JIMMA UNIVERSITYCOLLAGE OF SOCIAL SCIENCES AND HUMANITIES
DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

GIS BASED ANALYSIS OF FOREST COVER CHANGE, THE CASE OF LIMMU SEKA WOREDA, JIMMA ZONE, ETHIOPIA

BY

MENGISTU ABEBE

A THESIS SUBMITTED TO SCHOOL OF GRADUATE STUDIES OF JIMMA UNIVERSITY

COLLAGE OF SOCIAL SCIENCES AND HUMANITIES

DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES, IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTER OFSCIENCE IN GIS AND REMOTE SENSING

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OCTOBER, 2016

JIMMA, ETHIOPIA

Statement of the Author

I declare that this thesis entitled "GIS based Analysis of Forest Cover Change in Limmu Seka *woreda*, South-west Ethiopia" is my work and that all sources of materials used for this thesis have been appropriately acknowledged. This thesis is submitted in partial fulfillment of the requirements for M.Sc. degree in GIS and RS at Jimma University. I seriously declare that this thesis is not submitted to any other institution anywhere for the award of any degree or diploma.

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Declaration

This is to certify that this thesis entitled "GIS based analysis of forest cover change", the case of Limmu Seka *woreda*. Accepted in partial fulfillment of the requirement for the award of degree of masters of science in Gis and Remote sensing by the school of graduate studies of Jimma university through the collage of social science and humanities done by Mengistu Abebe is a genuine work carried by him under my guidance. The material embodied in this thesis work has not been submitted earlier for the award of any degree or diploma. The assistance and help received during the course of this investigation have been dully acknowledged. Therefore I recommended that it can be accepted as fulfilling the research thesis requirements.

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Major Advisor **Signature** **Date**

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JIMMA UNIVERSITY

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FINAL THESIS APPROVAL FORM

As members of the Board of Examining of the Final MSc. thesis open defence, we certify that we have read and evaluated the thesis prepared by Mengistu Abebe under the title “GIS based analysis of forest cover change, the case of Limmu Seka woreda, south west Ethiopia” and recommend that the thesis be accepted as fulfilling the thesis requirement for the Degree of Master of Sciences in GIS and RS.

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Certification of the final Thesis

I hereby certify that all the correction and recommendation suggested by the board of examiners are incorporated into the final thesis entitled **“**GIS based analysis of forest cover change, the case of Limmu Seka woreda, south west Ethiopia” by Mengistu Abebe.

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ACRONYMS

ADLI: Agricultural Development-Led Industrialization of FDRE

CSA: Central Statistical Agency

EMA: Ethiopian Mapping Agency

FCC: Forest Cover Change

EFAP: Ethiopian Forestry Action Program

ETM: Enhanced Thematic Mapper

FAO: Food and Agricultural Organization of the United Nations

FGD/s: Focus Group Discussion/s

FTT: Forest Transition Theory

FDRE: Federal Democratic Republic of Ethiopia

FRA: Forest Resource Assessment

GIS: Geographic Information System

FRL: Forest Reference Level

ITTO: International Tropical Timber Organization

LULC: Land Use Land Cover

LEPO: Land and Environmental Protection Office

MoA: Ministry of Agriculture

NMA: National Meteorological Agency (of Ethiopia)

REDD: Reducing Emissions from Deforestation and Degradation

UNFCCC: United Nations Framework Convention on Climate Change

WBISPP: Wood Biomass Inventory and Strategic Planning Project

ABSTRACT

The objective of this study was GIS based Analysis of Forest Cover Change in Limmu Seka Woreda, South West Ethiopia. The major data for this study were obtained from three successive Landsat satellite images of 1994, 2004 and 2014. GPS based ground information and socio economic surveys to identify the extent and rate of forest cover change in the last 20 years were assessed. The most important technical works for the study were geo referencing, satellite image enhancement, classification and forest cover change detection analysis. The result of change detection analysis revealed that the area has shown a remarkable land cover/land use changes in general and forest cover Change in particular during the last 20 years. As of the information obtained from satellite images Forest cover declined from 62162.73ha in 1994 to 43957.89ha in 2004 and 39733.03 *ha in the year 2014. The annual rate of forest cover change between 1994 and 2014 was 36ha/year. The socioeconomic factors like population growth, the demand for the expansion of agricultural land, fuel wood and construction materials were the major driving forces for the observed forest cover changes. As of the information obtained from the local community the productivity of the land in the last two decades has been declining. Therefore, in order to minimize the problem of forest cover change participatory forest management policy and afforestation and reforestation must be applied .In addition, improving land productivity should also be required.*

Key words: forest cover, GIS, change, Limmuseka ,Ethiopia

CHAPTER ONE

INTRODUCTION

1.1. Background of the Study

Defining what constitutes a forest is not easy. Forest types differ widely, determined by factors including latitude, temperature, rainfall patterns, soil composition and human activity. How a forest is defined also depends on who is doing the defining. People living in the British Isles or Scandinavia might identify forests differently from people in Africa or Asia. Similarly, a business person or economist might define and value a forest in a very different way from a forester, farmer or another.

The Food and Agriculture Organization of the United Nations, FAO (2000) has been assessing the world's forest resources at regular intervals. Its Global Forest Resources Assessments (FRA) are based on data provided by individual countries, using an agreed global definition of forest which includes a minimum threshold for the height of trees (5 m), at least 10 per cent crown cover (canopy density determined by estimating the area of ground shaded by the crown of the trees) and a minimum forest area size (0.5 hectares).

In February 2015 Ethiopia adopted a new forest definition as follows: 'Land spanning at least 0.5 ha covered by trees and bamboo), attaining a height of at least 2m and a canopy cover of at least 20% or trees with the potential to reach these thresholds in situ in due course (FAO, 2015).

This forest definition differs from the definition used for international reporting to the Global Forest Resources Assessment (FAO) and from the forest definition used in the National Forest Inventory which both applied the FAO forest definition with the thresholds of 10% canopy cover, a 0.5 ha area and a 5 m height.

The reason for Ethiopia to change its national forest definition is to better capture dry and lowland-moist vegetation resources. In specific, the reason for lowering the tree height from 5 to 2 m is to capture *Termilania-Combretum*dense woodlands found in Gambella and BenishangulGumuz Regional States which in its primary state consists of trees reaching a height of around 2-3 m and above. The proposed change in forest definition results in the inclusion of what previously was classified as Ethiopia's dense woodlands which have a wider distribution through the country (see Figure 1). Commercial agriculture is expanding mainly on dense woodlands and Ethiopia desires to allow the FRL to create REDD+ incentives for the conservation of these important areas. The reason for increasing the canopy cover threshold from 20 to 10% is to avoid acceptance of highly degraded forest lands into the forest definition and in this way provide incentives for protecting quality forest.

Forests and the benefits they provide in the form of wood, food, income, and watershed protection have an important and critical role in enabling people to secure a stable and adequate food supply. Deforestation and land degradation, however, are impairing the capacity of forests and the land to contribute to food security, and to provide other benefits, such as fuel wood and fodder in Ethiopia. Ethiopians are facing rapid deforestation and degradation of land resources.

The increasing population has resulted in extensive forest clearing for agricultural use, overgrazing, and exploitation of existing forests for fuel wood, fodder, and construction materials. Forest areas of the country have been reduced from 40% a century ago to an estimated less than3% today. The current rate of deforestation is estimated to be 160,000 to 200,000 ha per year. It is estimated that fertile topsoil is lost at a rate of one billion cubic meters per year (FAO, 2015), resulting in massive environmental degradation and constituting a serious threat to sustainable agriculture and forestry. Badege (2001).

The use of remote sensing data in recent times has been of immense help in monitoring the changing pattern of forest cover. It provides some of the most accurate means of measuring the extent and pattern of changes in cover conditions over a period of time.

