloud cover	Path	Row
1	Landsat(TM)	1986/15/1	USGS	30*30	0	170	54
2	Land sat(ETM^+)	2001/21/1	USGS	30*30	0	170	54
3	Land sat(TM)	2018/10/1	USGS	30*30	0	170	54

The description of land use applied to classify land cover types were applied based on discussion made with stakeholder, key informants, and local leader and natural resources expert (Table 2). Analyses of changes were undertaken in the year between 1986-2001, 2001-2018 and 1986-2018 years.

Table 2. Descriptions of land cover classes

No	Land cover type	Description
1	Forest	This is dense and closed canopy forest with no or little disturbance.
2	Agro forestry	Home garden and coffee with shade tree aggregation dominates the landscape
3	Crop land	Spatially continuous small household agricultural farms are included in this class
4	Settlement	This is the place where the community is settled and roads they use for their day to day careers

Source; Researcher

Furthermore, one focused group discussion consists of 6-8 key informants was carried out to confirm the LULCC in the area. Focused group discussants were selected purposively from community in consultation with kebele developmental agent (DA) and kebele leaders.

Focusdiscussion with age of 50-70 years were used. Historical change in land use land covers and soil fertility of the households in different time were the main points of discussion.

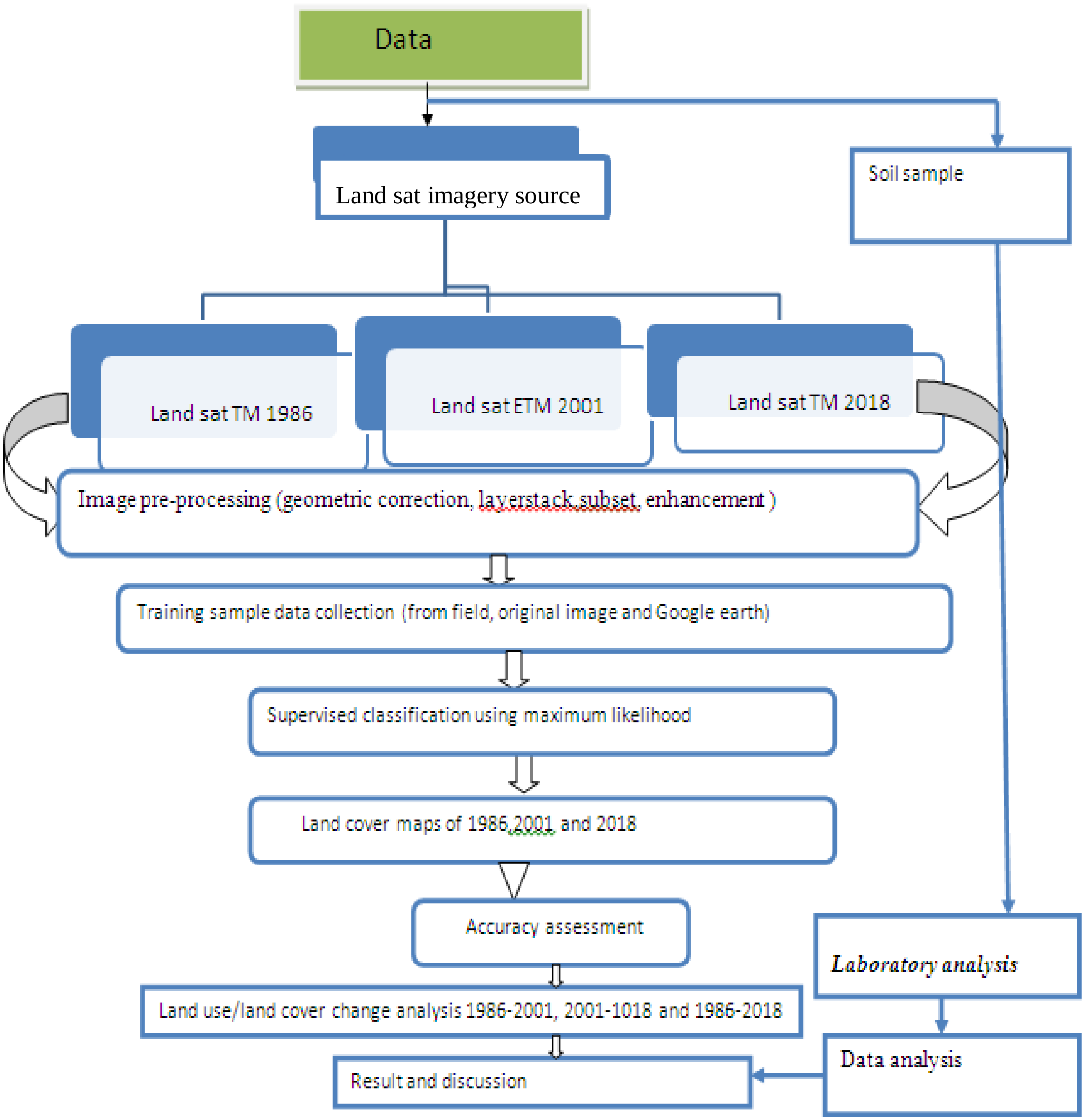


Figure 2. General procedure of the study

3.2.5 Soil sampling and analysis

3.2.5.1 Soil sampling techniques

The soil sampling sites of the study area were selected purposely depending onavailable land use types in the study area. Thus, three land uses such as cropland, forest land and agro forestrywere used to evaluatethe effect ofland use typeson soilphysico-chemical properties. In eachland uses, soil sample with replication of six were taken at depth of 0-30cm.Assessment of land use types on soil physico-chemical properties used the cropland as the basis for the comparisonbecause as the intention of assessment is what may be over cultivation affected soil physico-chemical properties. As a result plow depth is used to soil sample accordingly 30cm is preferred. The samples were collected at five points after removing aside vegetation and litter and were composited into one sample .Therefore, a total of eighteen (one kebeles*3LU*6replication) were taken. Disturbed soil samples were taken by auger while undisturbed soil sample were taken by core sampler (100cm^3) for bulk density analysis.

3.2.5.2 Laboratory analysis

Soils physico-chemical properties were analyzed in Jimma university soil laboratory using standard procedure based on selected soil parameters such as pH, available phosphorous (AP), total nitrogen TN, cation exchange capacity(CEC), electric conductivity(EC), soil organic carbon(SOC) ,soil organic matter (SOM), exchangeable base ($Ca^{2+,}$ $Mg^{2+,}$ Na^+, K^+),soil texture and bulk density.

Texture was analyzed using a hydrometer method (Bouyoucos, 1962). Bulk density (BD) was analyzed by usingcore method (Grossman and Reinsch 2002). Soil pH and electrical conductivity (EC) were analyzed with a 1:2.5 soil water suspension using a pH meter and EC meter, respectively. Cation exchange capacity of the soil was determined by extracting the soil with 1N ammonium acetate at pH 7 using 1:10 soil to extractant ratio. Availablephosphor (AP) is determined using Bray II method in 0.03 N NH_4F in 0.025 N HCl as extractant (Bray and Kurtz, 1945). Soil organic carbon (SOC) was analyzed using wet digestion with the Walkley-Black method and soil organic matter (SOM) wasobtained by multiplying SOC by 1.724 assuming 58% of SOM is SOC (Nelson andSommers, 1982). Total nitrogen (TN) was determined by using the Kjeldahl method by digesting soil samples in Kjeldahl apparatus and the amount of ammonia trapped (Bremner, 1996). After soil texture determined, soil textural triangle was used to determine the textural class.

3.2.6 Data analysis

Soil physico-chemical data collected from different land use typeswere analyzed using SAS software (V. 9.3).One way analysis of variance (ANOVA) was performed to test whether or not significant difference wereobserved on the values of selected soil physical and chemical properties among the land use types. The factors of land use and their interactions were tested at $\alpha = 0.05$. For those soil properties which were significantly affected by LULC change, LSD for multiple comparisons with a 95% confidence level was used to compare the averages differencebetween land use types.

4. RESULTS AND DISCUSSIONS

4.1. Land usecover change

As showed in the classification system agro forestry, cropland, forest and settlement are the main LULC classes for the study periods.

4.1.1. Land use land cover class ofthe study period

AccordinglyTable 4, presented the status of land use land cover among those period the classification result of the Land sat TM 1986 image showed that forest land constitute the largest proportion 37.84% of study area while settlement share the least 0.49%. On the 2001 LULC map of Figure(3) the classification result of the Land sat image of 2001 indicate that agro forestry constituted the largest proportion of land in the Semen Bench district with a value of *64.90%*Band from band 1 to 5 and 7 for TM 1986 and ETM+ 2001 and band 2 to 7 for TM 2018 BandsBand from band 1 to 5 and 7 for TM 1986 and ETM+ 2001 and band 2 to 7 for TM 2018 BandsBand from band 1 to 5 and 7 for TM 1986 and ETM+ 2001 and band 2 to 7 for TM 2018 Bandsand the lowest was Settlement*0.71%*.In the LULC class of 2018 Table 4 indicates agro forestry constituted the largest proportion of land in the Semen Bench district with a value of *27,100.15*ha (*70.26*%), forest which accounts for *8,959.86* (*23.25*%), followed by cropland *1,507.75* (*3.91*%) and Settlement *994.24 (2.58%)* respectively.

Table 3. Land use land covers class of Landsat TM 1986,ETM+2001 and TM 2018

	Land use Land Cover Class in Hectare and Percentage					
	1986		2001		2018	
Land Cover class	Hectare	%	Hectare	%	Hectare	**%**
Agro forestry	13838.88	35.89	25031.1	64.9	27100.2	**70.26**
Crop land	9944.41	25.79	3582.37	9.29	1507.75	**3.91**
Forest	14590.44	37.84	9674.25	25.1	8959.86	**23.25**
Settlement	188.27	0.49	274.23	0.71	994.24	**2.58**
Total	**38562**	**100**	**38562**	**100**	**38562**	**100**

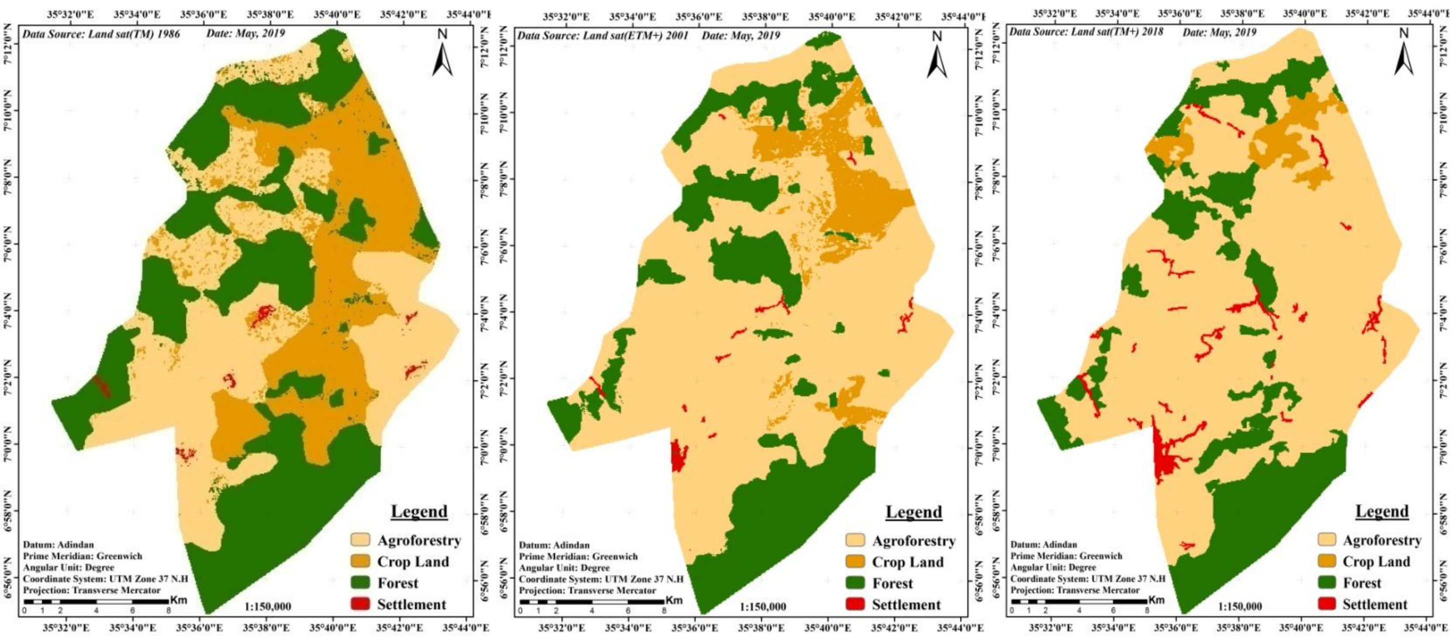


Figure 3. Land use land cover map of Semen Bench district in 1986, 2001, and 2018

4.1.4. Accuracy assessment

The overall classification accuracy for over the period of 1986,2001and 2018 was therefore 90%,87.5% and 90% with kappa coefficient of 0.87, 0.83 and 0.87 respectively the strong agreement(Table 5).Kappa value is characterized in to three grouping: value greater than 0.8 represents strong agreement, 0.4 - 0.8 represents moderate agreement and that of less than 0.4 is considered as poor agreement (Congleton, 1991).

Table 4. Classification Accuracy Assessment Report Landsat (TM) 1986 to 2018 and kappa statistics

Classification Accuracy Assessment Report Landsat (TM) 1986 and kappa statistics

Classified Data	Agro forestry	Crop Land	Settlement	Forest	Row Total
Agro forestry	9	1	0	0	10
Crop Land	1	9	0	0	10
Settlement	0	0	9	1	10
Forest	0	0	1	9	10
Total	10	10	10	10	40

Overall Classification Accuracy = 90.00% Overall Kappa Statistics = 0.8667

Classification accuracy assessment report of Landsat (ETM+) 2001 and kappa statistics

Classified Data	Agro forestry	Crop Land	Settlement	Forest	Row Total
Agro forestry	9	1	0	0	10
Crop Land	1	9	0	0	10
Settlement	0	0	9	1	10
Forest	1	0	1	8	10
Total	11	10	10	9	40

Overall Classification Accuracy = 87.50% Overall Kappa Statistics = 0.8333

Classification accuracy assessment report of Landsat (TM+) 2018 and kappa statistics

Classified Data	Agro forestry	Crop Land	Settlement	Forest	Row total
Agro forestry	9	1	0	0	10
Crop Land	1	9	0	0	10
Settlement	0	0	9	1	10
Forest	0	0	1	9	10
Total	10	10	10	10	40

Overall Classification Accuracy = 90.00% Overall Kappa Statistics = 0.8667

4.2. Land use land cover change analysis

In this research 32 year time span, and three period change detection have been made first period 1986 to 2001 , second period 2001 to 2018 and the third period from 1986 to 2018 (from initial to final years changes) which is moderately enough in showing long history of land use and land cover. These time periods were chosen based expansion coffee, fruits and spices by the project of Bench rural development (BRDP) (SBWA office,2000).