Satellite data have become a major application in forest change detection because of the repetitive coverage of the satellites at short intervals .Forest cover today is altered primarily by direct human use and any conception of global change must include the pervasive influence of human action on land surface conditions and processes .As indicated in several studies general information about change is necessary for updating forest cover maps and the management of natural resources.

Change detection as defined by Singh (1986) is a process of identifying changes in the state of an object or phenomenon by observing images at different times. According to him change detection studies seek to know (i) pattern of forest cover change, (ii) processes of forest cover change, and (iii) human response to forest cover change.Boakye et al (2008) explain that changes in forest cover are often the result of anthropogenic pressure (e.g. population growth) and natural factors such as variability in climate. They reported that tropical forests are exploited for varied purposes such as timber, slash-and-burn cultivation and pasture development. They further explained that degradation of forest have impact on catchment processes and biochemical cycles and leads to soil erosion and water shortage not only in the regions immediately affected by deforestation, but also in reasonably distant areas.

Many studies have been performed to identify factors that cause changes in forest cover in developing countries. One of those factors is inappropriate agricultural technology used in farm lands located around the forest area. The misuse of forest resources due to the centralization of forest management policy is considered as another factor for deforestation Moreover; Williams(2003)mentioned that conventional logging operation with unplanned-selective logging method also becomes one factor of deforestation. However, the most important factor that causes deforestation comes from illegal logging and trade.

Mapping LULC is now the standard way to monitor changes and in order to monitor land use change and development, a change detection analysis was performed to determine the nature, extent and rate of land cover change over time and space. The results will quantify the land cover change patterns in the area and demonstrate the potential of multi-temporal satellite data to map and analyse changes in land cover in spatio-temporal framework.

This can be used as inputs to land management and policy decisions with regard to varied themes that have link with space such as urbanization, water management, deforestation and land degradation. The aim of this research is to analyse the spatio-temporal forest cover change patterns using multi-temporal satellite images. Concurrent with this aim is to identify and quantify the major LULC classes, to detect changes using change detection techniques, and to identify the key driver(s) of change within the study area.

1.2. Statement of the Problem

Forest plays a significant role in the livelihood of rural people as they are highly depending on the forest resources. Environmental resource degradation in general and forest resource deterioration in particular have been a major global issue of these days and large portion of forest cover lands at global scale in general and in Ethiopia in particular have been modified and/or transformed in to other LU/LC classes.

The forest resources of the country should be, therefore, well managed in a scientific way to meet of ever increasing population on the sustainable basis. As of other rural areas of the country, most of the people in Limmu Seka *woreda* depend on forest for fuel wood, fodder, timber, coffee, honey and generate income from forest to maintain their daily needs. Forest cover is decreasing and deteriorating creating severs environmental problems. It is believed that Ethiopia in general and the study area in particular are characterized by severe environmental degradation and loss of bio-diversity at present than ever before because of population explosion .

Although some governmental sources are arguing about some progress in environmental protection activities and the resultant increase in forest cover following Ethiopian millennium afforestation and reforestation campaign in the country in the last decade, the rate of destruction seems worse in some forest cover areas. This is because, the carrying capacity of the available natural resource in general and forest resource in particular is below the need of the ever growing population There are still areas that are under severe environmental degradation at present. By taking in to account the above problem Limmu Seka*Woreda* was selected as a focus of this study.

The change in forest cover during the last three consecutive decades is the most severe human related problem that Ethiopia has seen. Researcher such as Reusing (1998) and (Tadesse *et al*, 2011) estimated that the closed high forest of South West Ethiopia dropped from 40% cover between 1971 to 1975 to only (around) 18% by 1997, which is loss of about 60%. Conversion of forestland to other land use types is the major cause of deforestation. Around 235,000 hectares of closed and slightly disturbed forest areas were deforested between 1971 and 1997, a loss of about 10,000 hectares of forest every year.

Besides to this, the research of Workaferaw (2015) and Demel (2010) agrees on the above factors and forwards that “the combined effect of population pressure, changes in settlement and land tenure policy, poor infrastructure development and expansion of large scale plantation, poor institutional and socio economic setting” are considered as the major drivers of the conversion of forest and shrub land to agriculture.”

Thus, the previous findings made analysis on prevailing problem on the study area and those studies give much concern from zonal prospective, they fail to apply GIS and Remote Sensing tools to show severity of the problem on the map. This study tries to apply these important tools for land use land cover change detection and it will provide relevant and easily accessible information for concerned bodies. The above research result illustrates the intensity of problem in the study area and initiate researcher to make study in that particular area using powerful techniques of remote sensing and GIS

1.3. Objectives of the Study

1.3.1. General objective

The general objective of this study is analysis of forest cover change in Limmu Seka *Woreda* Jimma Zone, South west Ethiopia.

1.3.2. Specific Objectives

The specific objectives of the study are to:

- Generate maps of various years (1994, 2004and2014) showing forest cover dynamics in the area

- Identify the major causes of forest-cover change in the study area

- Show the consequences of forest-cover changes in the area

1.4. Basic research questions

This research is intended to answer the following basic research questions.

1. What are the major driving forces for forest cover change in the *woreda*?

2. What amount of forest land is changed to other land uses in the last 20 years?

3. What measures are taken to minimize forest destruction in the *woreda?*

1.5. Significance of the Study

GIS-based analysis of forest cover change dynamics is one of the most precise techniques to understand how forest was changed in the past, the rate of changes are expected in the future, the forces and processes behind the changes and its implications on livelihoods, environmental degradation and others . Therefore, this study will be helpful to enhance the existing methods and techniques in the analysis of remotely sensed data so as to apply it in forest cover dynamics and environmental degradation. The output of this research is also essential for natural resources managers, development agents, socio-economic development planners and environmentalists in order to have appropriate environmental protection and development particularly, local community will be most beneficial.

1.6. Scope of the Study

This research has patio-temporal scope. Spatially it is confined to sample *kebeles* of Limmu Seka *woreda*.Temporally, since the focus of the research is analysis forest cover change three successive Landsat satellite image of the last 20 years (1994-2014) are used.

1.7. Limitation of the Study

Some of the limitations for this study include the unwillingness of some household members to respond to some of the questions especially those related to privacy which finally the researcher persuade them using different techniques, income and the archived data of offices/bureaucracy at *woreda* level are believed to have mislaid some crucial data for this study. In addition the then situation of the regional state had its own impact on the data collection.

1.8. Ethical Consideration

One of the main concerns in scientific research, that incorporates human subjects in the study, is ethical considerations for the research subjects. The researchers, cognizant of this will recognize the ethical principles of scientific research. (Belmont, 1979). By taking in to account this reality the researcher is planning to get the acceptance or will of household questionnaire survey respondents, focus group discussants and key informants. They were also being informed about the objectives and outcomes of the research quite adequately that it is only for academic purpose. They were also be informed that their personal information will be kept confidentially that will not be publicized nor given to any third party without their full willingness in case when need arises. Both researcher and the enumerators inform the respondents that their responses will be kept utmost confidential level. In addition; the researcher will try to cite and acknowledge all the information taken from scholarly literatures and data generated by other individuals or organizations.

1. 9.Organization of the Study

The thesis is organized into five chapters. Chapter I introduce and set out the rationale, objectives, research questions, limitations, delimitations and organization of the study. Chapter II attempts to review the works of other academia and research institutions to posit the study within a large context of scholarly literature. Chapter III focuses mainly on research methods and materials, Chapter IV concentrates mainly on deep analysis and discussions related to forest cover change ,rate and its causes in the *woreda* and finally chapter V deals with conclusions and policy implications of the findings believed to be thought-provoking for stakeholders so as to mitigate the existing forest degradation in the *woreda*.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1. Concept of Forest and Forest Cover Change

The definition of forest is still ambiguous. According to FAO (2005) forest is a minimum land area of 0.5-1 ha with tree crown cover more than 10-30% and tree height of 2-5m at maturity. FAO (2001) defined a forest as "land with a tree crown cover (or equivalent stocking level) of more than 10% and an area of more than 0.5 hectare; the trees should be able to reach a minimum height of 5 meter at maturity *in situ*.Yirdaw (2010).

The WBISPP defines forest as "land with relatively continuous cover of trees, which are evergreen or semi deciduous, only being leafless for a short period, and then not simultaneously for all species. The canopy should preferably have more than one story" (WBISPP 2004, 5). It defines woodland as "a continuous stand of trees with a crown density of between 20 - 80%. Mature trees are usually single storied, although there may be layered under-stories of immature trees, and of bushes, shrubs and grasses/forbs. Maximum height of the canopy is generally not more than 20 meters, although emergent may exceed this" (Yirdaw, 2010).

Forest cover change is a way in which the level of diversity and the density of individual species that make up dense vegetation structure are altered as a result of both natural and anthropogenic factors (Demel, 2010). Getachew (2013) also states that forest cover change involves the complete destruction of forest cover through clearing for agriculture, cattle ranching, small holder farming practice and large scale commodity crop production whether planned or spontaneous and their replacement by non-forest land use.(Berhan,2010).

Forests and woodlands are significant land cover covering nearly 40% of the total earth's surface, and are the most biologically diverse ecosystems in the world this is according to FAO (2001). In the tropics, forest resources are very vital in sustaining the livelihoods of millions of people Yirdaw (2006). These roles range from maintaining the ecological balance, providing fuel wood, habitat to important wildlife, soil and water conservation and purification of air. However, continued access to forest resources is increasingly getting challenged through deforestation and or forest degradation.

For several centuries the world‘s forests have been under strain due to escalating human population. These activities have resulted in loss of biodiversity, degradation of water catchments and increase in greenhouse gases which have far reaching effects. This has been blamed on poor monitoring and rule enforcement embedded in the institutions of management (Hiwot, 2008).

Studies have shown that there remain only few landscapes on the Earth those are still in their natural state. Due to anthropogenic activities, the Earth surface is being significantly altered in some manner and man’s presence on the Earth and his use of land has had a profound effect upon the natural environment thus resulting into an observable pattern in the land use/land cover over time zubair (2006).

Deforestation and forest degradation resulting from unsustainable utilization affects the continued provision of ecosystem services, puts in the balance the livelihoods of them who depend primarily on the forests for survival (Monica et al., 2010). FAO (2009) defines deforestation as the conversion of forest to another land use or the long-term reduction of tree canopy cover below the 10% threshold.

Forest degradation is the change within the forests that negatively affect the structure and the function of the stand or site, and thereby lower its capacity to supply products and services Depletion of forest affects many sectors of a country’s economic. This includes the extinction of biotic communities leading to loss of biodiversity, soil erosion, global warming and loss in income to adjacent local community (kimbile, 2009).

High rates of deforestation have been recorded in developing countries through the conversion of forest and woodlands into mainly farmlands (Michael and Janet, 2003). Forest covers change as a result of forest deforestation and degradation caused by different drivers acting at different levels of operation. These includes natural or/and anthropogenic factors acting at different times scales (FAO, 2001). The natural ones are either gradual, such as evolutionary or rapid such as volcanic eruption. Despite this human induced change, forest cover change are the most rapid driven by greed and need resulting into adverse effects including climate change, water balances disruption and soil erosion and ecological fragmentation.

It follows that sustaining these resources in the face of demographic and economic pressure is pegged on the success of the institution, cooperation of the forest adjacent communities and a good understanding of the trends in forest dynamics and vulnerability. The last quarter of the previous century has seen increase in population and poverty levels especially among the rural communities coupled with diminishing options of means to livelihood. These developments exerted more pressure on the forest and institutions governing their utilization leading to degradation. This fuelled the need to have a better understanding of trends in change and the risks level associated with the forests. (FAO, 2004).

In order to understand the forces and processes of forest cover changes, integrated synthesis of socioeconomic and biophysical data is essential. This study incorporates remote sensing for mapping change. It also integrates biophysical, and livelihoods data to interpret the forest change trends revealed by digital image analysis to identify high risk areas for future intervention. (Markim, 2000).

2.2. Global Forest Cover Changes: An Overview

Deforestation, one of the most commonly accepted forms of forest cover changes, is nevertheless plagued by inconsistencies in definitions (Williams, 2003). Food and Agriculture Organization of the United Nations defines deforestation as occurring where tree canopy falls below 10% in natural forest. On the basis of this definition and using forest inventories in different countries, expert estimates, forest department data and satellite remote sensing, the Global Forest Resources Assessment (FAO, 2000) estimated a net decrease in forest area of 9.4 million ha in the years^{-} from 1990 to 2000. This change was result of a 12.5 million ha year^{-} net decrease in natural forest. Most of the deforestation Occur in tropics, while most of the natural forest regrowth occurred in Western Europe and Eastern North America, the total net forest cover change was positive for the temperate regions and negative for tropical regions.

A recent Forest Resources Assessment (FAO, 2015) estimated the global forest cover at just over 4 billion hectares, which is 31% of total land area of the world, which corresponds to an average of 0.6 ha per capita. The five most forest-rich countries (the Russian Federation, Brazil, Canada, the United States of America and China) account for more than half of the total forest area. Ten countries or areas have no forest at all and an additional 54 have forest on less than 10 percent of their total land area. Concerning deforestation, mainly the conversion of tropical forests to agricultural land, the same report indicated signs of decreasing in several countries but continues at a high rate in others. Around 13 million hectares of forest were converted to other uses or lost through natural causes each year in the last decade compared to 16 million hectares per year in the 1990s. Both Brazil and Indonesia, which had the highest net loss of forest in the 1990s, have significantly reduced their rate of loss.

According to the International Tropical Timber Organization (ITTO) of the UN, it is estimated that deforestation and forest degradation rise 12.9 million hectares per year and the current area of degraded forest is 850 million hectares. Most of the changes in forest based ecosystems due to: a) conversion of land cover, b) land degradation c) intensification of land use (Lambin, 1994). These changes have resulted in coverage to a wide variety of ecological impacts, ranging from local to global scale, including changes in productivity and forests composition, nutrient dynamics, species diversity, and increased atmospheric carbon dioxide (lillesand, 2004).

Table 1.1.Global Forest Resources

Country	Total forest area(million ha)
Russia	809.0
Brazil	520
Canada	310
USA	304
China	207
DRC	154
Australia	149
Indonesia	94
Sudan	70
India	68
Other	1347.6
World	4033.6

Source: FAO, 2010

Africa:

Before the 19th century, land in Sub-Saharan Africa was used largely for hunting, gathering, herding and shifting cultivation (Kimble, 1962). Some settled agriculture existed in Africa long before the imposition of the colonial rule in the late nineteenth century, but in the pre-colonial period, demographic and economic needs allowed for land cleared for cultivation to be left fallow for long periods or abandoned as cultivators moved on land cleared new land. Cropland area in Sub-Saharan Africa is estimated to have been 119 million ha in 1961 and 163 million ha in 2000 (FAO, 2004), an increase of 37% in 40 years. The rate of clearing for long-term shifting cultivation has been even greater than the rate of clearing for permanent croplands in recent decades.

In the 20th century Miombo woodland of Central Africa plateau, the largest contiguous dry forest area, exceptionally high rate of change in forest cover (Mayauxetal. 2005). For example, Lusitu in Southern Zambia petit *etal.* (2001) assessed, an annual rate of land cover change 4% between 1986 to 1997, while in the Lake Malawi National Park of the Southern Malawi, intensive timber wood extraction caused rapid loss of closed forest cover canopy between 1982 to 1990 and ultimately replaced by sparse woodland cover which increased by almost 30% (Abbot and Homewood,1999).