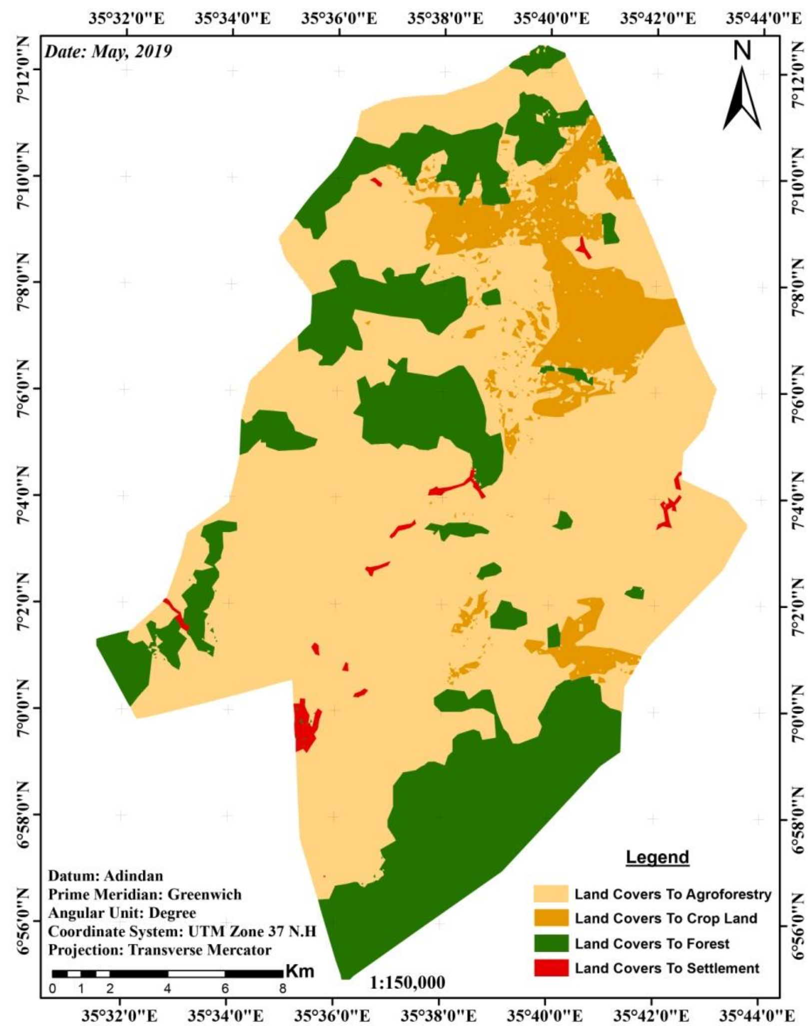


Figure 4. LULC map of 1986 to 2001

As presented in Table 6 , the total area of agro forestry changed from 13,838.88 in 1986 to 25,031.14 ha in 2018 and settlement from 188.27 ha in 1986 to 274.23ha in 2001 which means that agro forestry is increased by 49.62% and settlement by 0.38%. But cropland and forest were decreased from 9,944.41ha in 1986 to 3,582.37 in 2001 and 14,590.44ha to 9.674.25 ha in 2001 respectively. The cropland and forest were decreased by 28.24% and 21.76% in net 1986 to 2001 respectively. The Land covers change of 1986-2001 quantified by using differences from the earlier periods to later. The result of changing analysis of one and half decades of land cover maps of the study area showed major changes in all land cover classcategories over all the study periods(Fig .6). Empirical evidence from Table 6 indicates that forest land and cropland were dwindling net change through the year of 1986-2001.Whereas agro forestry and settlement was increasingnet change during the same year. This showed that high conversion of cropland and forestland class to agro forestry and settlement during these study periods. During the periods of 1986-2001 (Table7) agroforestry,cropland, forestland and settlement indicates high changes.

Table 5.LULC change rate of 1986 – 2001period.

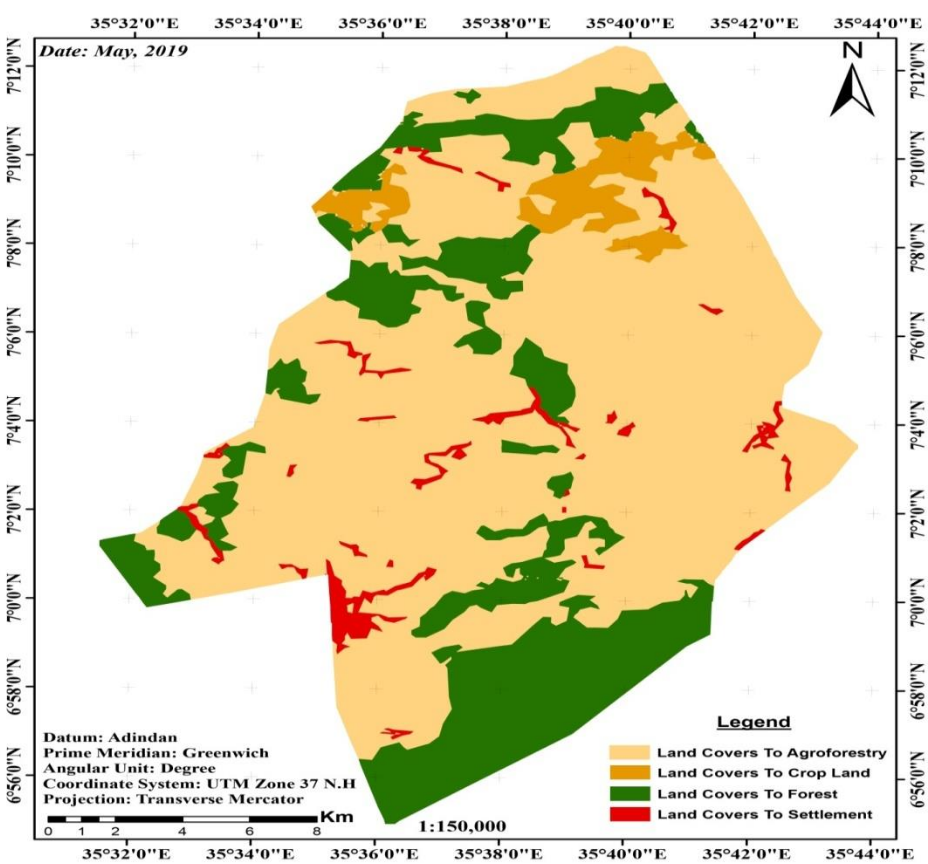
Land Cover Classes	Land use Land Cover Change in Hectare and Percentage from 1986 to 2001						
	1986		2001		Net change		Rate of Change
	Hectare	%	Hectare	%	Hectare	%	Hectare/ Year
Agro foresty	13,838.88	35.88735	25,031.14	64.90	11,192.26	49.62	746.1507
Crop Land	9,944.41	25.78811	3,582.37	9.29	-6,362.04	-28.24	-424.136
Forest	14,590.44	37.83632	9,674.25	25.10	-4,916.19	-21.76	-327.746
Settlement	188.27	0.488227	274.23	0.71	85.96	0.38	5.730667
Total	*38,562.00*	*100*	*38,562.00*	*100*	22,556.45		

Agro forestry and settlement increases (746.1507ha/year), and settlement (5.730667ha/year) in between 1986 to 2001 respectively. On the other hand cropland and forest classes losses (-424.136ha/year), andforest (-327.746ha/year) in the same periods (Table 6). This study showed that cropland and forest in maximum changed to agro forestry and settlement (Fig . 6). Agro forestry to agro forestry 12,766.49ha, cropland to agro forestry 6,842.27ha, forest to agro forestry 5,308ha and settlement to agro forestry 114.47 ha(Table 7).

Table 6. Cross tabulation in the year between 1986 and 2001

	Land Cover Categories	Land Use Land Cover in 1986				
		Agro Forestry	Crop Land	Forest	Settlement	Row Total
Land Use Land Cover in 2001	Agro forestry	12,766.40	6,842.27	5,308.00	114.47	25,031.14
	Crop Land	149.67	2,793.62	638.98	0.11	3,582.38
	Forest	768.05	276.75	8,624.06	5.39	9,674.25
	Settlement	154.76	31.77	19.40	68.30	274.23
	Class Total	13,838.88	9,944.41	14,590.44	188.27	38,562.00
	Class Changes	1,072.48	3102.14	9282.44	73.8	
	Image Difference	11,192.26	-6,362.03	-4,916.19	85.96	

Figure 5. LULCC map of 2001 to 2018



As indicated Table 8, though the period of 2001 to 2018 there substantial change in several LULCC categories including agro forestry (121.7ha) and settlements (42.35ha) area increased. Whereas cropland (-122.036ha) andforestland (-42.0229ha) area decreased. According to above table trend towards more land brought under agro forestry and settlement. These data expressly stated that increase in agro forestryand settlement resulted the permanent crop system is customized and population pressure on land at the period from 2001 to 2018.

Table 7. LULC change rate of 2001-2018 period.

Land Cover Classes	Land use Land Cover Change in Hectare and Percentage from 2001 to 2018						
	2001		2018		Net change		Rate of Change
	Hectare	%	Hectare	%	Hectare	%	Hectare/Year
Agro forestry	*25,031.14*	*64.90*	*27,100.15*	*70.26*	2,069.01	*37.10*	121.7065
Crop Land	*3,582.38*	*9.29*	*1,507.75*	*3.91*	-2,074.62	*-37.22*	-122.036
Forest	*9,674.25*	*25.10*	*8,959.86*	*23.25*	-714.39	*-12.78*	-42.0229
Settlement	*274.23*	*0.71*	*994.24*	*2.58*	720.01	*12.90*	42.35353
Total	*38,562.00*	*100*	*38,562.00*	*100*	5,578.03	*100*	

According to the below Table 9, conversion for the year 2001 - 2018, the change in the land use and land cover in the study area was by increase attributed to no change of agro forestry (21,923.45ha), forest (7,097.66ha), settlement (269.44ha) and crop land (731.93ha). This class has expanded at the expense of forest land and cropland. There was also significant change of forestland to agro forestry in this period. Generally there is a sharp decrease of forest and cropland in this period which goes to agro forestry and settlement.

Table 8. Cross tabulation of Study Area between 2001 and 2018

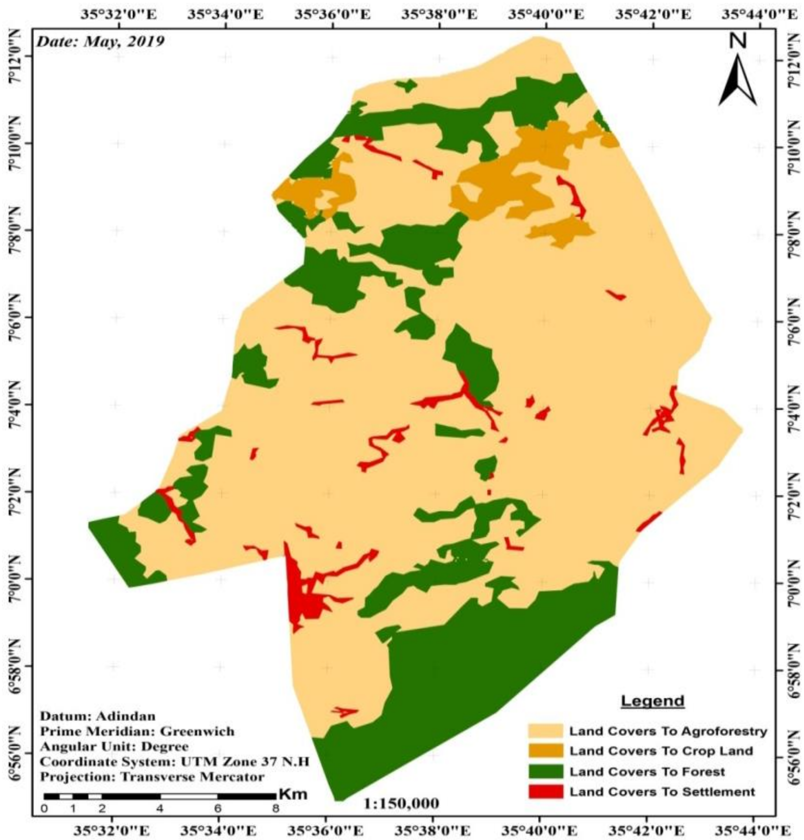
	Land Cover Categories	Land Use Land Cover in 2001				
		Agro Forestry	*Crop Land*	*Forest*	*Settlement*	*Row Total*
Land Use in Land Cover 2018	Agro forestry	21,923.45	2,727.65	2,444.51	4.54	27,100.15
	Crop Land	669.94	731.93	105.88	0.00	1,507.75
	Forest	1,788.24	73.71	7,097.66	0.25	8,959.86
	Settlement	649.51	49.09	26.2	269.44	994.24
	Class Total	25031.14	3,582.38	9,674.25	274.23	38,562.00
	Class Changes	3,107.69	854.73	7,229.74	269.69	
	Image Difference	2,069.01	--2,074.63	-714.39	720.01	

During the period of 1986to 2018 there is vivid expansion of several LULC categories including settlements (805.97 ha) or (2.87 %) and agro forestry (13,261.27 ha) or (47.13%) area increased and cropland decreased to (-8,436.66ha) or 30.02% .According to above Table 10, tendency towards more land brought under settlement and agro forestry. Also in the year agro forestry is increased by (414.4147ha/year) and settlement (25.2ha/year).Whereas cropland and forest decreases by -263.646ha/year and -175.956ha/year. Therefore, as the study area there was high expansion coffee and spices which results decreasing of forestland and cropland sizes.

Table 9. LULC change rate of 1986 to 2018 period

Land Cover Classes	Land use Land Cover Change in Hectare and Percentage from 1986 to 2018						
	1986		2018		Net change		Rate of Change
	Hectare	%	Hectare	%	Hectare	%	Hectare/Year
Agro forestry	13,838.88	35.90	27,100.15	70.26	13,261.27	47.13	414.4147
Crop Land	9,944.41	25.80	1,507.75	3.91	-8,436.66	-30.02	-263.646
Forest	14,590.44	37.81	8,959.86	23.25	-5,630.58	-19.98	-175.956
Settlement	188.27	0.75	994.24	2.58	805.97	2.87	25.18656
Total	38,562.00		38,562.00		28,134.48		

Figure 6. LULC map of 1986 to 2018



As the Table (11) showed from the total of 13,838.88ha of agro forestry187.57ha, 786.9ha and 616.13ha were converted to cropland, forest and settlement respectively. In maximum the land uses changed to agro forestry were cropland (8,433.43ha) and forest (6,318.31ha) from 1986-2018.

Table 10. Cross tabulation of Study Area between 1986 and 2018

		Land Use Land Cover in 1986				
	Land Cover Categories	Agro Forestry	Crop Land	Forest	Settlement	Row Total
Land Use Land Cover in 2018	Agro forestry	12,248.28	8,433.43	6,318.31	98.24	27,100.15
	Crop Land	187.57	874.23	444.37	0.00	1,507.75
	Forest	786.90	432.08	7,737.51	6.28	8,959.86
	Settlement	616.13	204.67	90.25	83.75	994.24
	Class Total	13,838.88	9,944.41	14,590.44	188.27	38,562.00
	Class Changes	1,590.60	1,510.98	8,272.13	90.03	
	Image Difference	13,261.27	-8,436.66	-5,630.58	805.97	

4.3. Summary of land use and land cover change detection from1986-2018

The result indicated that, the largest amount of the area was covered by forest (37.81%) and agro forestry (35.90%). Cropland cover accounts about 25.80% and settlement 0.75% in 1986 (Table 12). The land cover class of 2001 (Table 12) showed that from the total coverage agro forestry was 64.9% but forest , cropland and settlement were 25.1%,9.29% and 0.71% respectively. Also in 2018 forest, cropland and settlement were 23.25%, 3.91% and 2.58% respectively, while agro forestry was the highest from the total (70.26%). Still significant positive change was observed in agro forestry and settlement 35.90% in 1986 to 70.26% in 2018and 0.75% in 1986 to 2.58% in 2018 respectively. On the other side, forest and cropland were decreased from 37.50 % in 1986 to 23.25% in 2018 and 25.8% in 1986 to 3.91% in 2018 respectively. Therefore, the net change of land cover class from 1986 to 2018 to agro forestry 47.13529% and settlement by 2.86% and forest land decreased by *19.98*% and cropland decreased by *30.02*%. Generally, the classified satellite image indicates that there is a change in LU/LC.Agro forestry, crop land and forest were the main land uses in the study area. These land use and land cover classes are found to have different spatial and temporal patterns. The land cover change analyses have exposed that some land use and land cover types have gained an area while other lost. From the Land sat image of 1986, 2001 and 2018 for semen Bench district study site LULCC classification maps of forest land, cropland, settlement and agro forestry were developed for these years. From the LULC map of the area coverage agro forestry land was higher than for the other land classes and settlement had low proportion. A evaluation of the land use and land cover for each class between the years of 1986, 2001, and 2018 showed that the agro forestry was increased by 414.4147ha/year. Settlement had increased by 25.18656ha/year, whereas crop land and forest land were decreased by 263.646ha/year and 175.956ha/year respectively *(Table 12)*.

The land sat image of 1986, 2001 and 2018 analyses described was confirmed by those who living in the area of study. During the focused group discussion of with residence living around the site was requested to appraise the trend of LULC change. As they responded forest lands are converted to agro forestry, croplands and settlement. The change to Agro forestry is more evident 1986 up to 2001. At mentioned year almost it was the period of coffee diversification. But in the mid the price of coffee decline instead coffee they planted khat because the price of khat is better than coffee. As result the croplands and forestlands are changed to khat land. So, the LULCC analyses the increment of agro forestry is in relation to coffee, khat(Catha edulis) and fruits. Forestlands and cropland is more converted to agro forestry and settlement. So, current the major land uses is agro forestry. The focused group discussion revealed that there was land use and land cover change in the study area. Finally, forest cover was cleared and changed to other land use by the people who residing in around of forest.