Ethiopia

Ethiopia‘s location makes it a country with a large number of species with a significant rate of endemism. Ethiopia has very low forest cover relative to the total land area and deforestation and forest degradation are important problems. The rate of use of forests and forest products is far above the incremental yield of forests. Problems associated with this include land degradation, possible flooding, and loss of biodiversity and climate change (Yirdaw, 1996).

Like other developing countries forest resources of Ethiopia have experienced so much pressure due to increasing need for wood products and conversion to agriculture. The trend in Ethiopia today is to protect the remaining natural forests for their various social, economic and environmental values. On the other hand, there is increasing demand for wood and wood products .To strike the balance between the two interests, afforestation/reforestation (plantations) is very important. Plantations are even-aged forest stands deliberately established by humans on formerly non-forested lands or deforested lands. The purpose can be wood production or protection under the ownerships of the private sector, individual farmers, the community, or the state. (Badege, 2005).

Threats to Ethiopia's forests and resource base can be broadly linked to limited governmental, institutional, and legal capacity; population growth; land degradation; weak management of protected areas; and deforestation. These threats are largely interrelated and self-reinforcing, whether they are direct (such as charcoal-driven deforestation) or indirect (such as limited governmental capacity as seen in the lack of enforcement of natural resource related policies). It is therefore important not only to understand the individual threats but also to examine them in a holistic fashion that recognizes their interrelation and to address these threats with a multi-sectoral approach. (Bereket 2008).

Ethiopia has a number of plant and animal species with a considerable rate of endemism. Forests and woodlands provide various benefits in the country including as sources of wood and construction materials, land for farming and grazing, non-wood forest products and services and various ecological functions some of which have global values.(*Alemu Mekonnen and Bluffstone R.l)* However, with a growing human population of about 75 million largely dependent on low-productivity and rain-fed agriculture and over 70 million livestock population competing for land and forest resources, deforestation and forest degradation are important problems in Ethiopia. The forest cover in Ethiopia is estimated at less than4% compared, for example, with an average of 20% for sub-Saharan Africa (Earth Trends, 2007; WBISPP, 2004b). The rate of deforestation is estimated to be as high as 5% per year (EFAP, 1994a; Reusing, 1998; WBISPP, 2004b).

Reduction in forest cover has a number of effects including soil erosion and reduced capacity for watershed protection with possible flooding, reduced capacity for carbon sequestration, reduced biodiversity and instability of ecosystems and reduced availability of various wood and non-wood forest products and services. Although the causes of deforestation and forest degradation differs from region to regions, their general nature is similar and include population and income growth leading to increased demand for other uses of land such as farming, grazing and urbanization, clearing or changing forest lands to other land use, settlement, and increased demand for wood and non-wood products and services such as construction and energy. Poverty also contributes to the problem as millions of poor people are heavily dependent on forests and forest products for their livelihood. . (Hellden, (1997).

Even though there are policies and legislation designed and implemented and institutions set up by governments to tackle the problem, policy failure would also contribute to the problem as long as there are design and implementation problems with policies. Recent trends in a number of countries to decentralize management and use of forests are indicators of the realization that forests are more likely to be managed and used at lower levels such as villages and communities or even individuals.

The low and decreasing forest cover in Ethiopia has been a cause for concern for the past and present governments and other agents. The attempts made to tackle the problem of deforestation and forest degradation by various agents including governmental and non-governmental organizations operating in Ethiopia indicates the realization by these agents that the low and decreasing forest cover is a cause for concern and that there are important policy failures. Various policies and projects have been in place and attempts have also been made to implement these with the objective of addressing the problem. However, these attempts do not seem to have brought about improvements and in fact the problem is worsening in a number of places. (Hellden, 2007).

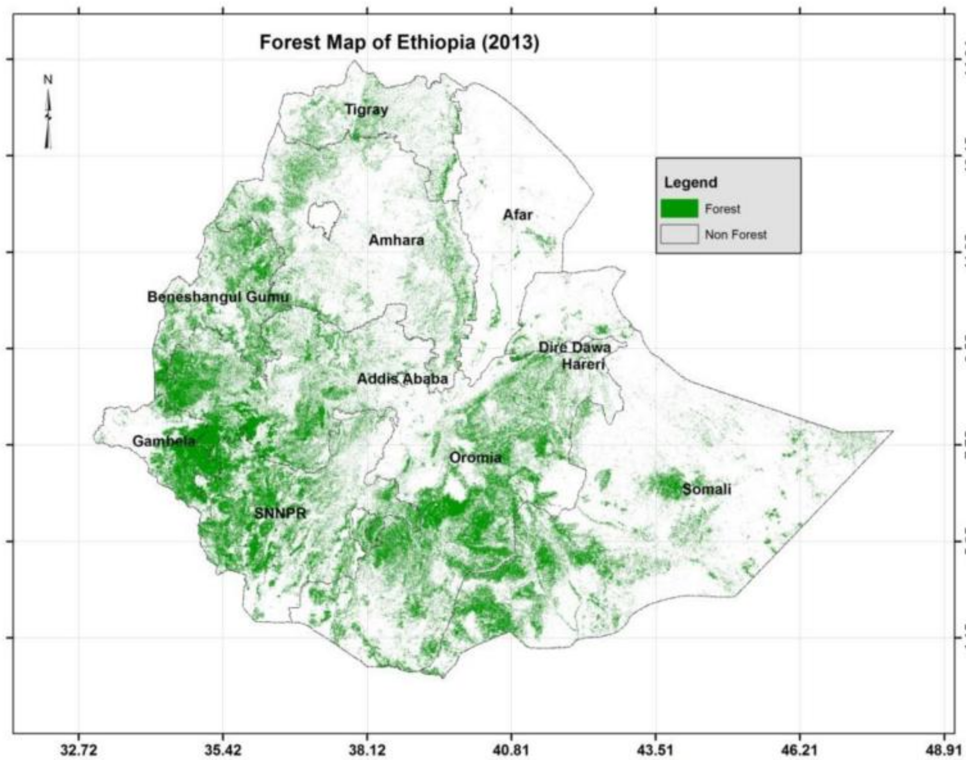

Fig.2.1Ethiopian forest map in current definition

Source: FAO (2015)

2.3. Impact of Forest Cover Change in Ethiopia

The decline of forest cover in many developing countries creates several wood constraints. Hartshorne (1998) argued that in many areas of Asia and Africa peasants scavenging for wood possess a major effort. Where wood cannot be found, dried cattle dung serves as a substitute fuel which finally has an impact on fertility of the soil. Besides, the immediate human suffering from lack of wood, the depletion of forest resources is associated with increased erosion, siltation, and flooding, climatic change and declining of biodiversity. Being a developing country, the same is true for the impact of forest cover change in Ethiopia. Regarding this, some of the major identified impact of the destruction of forest resources beyond its regenerative capacity in Ethiopia is land degradation, soil erosion mainly by water, frequently happening drought, declining of biodiversity, shortage of fuel wood and constructional materials and unbelievable high cost of fire wood products (Workaferaw, 2015).

2.3.1. Degradation of the land and Soil Erosion

The term land degradation is a process, which resulted in a radical change in the complete character of the land due to the loss of plant nutrients and organic matter, the breakdown of soil structure and destruction of vegetation cover (Markos and Delnessaw, 1998). Land degradation is the decrease in biological productivity of land use resulted from Unsustainable land uses such as over cultivation, deforestation, overgrazing, poor Management and poor cultivation. It is a process, which results in an absolute change of the complete characteristics of the land due to the loss of minerals and disappearance of the organic matter .One can argue that unrestricted removal of vegetation cover from the land is the most important factor encouraging land degradation (Harrison, 1999).

Land degradation accelerates soil erosion, which is defined as the removal of loose surface materials and nutrient content by different agents mainly water and wind. It is largely accelerated in many cases by human activities and grazing animals especially in the removal of vegetation. Due to high population concentration, land degradation in the form of soil erosion is common particularly in areas where the removal of forest has been observed(Harrison, 1999).

Fig.2.2.degraded land

2.3.2. Run-off and Flooding

Forests help to conserve and enrich the environment in several ways. For example, forest soils absorb large amount of rainfall, thus, it prevents the rapid runoff that can cause erosion and flooding .Besides, rain is filtered as it passes through the soil and become ground water flows and provides a clean source of water for streams, lakes and wells (Temesgen, 1994).However, according to the view of agricultural officers and developmental agents of the respective *kebeles* runoff and flooding is intense during rainy season.. This situations directly or indirectly the result of forest cover change.

2.3.3. Declining Bio- Diversity

As it has been stated previously, the geographical setting of the woreda has a diverse and conducive ecological condition due to its wide range of altitude and relatively high amount of rain fall. As a result of this, the woreda is the land of many indigenous tree species such as Juniperusprocora, Oliaafricana, Acacia abyssinica, Acacianugri, Hageniaabyssinica (almost most of the broad leafed trees) and other valuable tree species to name but a few. However many of tree were over exploited due to selective cutting and currently confined only in few inaccessible areas such as government protected areas and at the hilly lands of the woreda.. This clearly shows that the exploitation of indigenous forests through selective tree cutting greatly affects the biological diversity of the *woreda*. In Addition, according to the interview made with elders various types of wild animals who used to inhabit the locality has now disappeared due to deforestation of the area.

Generally, the major consequence of forest cover change in the study area is land degradation with associated variables such as soil erosion, rapid runoff and deteriorating of biodiversity. The destruction of indigenous tree species of the study area has been in a very systematic way.since most of the forest in the *woreda* has been used for the shade of coffee and occupied by the local people, the owners of the land can get the opportunity to destroy indigenous trees without any fear since the land is belongs to them or under the control of farmers.

2.4. The Concept of Forest Transition in Countries

In describing how forests cover changes through the developmental phases of a country the concept of forest transition is a useful way of depicting such changes. In that regard, the forest transition (FT) model describes the overall human induced changes of forest cover over time and basically presents the combined effect of various drivers on a national scale. The concept was proposed and articulated by Mather (1992) and later expounded by Rudel (2005) and Kauppi *et al.* (2006).

The model basically shows the transition in which, a country with, say 40% forest cover, goes through phases of decreasing forest cover through human activity till a period of maximum decrease, before a country realizes that it can no longer afford to lose more forest cover and at which time, it begins to stop further net loss of forest cover and put in policies and measures to increase forest cover which can be categorized in to four phases namely; pre-transition, early-transition, late-transition and post-transition. These phases generally represent a time sequence of national development (Honosuma *et al*, 2012).

In general, their assessment suggested that deforestation drivers are similar for Africa & Asia, but for forest degradation, drivers were more similar between Asia and Latin America and the Caribbean. In most cases, commercial agriculture was the most prevalent driver, in 40% of countries and tends to feature most strongly in the early transition phase, followed by local subsistence agriculture which accounted for 33 % of deforestation.

In Africa in particular, – subsistence Agriculture remains the dominant driver but the effect of commercial agriculture likely to increase in 'early transition in countries such Angola, DRC, Zambia, Mozambique. With respect to forest degradation, logging accounts for 52%, fuel wood and charcoal 31%, fire 9% and livestock grazing 7%. The Forest Service of Kenya can use its position on the curve for purposes of policy advocacy for the forest sector in general and for REDD+ in particular. In summary, Honosuma *et al*, (2012) observed that the phases of transition are associated by drivers of varying significance.

Forest cover begins to decrease as agricultural frontiers begin to expand into new areas as population and economic growth begin in a country. FTT also states that the rate of deforestation eventually slows down and is followed by a gradual increase in forest cover as industrial activities such as construction, services and manufacturing replace agriculture as a means of livelihood. Although this is the general principle of FTT, there is a diversity of other factors that may lead to alternate pathways of forest cover increase. Initial works in forest transitions focused on the factors that lead to forest transitions in now developed countries such as the United States (Foster, 1992) and France (Andre, 1998; Mather *et al*., 1999).

More recent works on forest transition have focused on cases in the developing world where forest transitions are believed to be going on. Unlike case studies in the past, developing world forest transitions seem to have a greater diversity of underlying causes which vary from case to case. War, free trade agreements, international migration, environmental policy and diminishing soil fertility are only a few examples of these (Southworth and Tucker, 2001; Klooster, 2003; Grau*et al.* 2003; Hecht, 2005).

Buttrick (1971) cites three main reasons for agricultural land reverting back to forestland: 1) loss of fertility 2) changes in economic conditions rendering cultivation unprofitable and3) discovery that certain lands are not suited to agriculture. Another alternate mechanism of forest transitions is the effects of globalization (Rudel, 2002; Klooster 2003).Rudel also describe globalization as “destroying first nature and creating second nature”. By this he means that in many countries affected by globalization older forest growth tends to be depleted while many agricultural areas tend to be abandoned giving way to secondary vegetation growth.

It is of high importance for governments of countries undergoing forest transitions to monitor this process. For one part to quantify the benefits and opportunities these new forest may bring to its population, but also to understand the underlying social causes of these transitions and the risks these may present. The increment in forest area brings many benefits to a country’s ecological support system. It is important for governments to acknowledge and keep track of the distribution of these forestlands the economic value they have in increasing water infiltration, flood mitigation, reduction of erosion and sedimentation of dams, carbon dioxide sinks, and wildlife habitat. All these values often go unacknowledged and their inclusion in the economy could serve as an income for people owning lands in the marginal areas where forest transitions tend to happen. (Yirdaw, 1996).

Direct economic benefits can also be obtained by efficiently managing new forests. Control over the diversity and composition of these forests, management to promote the regeneration of commercially valuable species, as well as promoting afforestation with commercially valuable species can help make the forest transition a source of income for landowners in marginal areas.

Another opportunity forest transitions pose is the integration of these into a carbon offset market, whereby land owners may receive an additional income from foreign companies for the carbon that is being fixed by these secondary forests.

Finally, conservation efforts in countries with forest transitions can greatly benefit from knowing which lands are more likely to remain unused as the forest transition continues. The concentration of protection efforts in places where there is little demand for farmlands may help the success of conservation programs. The monitoring and understanding of forest transitions associated with globalization could ideally lead to a shift towards the path of economic development. Using forest transitions as a means to create economic growth through timber production, payment of environmental services, conservation and tourism, may lead to improve livelihoods and perpetuate the existence of these new forests.

Viewing the Earth from space is now crucial to the understanding of the influence of man's activities on his natural resource base over time. In situations of rapid and often unrecorded land use change, observations of the earth from space provide objective information of human utilization of the landscape. Over the past years, data from Earth sensing satellites has become vital in mapping the Earth's features and infrastructures, managing natural resources and studying environmental change. (zubair 2006).

Remote Sensing (RS) and Geographic Information System (GIS) are now providing new tools for advanced ecosystem management. The collection of remotely sensed data facilitates the synoptic analyses of Earth - system function, patterning, and change at local, regional and global scales over time; such data also provide an important link between intensive, localized ecological research and regional, national and international conservation and management of biological diversity (zubair, 2006).