Table 11. LULC change rate of 1986 – 2018 period

Land cover class	Land use Land Cover Change in Hectare and Percentage from 1986 to 2018								
	1986		2001		2018		Net of Change from 1986 to 2018		Rate of Change from 1986 to 2015
	Hectare	%	Hectare	%	Hectare	%	Hectare	%	Hectare/year
Agro forestry	*13,838.88*	*35.90*	*25,031.14*	*64.90*	*27,100.15*	*70.26*	13,261.27	*47.13*	414.4147
Crop Land	*9,944.41*	*25.80*	*3,582.38*	*9.29*	*1,507.75*	*3.91*	*-8436.66*	*-30.02*	-263.646
Forest	*14,590.44*	*37.81*	*9,674.25*	*25.10*	*8,959.86*	*23.25*	*-5630.58*	*-19.98*	-175.956
Settlement	*188.27*	*0.75*	*274.23*	*0.71*	*994.24*	*2.58*	*805.97*	*2.87*	25.18656
Total	*38,562.00*		*38,562.00*		*38,562.00*		*28,134.48*		

4.4. Land Use Types on Soil Physico-Chemical Proprieties

4.4.1 Land use types on soil physical properties

Soil texture

The result (Table 13) indicated that the texture classes of the study land uses were sandy loam that could be due to similarity in parent material across all the land use. Particle size distribution (sand, clay andsilt)were not significantly different across all the land uses(P> 0.05)(Appendix Table 5).The mean variation of silt content was highest (30.67%) in forestland and highest (60.833%) mean sand fraction was recorded in agro forestry though it was not significantly affected by land uses (p>0.05). This is because the soil textural could notchange in short time with a land use change. This is in agreement with the previous finding of Kifle and Beyne(2013) that , they observed non-significant variation different land use types in Abobo area and suggesting that soil texture, since texture is an inherent soil property that might not be influenced in short period of time following land use change.

Table 12. Mean value of particle size distribution and bulk density influenced by land uses

	Particle size distribution			Texture class	BD (g/cm^3)
Land use	sand	Silt	Clay		
Agro-forestry	60.83[a]	23.67[a]	15.5[a]	sandy loam	0.96[b]
Cropland	55.17[a]	28.33[a]	16.5[a]	sandy loam	1.03[a]
Forestland	57.33[a]	30.67[a]	14.33[a]	sandy loam	0.78[c]
LSD	NS	NS	NS		0.07
CV%)	6.9	22.04	15.66		6.37

Means within column followed by the same letter are not statistically different from each other at P > 0.05; LSD = least significant difference; NS= non- significant; CV = coefficient of variation; Agro forestry; cropland; 3=forest land. BD = bulk density

Bulk density

Soil bulk density was highly significantly (P <0.05) affected by land use (Appendix Table1). The highest mean (1.03gcm^{-3}) value of bulk density was recorded on thecrop land and lowest mean (0.78 gcm^{-3}) in the forest land (Table 13). The result is agreement with that of Yalew and Gebrekidan (2011).The higher bulk density under the croplandsmay be due totherepeated tillage practices and compaction which might destroy the pore space in croplands. Furthermore, continuous exposure of the bare soil surface under crop land to the direct impact of rain drops due to removal and lower vegetation cover in crop fields might contributed to the increment of bulk density as rain drop impacts cause soil compaction throughdisintegration of the soil structure and percolation of clay to clog pore space. Besides, the lowest organic matter (OM) contentin the cultivated land soils also contributes to the highest bulk density. Cultivationhave a negative impact on the soil OM due to the removal of crop residues and tillage effects, leading to lower structural stability and higher soil bulk density (Yalew and Gebrekidan .,2011). Also intensive cultivation increases bulk density resulting in reduction oftotal porosity. Furthermore, the density of OM is very low as compared to the mineral particles and hence higherOM content results in lower density in forest land. Thus, study indicated the forest conversion to cultivated land negatively affectland productivitybecause it hinders the growth of crop root and promote soil erosion and downward percolation of water to recharge water table.

4.4.2. Assessment of land use types on soil chemical properties

Soil pH

The mean pH of the study land uses are 5.49, 6.11 and6.37 respectively forcropland, agro forestry, and forest lands (Table14) respectively. The mean differencebetween forestland and cropland issignificant (P<0.05), but the mean variation between forestland and agro forestry is not statistically significant (P>0.05).Soil pH is an important indicator of soil quality in different land uses(Saha and kukal,2015). It affects the process ofnutrient transformations, solubility, or availability of many essentialnutrients to plants and also affects the quantity, activity, and types of microorganisms in soils which in turn influence decomposition of organic materials (Barua and Haque,2013; Mckie,2014). Low pH favors free metal cations and protonatedanions, while higher pH favors carbonate or hydroxyl complexes (Tejada and Bentez, 2014; Yao *et al*., 2010). According to Tejada and Bentez (2014), the soil pH of the study area is the range between moderate to slight acidity denominations. The cropland appeared moreacidic than that of the forest and agro forestry lands due to constantly cropped land and intensive farming. Similar study was reported by Gelaw *et al*., (2013). The pH of the crop land is below 5.5, a level that creates aluminum toxicity to crops. Lifting the soil pH of crop land to >5.5 effectively can eliminate this toxicity and there should be an adequate supplyof molybdenum available for legumes to flourish which in turn could fix good quantitiesof nitrogen in the soil (McKie, 2014). pH also influences plants' N uptake. Plants and crops can take up N inthe form of ammonium ($NH4^{+}$) and nitrate ($NO3^{-)}$ respectively (Zeng *et al*., 2009). AtpH'-s between 6 and 7, the microbial conversion of $NH4^{+}$ to nitrate (nitrification) will berapid, and crops generally take up nitrate, while in acid soils (pH<6), nitrification willbe slow, and plants with the ability to take up $NH4^{+}$ may have an advantage (Parra-Alcantra *et al*., 2013). Thus, the pH of crop land of the study area lessthan 6, hence nitrification will be slow, and crops with the ability to take up nitrate ($NO3^{-}$) may face difficulty. Problem of soil acidity of crop land can be managed by soilliming program (Gelaw *et al*., 2013).Some other studies (Abbasi and Rasool , 2005);Kidanemariam*etal*.,(2012);Emiru and Gebrekidan (2013),conclude that soil pH was found to be higher in soils under forest land use and generally become in cultivated land. According to these authors, the lower pH in soils of the cultivated land could be attributed to the removal of basic cations by crop harvesting and leaching as the region is high rainfall area. Liming is important to increase the soil PH and to maintain essential nutrients like Ca^{2+} and $Mg^{2+.}$Different researcherssuch as Yao et al.(2010),reported that soil liming can increase soil pH, supply essential plant nutrients (Ca2+ and $Mg^{2+),}$ make other essential nutrients more available and prevent Mn and Al from being toxic to plant growth. Also the correlation of pH ispositively correlated with OM,TN,AP,CEC,EC and negatively correlated withsand, clay and silt(Appendix Table 6).

Table 13. Mean values of pH, organic carbon, soil organic matter (OM), total N (TN), Available P and EC

LULC	pH	OC%	OM%	TN%	AP mgp/kg	EC MS/cm
Agro forestry	6.11[a]	3.37[b]	5.81[b]	0.22[b]	14.31b	73[b]
Cropland	5.49[b]	1.86[c]	3.21[c]	0.09[c]	9.32c	44.53[a]
Forestland	6.36[a]	4.82[a]	8.32[a]	0.38[a]	19.45a	47.16[a]
LSD	0.25	0.52	0.91	0.08	2.62	16.73
SEM	0.08	0.16	0.28	0.028	0.83	5.31
CV	3.32	12.24	12.24	29.57	14.19	23.70

SEM = Standard error of means LSD = least significant difference; CV = coefficient of variation.

Soil organic carbon

Soil organic carbon is highly significantly different among three land uses ($p<0.0001$) (Appendix Table 5). The soils in theland uses have a mean SOC of 1.87, 3.37 and 4.83 respectively in cropland, agro-forestry, and forest lands (Table 14). The mean differences between forestland and cropland, and forest land and agro forestry are statistically significant, but the mean difference between forestland andcropland is highly significant. This study is in agreement with finding of Worku *et al*., (2014). Organic carbon is high under soils of forest and agro forestimplies that there is more supply of litters and return of OM to the soils and low OC on crop lands is due to removal of biomass from the cropland. Organic carbon is highlycorrelated with OM, TN,AP and Mg. Alsovery highly correlated with EC, Ca, K and Na (Appendix Table 6).