Following the advances in high resolution Remote Sensing Digital Data and Aerial Photography, mapping of the trends of cover changes have become relevant source of information for understanding land-cover pattern changes. Presently, with the supplement of ground information, remotely sensed data are the main source of information about land-use pattern changes. Various studies clearly demonstrated the potential of integrating remote sensing, GIS and field information for landscape assessment. In particular to the assessment of forest cover usage; this technology helps us to see the revealing trends and interrelationships of the dynamics with socioeconomic and topographic factors.

International and domestic forestry applications where remote sensing can be utilized are diverse and include sustainable development, biodiversity, land title and tenure (cadastre), monitoring deforestation, reforestation monitoring and managing, commercial logging operations, shoreline and watershed protection, biophysical monitoring (wildlife habitat assessment), and other environmental concerns. In this study information generated using both remote sensing and GIS to detect change on forest land cover over decades will be used, also the vulnerability to change taking into consideration the underlying socioeconomic, physiographic/accessibility and institutional/organizational factors is investigated. Successive study on the trends of land-use and land-cover changes using Remote Sensing technologies and implementation of GIS mapping techniques help to understand the severity of changes and its effects. (Aswani, 2013)

2.5. Reducing Emissions from Deforestation and Degradation (REDD)

Deforestation and forest degradation due to agricultural expansion, conversion to pastureland, infrastructure development, fires, destructive logging, including nearly 20 % of global emissions of greenhouse gases. Limiting the impact of climate change within limits that society can tolerate, the global average temperature must be stabilized within the range of two degrees Celsius above the current temperature. This is almost impossible without reducing emissions from the forest sector, including mitigation measures.

The initiative for Reducing Emissions from Deforestation and Degradation (REDD, 2008), is an effort to create a financial value for the carbon stored in forests. This provides incentives to developing countries to reduce emissions from forested lands and invest in routes of low-carbon sustainable development. “REDD +" goes beyond deforestation and forest degradation, and includes the role of conservation, sustainable management of forestland enhancement of forest carbon stocks.

2.6. The Context of REDD+ in Ethiopia

Located in the Horn of Africa, Ethiopia covers a total area of 1.1 million square kilometres. The country had an estimated population of 95,045,679 in 2014, with an annual growth rate of 2.58% (Getachew2013). Historically, smallholder-based traditional agriculture has been the mainstay of Ethiopia's economy. However, since 1992 the country's government has introduced a variety of reforms aimed at improving macroeconomic stability, accelerating economic growth and reducing poverty. Consequently, Ethiopia has taken a development path that puts the alleviation of poverty and enhancement of its people's livelihoods as its priority. FAO (2015).

According to the government's development plan (Plan for Accelerated and Sustained Development to End Poverty, PASDEP), the country envisages rapid economic development through accelerated agricultural growth as a stepping stone to the subsequent development of other economic sectors. And indeed the country has achieved remarkable economic growth, particularly in the last decade (MoFED, 2013). However, this economic growth is at the centre of a heated debate on how the country's natural resources will meet with the government plan of achieving rapid economic development through promoting environmentally 'insensitive' agricultural expansion and large-scale commercial investment in forest areas.

The country's forest resources provide vital economic benefits and livelihood supports in addition to critical environmental functions such as land stabilization, erosion control, regulation of hydrologic flows and climate change mitigation, among others. But recent data on the status of Ethiopia's forest resources, as reported by the Food and Agriculture Organization of the United Nations (FAO) (2010)and cited by Markim (2000), places Ethiopia among those countries with a relatively high rate of deforestation – around 1.0 % per annum. This is the result of over half a century of deforestation and forest degradation driven by several complex factors. Recognizant of the enormous pressure of these factors and the growing impact of climate change on the country's economic growth and the wellbeing of its people, the government is now taking measures to reduce deforestation and land-use conversions.

Reducing Emissions from Deforestation and forest Degradation (REDD+) is one of the schemes that the government has shown commitment to as an alternative mechanism for financing its forestry development and enhancing the country's climate change mitigation potential. In view of that, Ethiopia became an official member of the UN-REDD Programme in June 2011, and so became eligible to access funding and capacity building support for REDD+ policy development. In October 2012, the World Bank's Forest Carbon Partnership Facility (FCPF) approved a Readiness Preparation Grant for the Ethiopian government to formulate a National REDD+ Strategy and advance its institutional and technical readiness for REDD+. (Melaku *et.al*, 2015)

Accordingly, the government is taking steps to set up essential institutional arrangements for managing and coordinating REDD+ in the country. To that effect, the national REDD+ Secretariat was officially established in 2009 under the Environmental Protection Authority (EPA) as the body responsible for the overall implementation of the readiness process outlined in the Readiness Preparation Proposal (R-PP). In January 2011 the government established the REDD+ Technical Working Group (RTWG) as one of the members1 REDD+ is a mechanism to reduce emissions from deforestation and forest degradation plus conserve forests to enhance forest carbon stocks. It is expected to present an opportunity for developing countries to limit CO2 emissions through payment for actions that prevent forest loss or degradation. FAO (2015),

2.7. Remote Sensing In Monitoring Land Cover Change

The use of remote sensing data in recent times has been of immense help in monitoring the changing pattern of forest cover. It provides some of the most accurate means of measuring the extent and pattern of changes in cover conditions over a period of time. Satellite data have become a major application in forest change detection because of the repetitive coverage of the satellites at short intervals. Forest cover today is altered primarily by direct human use and any conception of global change must include the pervasive influence of human action on land surface conditions and processes. As indicated in their studies general information about change is necessary for updating forest cover maps and the management of natural resources. (Lambin, 1994).

Change detection as defined by Singh (1986) is a process of identifying changes in the state of an object or phenomenon by observing images at different times. Accordingly change detection studies seek to know (i) pattern of forest cover change, (ii) processes of forest cover change, and (iii) human response to forest cover change. Lambin (1994) also listed five categories of causes that influenced forest cover change. Boakye *et al* (2008) explain that changes in forest cover are often the result of anthropogenic pressure (e.g. population growth) and natural factors such as variability in climate. They reported that tropical forests are exploited for varied purposes such as timber, slash-and-burn cultivation and pasture development. They further explained that degradation of forest have impact on catchment processes and biochemical cycles and leads to soil erosion and water shortage not only in the regions immediately affected by deforestation, but also in reasonably distant areas(.Gong,2003).

Land use/cover is two separate terminologies which are often used interchangeably (Dimyati *et al.*, 1996). Land cover refers to the physical characteristics of earth's surface, captured in the distribution of vegetation, water, soil and other physical features of the land, including those created solely by human activities e.g., settlements. While land-use refers to the way in which land has been used by humans and their habitat, usually with accent on the functional role of land for economic activities. The land use/cover pattern of a region is an outcome of natural and socio-economic factors and their utilization by man in time and space.

Information on land use/cover and possibilities for their optimal use is essential for the selection, planning and implementation of land use schemes to meet the increasing demands for basic human needs and welfare. This information also assists in monitoring the dynamics of land use resulting out of changing demands of increasing population. Land use affects land cover and changes in land cover affect land use. Changes in land cover by land use do not necessarily imply degradation of the land. However, many shifting land use patterns driven by a variety of social causes, result in land cover changes that affects biodiversity, water and radiation budgets, trace gas emissions and other processes that come together to affect climate and biosphere(Lillesand,2004).

Land use/cover change detection is very essential for better understanding of landscape dynamic during a known period of time having sustainable management. Land use/cover changes is a widespread and accelerating process, mainly driven by natural phenomena and anthropogenic activities, which in turn drive changes that would impact natural ecosystem (green,2004). Understanding landscape patterns, changes and interactions between human activities and natural phenomenon are essential for proper land management and decision improvement. Today, earth resource satellites data are very applicable and useful for land use/cover change detection studies (Lillesand, 2004).

With the invent of remote sensing and Geographical Information System (GIS) techniques, land use/cover mapping has given a useful and detailed way to improve the selection of areas designed to agricultural, urban and/or industrial areas of a region (Mario, 2013).
Application of remotely sensed data made possible to study the changes in land cover in less time, at low cost and with better accuracy (Campbell,1997) in association with GIS that provides suitable platform for data analysis, update and retrieval (Mario,2013). The advent of high spatial resolution satellite imagery and more advanced image processing and GIS technologies, has resulted in a switch to more routine and consistent monitoring and modelling of land use/land cover patterns. Remote-sensing has been widely used in updating land use/cover maps and land use/cover mapping has become one of the most important applications of remote sensing (Mario, 2013).

Landsat-TM images represent valuable and continuous records of the earth's surface during the last 3 decades (USGS, 2014). Moreover, the entire Landsat archive is now available free-of-charge to the scientific public, which represents wealth of information for identifying and monitoring changes in manmade and physical. Several studies acknowledged the importance of pre-processing (i.e., data selection, co-registration, radiometric calibration and normalization) in performing accurate and reliable change detection analysis (Workaferahu, 2015).

CHAPTER THREE

3. DESCRIPTION OF THE STUDY AREA, RESEARCH METHOD AND MATERIAL

3.1. Description of the Study Area

3.1.1. Location

Limu Seka *Woreda* is one of the *woredas* found in Oromia National Regional State. It is named in part after the former kingdom of Limmu-Ennarea, whose territories included the area this *woreda* now covers. It is situated at about 462 km south west of Addis Ababa and around 110 km from capital the zone, Jimma town. Astronomically it is located at about 8º09ˈ-8º53ˈNorth latitude and 36 º 16ˈ-37 º 38ˈEast longitudes.

Part of Jimma zone, Limmu Sekka is bordered on the southwest by the Didessa River which separates it from the Illubabor zone, on the northwest by the East Welega zone, on the northeast Gibe River which separates it from the West Shewa zone, and on the southwest by Limmu Kossa. The administrative centre of the woreda is Atnago.

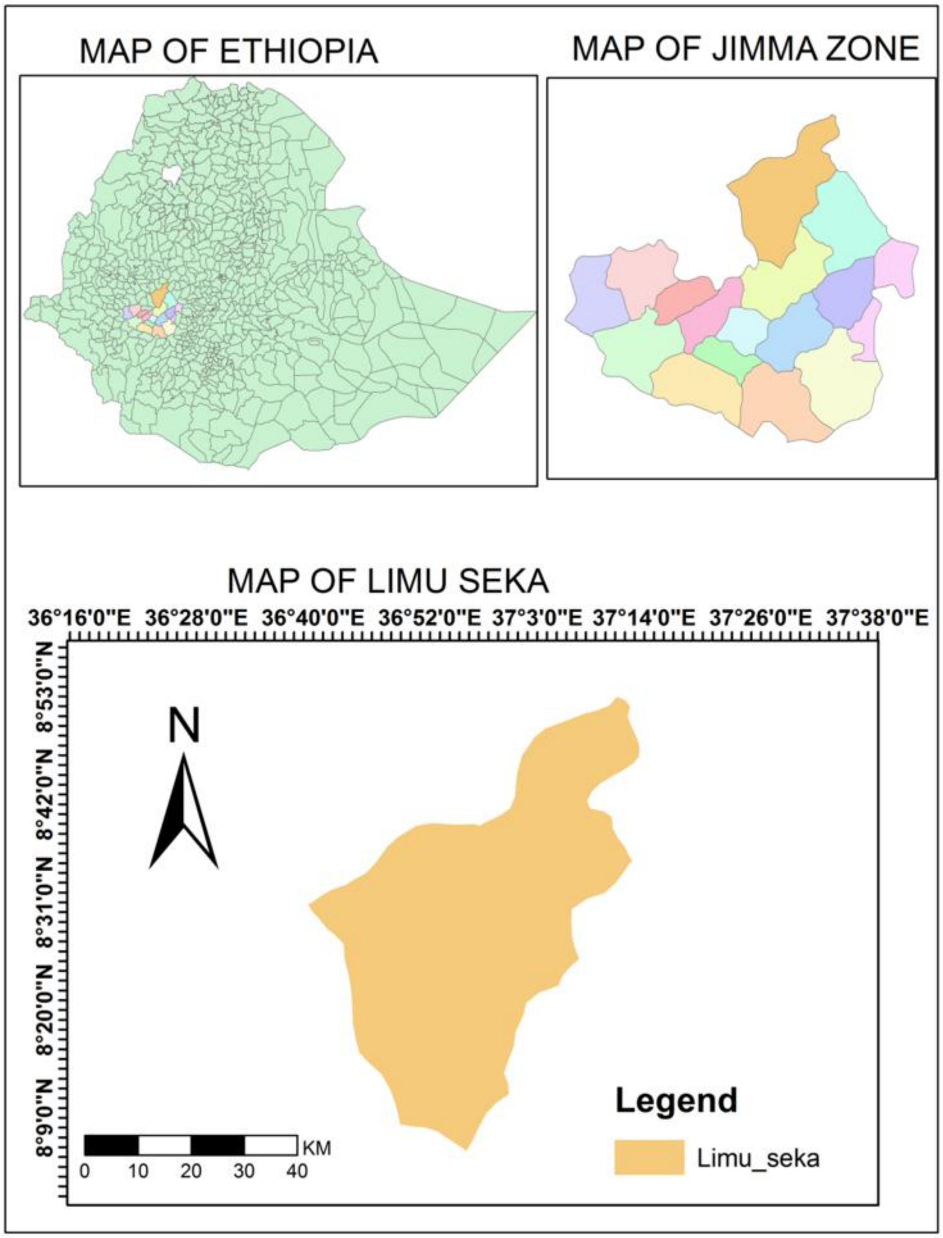

Fig.3.1. Location Map of the study area

The 1994 national census reported a total population for this *Woreda* was 122, 370, of whom 60,099 were men and 62,271 women; 3,400 or 2.78% of its population were urban dwellers at the time. The2007 national census reported a total population for this *woreda* was187, 222, Out of this 94,754 are male and 92,468 are female (CSA, 2008). 6,082 or 3.59% of its population were urban dwellers, which is less than the zone’s average of 12.3%. With an estimated area of

2,416.10 square kilometres, Limmu Seka has an estimated population density of 70.2 people per square kilometre, which is less than the zone‘s average of 150.6 The two largest ethnic groups reported in the *woreda* were the Oromos (95.19%) and the Amhara (3.4%). The majority of the inhabitants were Muslims with 57.7% of the population having reported they have practiced that belief, while 32.44% of the population were followers of Ethiopian Orthodox Christianity and 9.72% were Protestants. Moreover, the urban area Atnago, the capital of the *woreda* is 110 kilometre distance from Jimma town and about 462km south west of Addis Ababa.

The agro-ecology of the *woreda* is characterised by 13% highland and 55% mid-highland and 32% lowland. The altitude of the *woreda* is between 1,400 and 2,200 metres above sea level (masl). In the woreda, 10,241 hectares (ha) are currently covered by forest and bush, while 38,874 ha are used for crop production. There are two distinct seasons in Limu Seka: the rainy season starting in late March and ending in October, and the dry season occurring during November to early March. The rainfall is often in excess of 1,800 mm per annum. Limu Seka *woreda* has 173,884 cattle, 14,357 sheep, 47,909 goats and 5,600 mules. The varied topography includes hills, undulating landscape and plains. Moderately dense vegetation coverage includes forests, bushes, scrublands and grasslands. Natural resources such as stone, sand, forest resources such as coffee spices, honey, timber and wild animals are also found here.

The *woreda*’s potential for agriculture is estimated to be around 42,704 ha of land. In terms of cereal crops, sorghum covers 21,538 ha and maize covers 1,266 ha. Coffee is the major cash crop produced by the majority of farmers as the main source of income and covers more than 12,964 ha of land. The *woreda* has more than 3427 ha of land under irrigation, 109 ha of which is irrigated by modern motor pump technology.