Soil Organic Matter

Soil organic matter is an important displayer of soil and land health as it integrates several inherent soil properties and responds strongly to land-use change and land degradation processes (Aguilera et al., 2013;Vågen and Winowiecki, 2013). The higher organic matter found in forest land was due to litter coversoil macro fauna(worms, largeinsects, etc.)and micro fauna (bacteria, fungi, algae, protozoa etc). The leaves from trees fall to the soil surface and dead of macro fauna, micro fauna and micro flora in the soil decomposed and form organic matter in the forestland. In the study site SOM content wassignificantly ($P <0.05$) affected by land use. The mean value ofSOM was the highest in forest land (8.32%) and the lowest in cropland (3.27%) intermediate inagro forestry (5.81%). The decline in soil OM contents in cropland wasattributed to accelerated rates following deforestation high decomposition rate due to increase in temperature and reduction in moister, which have direct association with microbial activity for increasing decomposition and reduction of OM. The relatively low soil OM under cropland soils as compared to forestland could be attributed to intensive cultivation, which aggravated oxidation of organic carbon. The result, on the other hand indicated lower availability of essential nutrients TN and AP.Also OM is perfectly correlated TN and AP.Therefore, the result is in line with the general truth was assured by Adugna and Abegaz(2016) and revealed land use change have negative influence on OM hence requires sustainable management of OM.

Total Nitrogen

The results revealed thattotal N content of the study land uses were very highly significantly ($p=0.0001$) affected by land use change. The mean value of nitrogen in cropland (0.09%) is lowest when compared to agro forestry (0.2%), andforestland (0.38%). This means the accumulation of organic residues in cropland is low. This result was similar with study reported by Adugna and Abegaz(2016). Besides, mineralization of the accumulated SOM to ammonia and fixed atmospheric nitrogen by nitrogen fixing bacteria in cropland are causes for low TN which converts nitrogen to ammonia (Galloway *et al*. 2004).Finally, the land use land cover change reduces the vegetation cover and resulted in reduction of total nitrogen which may affect the fertility and productive capacity of soil as nitrogen is among the importantfundamentals to plant growth.

Available Phosphorus

The results in Table 14 indicated that available phosphorus (AP) content was very highly significantly ($P <0.05$) affected by land uses (Appendix Table 1). The highest mean value of available phosphors was recorded in forestland (19.458mg/ kg) followed by agro forestry. The reason for relatively high AP content of might be addition organic matter in forestland and low soil erosion. A lower content of AP in cropland might be due tointensive cultivation and removal of phosphate anion by erosion andcrop and residualharvesting. In addition to that fixation of phosphorus is problematic in acidic soil, which could be the causes for lower AP (Mulatu *et al*., 2014).   The results disagree with finding of Tilahun(2007), who reported the highest and the lowest AP contents under cultivated and forestlands respectively. But the study agree with the study reported by Chimdi*et al*. (2012)**,**who reported low AP in cultivated lands compared to soils of forestlands and grazing lands. Generally, Phosphorus (P) is the most commonly plant growth limiting nutrient in the tropical soils next to water and N (Solomon*et al*., 2002). This deficiency is primarily caused either by the inherent characteristics of the parent material or by the strong sorption of PO_4^{3-} to Al and Fe hydroxides and oxides, which turns large proportions of total soil P into unavailable forms. So, they also suggested the possibility of the effect of applying cattle dung and inorganic fertilizer as a soil conditioner in cultivated fields has been substantial.

Electrical conductivity

The value of electric conductivity was significantly ($p<0.05$) affected by land uses (Appendix Table 1). The highest mean EC value was recorded in agro forestry (73mS/cm) and lowest recorded in croplands (44.53mS/cm). There is statistically significant difference in EC value between agro forestry and croplands. In the contrary forestlands and croplands are not statistically significant. The highest value of EC in agro forestrymight be due to high organic matter in the agro forestry release basic cation which increases the value of EC. On the other hand lowest value of EC on cropland might be due to the loss of basic cation due to intensive cultivation and leaching below the root zone of erosion because of highrainfall. This result is in agreement with the results reported by Mishra and Defera(2018). As per the rating established by US Salinity Laboratory Staff (1954), the soils of the study area fall under non saline (low EC, <2 dS/m) condition. This might be due to relatively higher rainfall and the rolling nature of the watershed with free drainage conditions, which favored the removal of soluble salts with the percolating and drainage water. This was also similar to the research finding, reported by Swarnam*et al.* (2004).

Cation Exchange Capacity

Thecation exchange capacity (CEC) values of the soils in the study area are highly significantly ($P \leq 0.0001$) affected by land usechange (Table 15). Considering the main effects of land use, the highest (25.4 cmol (+)/kg) and the lowest (13.91 cmol (+)/ kg) values of CEC were observedunder the forest and the cultivated lands, respectively (Table 15). According to Landon (1991) classification, the top soils CEC as high (> 25 cmol(+)/kg), medium (15-25 cmol(+)/kg), low(5-15 cmol(+)/kg) and very low(< 5 cmol(+)/kg).The CEC of the forest land high, that agro forestry was medium and the croplands was qualified as low**(**Table15**).** The result is in agreement with the reported by Tilahun (2007). This indicated that, deforestation and conversion especially from forest and agro forestry to crop land without proper management aggravates soil fertility reduction. Processes that affect texture (such as clay) and OM due to land use changes also affect CEC of soil. The soil CEC values in agricultural land uses decreased mainly due to the reduction in organic matter content (Teshome et al., 2013). The authors accounted that conversion of natural forest land into cultivated lands caused losses of CEC. In addition the reduction of SOM following removing vegetation is also important for reduction of CEC. The difference in CEC values of the studied soils may be because of variation in OM, type and amount of clay, and soil management practices (intensity of cultivation). Therefore, soil CEC is predictable to increase through improvement of the soil OM content. Generally, it is the dominant factor in measuring soil fertility which affects exchange of ions on the clay surface Taye and Yifru(2010).Therefore, the result indicated that deforestation have significant effect on CEC of the soil.Also CEC is reasonable correlated with pH (Appendix Table 6).

Exchangeable bases

The content of exchangeable calcium ($Ca^{2+)}$ was significantly ($P <0.05$) affected by land use(Appendix Table 5).The mean values of exchangeable calcium (Ca2+) under the forest, agro forestry and croplands were 15.82, 11.95 and 8.06cmol(+)/kg, respectively (Table 15). The highest exchangeable Ca2+ observed on soils of the forestland could be due to the relatively higher CEC content of the soil. The lowest Ca^{2+} in the soils of the croplands could be due to lower pH and SOC (Table14). Low Ca^{2+} could be due to its removal with crop harvest with no or little organic matter input into the soil leaching and erosion. This result is in agreement with the findings of Wakene (2001) and Wakene and Heluf (2003) who indicated that cultivation enhances leaching of Ca^{2+} especially in acidic tropical soils. Similarly ,Donis and Assefa (2017) reported lower exchangeable Ca^{2+}in the surface horizon of the cultivated field and attributed to the removal of Ca^{2+} with crop harvest, high leaching as a result of continuous cultivation and OM decomposition. Besides erosion of surface soil and leaching them from top to subsurface in high rainfall area like south west Ethiopia are an important reason low Ca^{2+} in cropland. Finally, the release of Ca or Mg from the exchange complex and their ease of use to crop plants depends upon the total Ca or Mg supply, the type of clay mineral present, the CEC of soil, soil pH and the ratio of Ca^{2+} or Mg^{2+} to the other cations in the soil solution.

Exchangeable magnesium($Mg^{2+)}$ content was highly significantly ($P < 0.0001$) affected by land use changes(Appendix Table 5).The mean value of Mg2+ in forestlands, agro forestry and croplands were 1.95,1.58 and 1.12cmol(+)/kg respectively. The result revealed that the mean Mg^{2+} value was highest (1.95cmol (+)/kg) under the forest land and lowest (1.12cmol (+)/kg) on the croplands (Table 15). The Mg^{2+} decreased from the forestland to cropland could be attributed to the higher SOC observed in the forestland surface. This is in harmony with the finding of Nega (2006) who reported that forest and shrub land soils are somewhat richer in Mg2+ contents than other land uses such as croplands.

Exchangeable potassium K^+ content was highly significantly ($P <0.0001$) affected by land use (Appendix Tables 5).The mean value of potassium $K^+$was highest (14.73 cmol(+)/kg)in the forest land and lowest (6.96 cmol(+)/kg) in the cropland. The highest content in theforest land was related with its high pH value and was in agreement with study results reportedby Mesfin (1996) that high K^+ was recorded under high pH tropical soils. The lowest value of potassium occurred in croplands of study area was due to deforestation and intensive cultivation force on distribution of K^+ in soils and enhance its depletion. The similar study carried out by Saikh*et al*. (1998). This might be the possible reason for the relatively low exchangeable K^+ in soils of the croplands. Potassium content and its availability varies with type of parent material, degree of weathering, management practices, OM content and clay content as well as type (Ayele*et al*., 2013). Available K increase with OM content, as reported by Singh and Mishra(2012). This might be due to creation of favorable soil environment with presence of OM.

Exchangeable Na+ content was significantly ($P \leq 0.0062$) affected by land use(Appendix Tables 1).The mean value of Na+ in forestland, agro forestry and cropland were 0.0094,0.0146 and 0.0089 cmol(+)/kg respectively. The mean values highly werestatistically significantly in agro forestry and forest land. But mean value of forestland and croplands are not statistically significant. As per exchangeable Na+ ratings by Roy et al., (2006), the mean exchangeable Na+ values were medium in the soils of all land uses types (Appendix Table 1). According to Sposito (1989) exchangeable Na+ alters soil physical and chemical properties mainly by inducing swelling and dispersion of clay and organic particles resulting in restricting water permeability and air movement and crust formation and nutritional disorders. Moreover, it also adversely affects the population, composition and activity of beneficial soil microorganisms directly through its toxicity effects and indirectly by adversely affecting soil physical and as well as chemical properties. In general, high exchangeable Na+ in soils causes soil sodicity which affects soil fertility and productivity. Lowest possible level could be taken as an opportunity because Na+ concentration is not recommendable to high level as it deteriorates soil structure and make the soil liable for soil erosion and devoid of beneficial organisms (Taye and Yifru, 2010). Therefore, the level of exchangeable Na^+ in the study area was lowest in all land uses which revealed that it had lowest negative impact on soil structure and useful for soil microorganism. According to Gebrekidan and Negassa (2006) the variations in the distribution of exchangeable bases depends on the mineral present, particles size distribution, degree of weathering, soil management practices, climatic conditions, degree of soil development, intensity of cultivation and the parent material from which the soil is formed. But in the study area deforestation and intensive cultivation affects exchangeable bases by accelerating erosion and leaching which causes the losses of basic cation. The order/distribution of exchangeable basic cations in most agricultural soil is generally Ca> Mg > K > Na with a pH of 5.5 or more. So, the result of this study showed that the relative abundance of exchangeable basic cations in the exchange complex of the studied soils was in order of Ca> Mg > K > Na. Finally, under all land uses exchangeable bases are highly correlated with OC,OM, TN, AP and EC but exchangeable $Na^+$is perfectly correlated with EC.

Table 14. Exchangeable bases (Ca2+, Mg2+, K+, and Na+) and CEC as influenced by the land uses

Land use	CEC	Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}
Agro forestry	20.19^{b}	11.95^{b}	1.58^{b}	11.35^{b}	0.0146^{a}
Cropland	13.91^{c}	8.06^{c}	1.12^{c}	6.96^{c}	0.00890^{b}
Forestland	25.40^{a}	15.82^{a}	1.95^{a}	14.73^{a}	0.0094^{b}
LSD	1.93	2.61	0.26	1.83	0.003
SEM	0.73	0.94	0.09	0.61	0.00098
CV	7.58	17.01	13.26	12.93	23.69

Means with in column followed by the same letter are not statistically significant from each other at P > 0.05. LSD = Least significant difference’s = Coefficient of variation; SEM=Standard error means

5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

Land use/land cove change detection carried out the study revealed that there was land cover change during the last three decades. The LULCC the classification from land sat image of 1986, 2001 and 2018 and land covers change detection analyses revealed some land use and land cover types had gained while others lost. Thus, forest and cropland were decreased from 1986 to 2018 while agro forestry and settlement were increasing it coverage in the same year. Hence, agro forestry and settlements were increased by 414.41ha/year and 25.18ha/year respectively, whereas crop land and forest land were decreased by 263.64ha/year and 175.95ha/year respectively. Besides, the major conversion observed was forest land and cropland to agro forestry and settlement. According to this result, thoughincrease in agro forestryalong with decreasing forest cover and cropland is good compared to settlement, the conversion of forest might cause the loses of biodiversity within it and associated ecosystem services. The result also revealed the conversion has significant impact on soil physico-chemical properties such as organic matter, available phosphorus, total nitrogen, CEC bulk density. Therefore, it can be conclude that land use land cover change had significant adverse impact on soil quality and sustainability of agriculture in the area.

5.2. Recommendation

The major output of this study indicated that forest covers wereconverted to agro forestry and settlement along with adverse soil physico-chemical properties. Therefore, scientific measure is needed to be taken to reduce further conversion forest and soil degradation. Hence based on these, the following points are recommended:

- To reduce the conversion of forest to other land uses, sustainable forest conservation measure is needed to sustain the forest resources,
- Reduction of soil quality following land use cover change requiressound nutrient management and soil conservation practices like mulching, crop rotation, encouraging participatory watershed management and avoiding inappropriate land use system by developing sustainable land management system.

- ❖ The acidity of cropland needs limingto increase soil pH to optimum level required for major crop grown in the study area.
- ❖ Furtherstudies are needed to assess the impact LULC change on plant/animal biodiversity, ecosystem services and its impacts on the livelihoods of the community

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7. APPENDIX

Appendix 1. Sample data collected from field observation and Google earth which were used for classification and accuracy assessment

no	land use type	GCP_longit	GCP_latitu	no	land use type	GCP_longit	GCP_latitu
1	Forest	35.65341024400	6.97555785500	27	Agro forestry	35.65471652100	7.08455584600
2	Forest	35.65994382300	6.98080510800	28	Agro forestry	35.64988172500	7.08894230300
3	Forest	35.65047731200	6.98319773200	29	Agro forestry	35.66286141200	7.09271187900
4	Forest	35.64661290400	6.98695916200	30	Agro forestry	35.66010688100	7.10424179500
5	Forest	35.67882114200	6.99368453400	31	Agro forestry	35.66402018200	7.10016128600
6	Forest	35.68259369500	6.99133638800	32	Agro forestry	35.62420400500	7.11668932600
7	Forest	35.68638139000	6.99751922800	33	Agro forestry	35.63838861500	7.11767082500
8	Forest	35.64499586000	7.07456939400	34	Agro forestry	35.64140229700	7.11521141400
9	Forest	35.64209095100	7.08310858400	35	Agro forestry	35.64296658500	7.12031229000
10	Forest	35.64222922800	7.08228482500	36	Agro forestry	35.64229179600	7.10938093300
11	Forest	35.62198319600	7.12565147800	37	Cropland	35.63071590300	7.10562075400
12	Forest	35.62109049000	7.13291208400	38	Cropland	35.63015452100	7.10937372700
13	Forest	35.62827771100	7.13107626300	39	Cropland	35.63540926100	7.11248308100
14	Forest	35.63482763000	7.13134697300	40	Cropland	35.64757500100	7.11011696600
15	Forest	35.64322605200	7.17664907800	41	Cropland	35.63517396900	7.12061890400
16	Forest	35.66161965000	7.18304410700	42	Cropland	35.64840215900	7.13018157000
17	Agro forestry	35.64081682100	7.00231197800	43	Cropland	35.65356436300	7.15865069900
18	Agro forestry	35.63779986400	7.00271251100	44	Cropland	35.65558632600	7.15950232000
19	Agro forestry	35.64667373500	6.99301134300	45	Cropland	35.65792931500	7.16073939600
20	Agro forestry	35.64771253500	6.99367775300	46	Cropland	35.66224951400	7.15650101600
21	Agro forestry	35.64304994500	6.99210125800	47	Cropland	35.64969753900	7.15971101400
22	Agro forestry	35.64460529300	6.99372281300	48	Cropland	35.63376954900	6.98808086800
23	Agro forestry	35.64358046500	6.99395457900	49	Cropland	35.64875942400	6.99548820900
24	Agro forestry	35.64287481200	6.99362537100	50	Cropland	35.64576368500	6.99604863100
25	Agro forestry	35.64459687400	6.99264400300				
26	Agro forestry	35.65873441300	7.08395698000				

Appendix 2. Classification accuracy assessment report for the year 1986

CLASSIFICATION ACCURACY ASSESSMENT REPORT

Image File : g:/customer document/mesifin/1986sup_new.img

User Name : GIS

Date : Wed May 15 11:01:09 2019

ERROR MATRIX

Reference Data

Classified Data	Agroforestry	Crop Land	Settlement	Forest
Agroforest	9	1	0	0
Crop Land	1	9	0	0
Settlement	0	0	9	1
Forest	0	0	1	9
Column Total	10	10	10	10

----- End of Error Matrix -----

ACCURACY TOTALS

Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy
Agroforest	10	10	9	90.00%	90.00%
Crop Land	10	10	9	90.00%	90.00%
Settlement	10	10	9	90.00%	90.00%
Forest	10	10	9	90.00%	90.00%
Totals	40	40	36		

Overall Classification Accuracy = 90.00%

----- End of Accuracy Totals -----

KAPPA (K^) STATISTICS

Overall Kappa Statistics = 0.8667

Conditional Kappa for each Category.

Class Name	Kappa
Agroforestry	0.8667

Appendix 3. Classification accuracy assessment report for the year 2001

CLASSIFICATION ACCURACY ASSESSMENT REPORT

Image File : g:/customer document/mesifin/2001sup_new.img

User Name : GIS

Date : Wed May 15 11:08:35 2019

ERROR MATRIX

Reference Data

Classified Data	Forest	Agroforestry	Crop Land	Settlement
Forest	9	1	0	0
Agroforest	1	9	0	0
Crop Land	0	0	9	1
Settlement	1	0	1	8
Column Total	11	10	10	9

----- End of Error Matrix -----

ACCURACY TOTALS

Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy
Forest	11	10	9	81.82%	90.00%
Agroforest	10	10	9	90.00%	90.00%
Crop Land	10	10	9	90.00%	90.00%
Settlement	9	10	8	88.89%	80.00%
Totals	40	40	35		

Overall Classification Accuracy = 87.50%

----- End of Accuracy Totals -----

KAPPA (K^) STATISTICS

Overall Kappa Statistics = 0.8333

Conditional Kappa for each Category.

Class Name	Kappa
Forest	0.8621
Agroforest	0.8667
Crop Land	0.8667
Settlement	0.7419

----- End of Kappa Statistics -----

Appendix 4. Classification accuracy assessment report for the year 2018

CLASSIFICATION ACCURACY ASSESSMENT REPORT

Image File : g:/customer document/mesfin/2018sup_new.img

User Name : GIS

Date : Wed May 15 11:17:32 2019

ERROR MATRIX

Reference Data

Classified Data	Crop Land	Forest	Settlement	Agroforestry
---------------	----------	----------	----------	----------
Crop Land	9	1	0	0
Forest	1	9	0	0
Settlement	0	0	9	1
Agroforestry	0	0	1	9
Column Total	10	10	10	10

----- End of Error Matrix -----

ACCURACY TOTALS

Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy
Crop Land	10	10	9	90.00%	90.00%
Forest	10	10	9	90.00%	90.00%
Settlement	10	10	9	90.00%	90.00%
Agroforestry	10	10	9	90.00%	90.00%
Total	40	40	36		

Overall Classification Accuracy = 90.00%

----- End of Accuracy Totals -----

KAPPA (K^) STATISTICS

Overall Kappa Statistics = 0.8667

Conditional Kappa for each Category.

Class Name	Kappa
----------	-----
Crop Land	0.8667
Forest	0.8667
Settlement	0.8667
Agroforestry	0.8667

----- End of Kappa Statistics -----

Appendix 5.Analysis of variance (ANOVA) results of soils under the three land use types (forest, agro forestry and crop land)

Parameter	DF	Type III SS	mean square	F Value	Pr>F
pH	5	26.4	1.2	30.25	<0.0001
OC	5	78.22	13.16	77.92	<0.0001
OM	5	0.26	39.11	77.92	<0.0001
TN	5	307.98	0.13	27.91	<0.0001
AVP	5	2970.12	153.99	37.05	<0.0001
EC	5	98.11	1485.06	8.77	<0.0063
Sand	5	24.78	49.05	3.07	< 0.0914
Clay	5	101.33	7.05	0.61	<0.5630
Silt	5	397.44	76.22	4.09	< 0.0503
CEC	5	180.436	198.72	87.71	<0.0001
Ca	5	2.11	90.21	21.84	<0.0002
Mg	5	0.00012	1.05	24.83	<0.0001
K	5	182.18	5.95	44.86	<0.0001
Na	5	0.00012	91.09	8.81	<0.0062
BD	5	0.211	0.1	30.32	<0.0001

DF = degree of freedom; P = probability; EC = electrical conductivity; OM = organic matter; AP = available phosphorus; exchangeable Ca, exchangeable Mg, exchangeable K,exchangeable Na;TN=total nitrogen

Appendix 6.Pearson’s correlation matrix for different soil physicochemical parameters

	pH	**OC**	**OM**	**TN**	**AP**	**EC**	**Sand**	**Clay**	**silt**	**CEC**	**Ca**	**Mg**	**K**	**Na**	**BD**
pH	1														
OC	0.25465	1													
	0.3078														
OM	0.46064	0.79604	1												
	0.0544	<.0001													
TN	0.46064	0.79604	1	1											
	0.0544	<.0001	<.0001												
AP	0.49051	0.7291	0.83613	0.83613	1										
	0.0388	0.0006	<.0001	<.0001											
EC	0.4357	0.82636	0.80425	0.80425	0.62944	1									
	0.0707	<.0001	<.0001	<.0001	0.0051										
sand	-0.6424	0.17638	0.01838	0.01838	0.15252	-0.0879	1								
	0.004	0.4838	0.9423	0.9423	0.5457	0.7287									
clay	-0.3282	0.23448	0.20851	0.20851	0.13995	0.15308	0.55968	1							
	0.1836	0.349	0.4064	0.4064	0.5797	0.5442	0.0157								
Silt	-0.198	-0.3128	-0.3897	-0.3897	-0.0836	-0.4024	0.07005	-0.2401	1						
	0.4309	0.2063	0.11	0.11	0.7416	0.0979	0.7824	0.3372							
CEC	0.43259	0.03207	0.11225	0.11225	-0.0583	0.16973	-0.5367	-0.6846	-0.5432	1					
	0.073	0.8995	0.6574	0.6574	0.8183	0.5007	0.0217	0.0017	0.0198						
Ca	0.42591	0.8317	0.79252	0.79252	0.83772	0.77627	0.1427	0.14025	-0.1035	-0.0436	1				
	0.078	<.0001	<.0001	<.0001	<.0001	0.0002	0.5722	0.5788	0.6827	0.8637					
Mg	0.42364	0.79757	0.71238	0.71238	0.77934	0.7266	0.07462	0.03129	-0.102	0.04956	0.87292	1			
	0.0798	<.0001	0.0009	0.0009	0.0001	0.0006	0.7685	0.9019	0.687	0.8452	<.0001				
K	0.38167	0.81187	0.7232	0.7232	0.72746	0.77228	0.01263	0.07668	-0.0413	-0.0353	0.89481	0.88265	1		
	0.1181	<.0001	0.0007	0.0007	0.0006	0.0002	0.9603	0.7623	0.8709	0.8893	<.0001	<.0001			
Na	0.38051	0.88646	0.8039	0.8039	0.6706	0.95788	0.01817	0.1471	-0.4388	0.20225	0.80343	0.77941	0.81872	1	
	0.1193	<.0001	<.0001	<.0001	0.0023	<.0001	0.9429	0.5602	0.0685	0.4209	<.0001	0.0001	<.0001		
BD	-0.6433	0.17556	0.01848	0.01848	0.15174	-0.0892	0.99998	0.559	0.07061	-0.5365	0.14263	0.07387	0.01189	0.01651	
	0.004	0.4859	0.942	0.942	0.5478	0.7248	<.0001	0.0159	0.7807	0.0217	0.5724	0.7708	0.9626	0.9479	

Appendix figure 1. Photo of sample area