3.1.2. Climate and Topography

The *woreda* has diverse topography. Of these Dora Gabena, Chalete and Atokelala are amongst the highest points in the *woreda*. Since Ethiopian climatic condition is mostly controlled by altitude; the *woreda* has diverse agro climatic zones which are favourable for the cultivation of different crops. . The area is one of few places of the country which experiences heavy rainfall through out of the year with few variations during winter season.

3.1.3. Economic Condition

As the large majority of the people live in rural area which is above the zone's average, agriculture is the main stay for the people of the *woreda*. A survey of the land in the *woreda* shows that 57.3% is arable or cultivable land, 22.8% pasture, 4.9% forest, and the remaining 15%is considered swampy, degraded or otherwise unusable. Teff, oranges and bananas are important crops. Coffee is also an important cash crop for this *woreda*; over 5,000 hectares are planted with crop. Based on the 2009 *woreda* official report, two health stations and 14 health posts were ready for service. At current time there are some 35 health posts and five health stations.

3.2. Methods and Materials

3.2.1. Materials

3.2.1. 1. Satellite Imageries and Ancillary Data

Satellite imageries and ancillary data were collected in order to identify successive forest cover changes. The image data that was used for this study are Landsat TM & ETM+, Topographic maps at the scale of 1:50,000 were emanated from the Ethiopian Mapping Agency (EMA).GPS recorder was also most important tool for ground assessment, or to make ground verification. The majority of primary data necessary for the study has been extracted from satellite images. Forest cover types at various times have been extracted from Land sat MSS (1994), 2004 and 2014 images.

3.2.1.2. Criteria for Spatio-Temporal Identification (site and year selection)

The reason for the selection of the *woreda* as the study area is because it is one of few areas of the country where natural forests are found and because of the dependence of the large majority of the people on the forest, recent settlement program and proximity of the *woreda* with other zones of the region and influx of the people to this woreda.as far as temporal identification of the *woreda* is concerned, the year 1994 was the time of transitional government in Ethiopia and when strict forest related laws were not implemented and the year2014 was used in order to get up-to-date information and in order to balance the time interval.

3.2.2. Methods

The procedure followed in this study is presented using the flow chart (Figure 3.2). It shows the steps followed beginning from the acquisition and classification of multi-temporal satellite image of the study area to the extraction of the required information both secondary and primary data to answer the research questions.

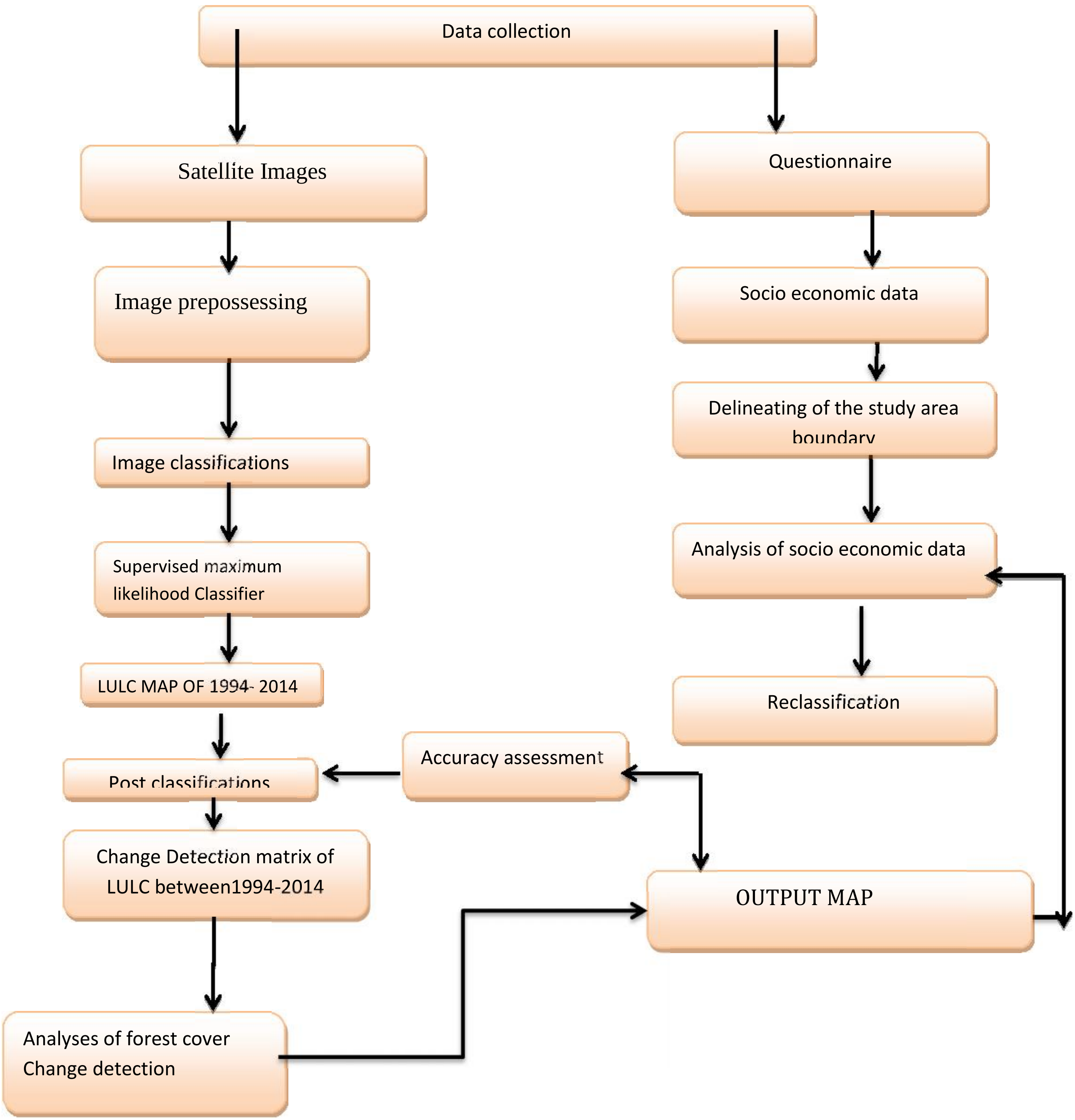

Fig.3.2.General methodological flow of the study

The above figure (fig 3.2) clearly indicates research flow chart start from data extraction up to weighted overlay analysis and making the output map. Landsat images of 1994, 2004 and 2014 were downloaded from global land cover facility in tiff format and bands are stacked together. Second, all images were masked (delineated) based on study area boundary then radiometric and geometric correction methods were applied to make suitable for further analysis. Third, land cover classification method by applying maximum likelihood supervised classification was applied and based on classification result ground verification was done. Fourth, after accuracy assessment important land use land cover categories (factor maps) were digitized for weighted overlay purpose and those land use land cover types were (forest and the other LU/LC classes to non-forest).

3.2.3. Data collection and data processing

Data are generally classified as either primary or secondary. The primary data was obtained by field surveys recorded during the fieldwork. A global positioning system (GPS) and camera were used during the field visit(s). Field visit was carried out to get an overview of the study area, identify various forest cover types and to record GPS readings concerning various features and forest cover types. It was undertaken to verify the various land-cover types identified through satellite image manipulation and by observing exactly available land cover type in the study area. These data are used for designing the final image classification, verifying sample sites and for land cover map validation.

Secondary data was obtained from various sources like topographic maps, *woreda* agricultural bureau and satellite imageries. The Imageries of 1994,2004 and 2014 were referenced using ground control points .The Universal Transverse Mercator (UTM) geographic projection, and Adindan (Ethiopia) zone 37 North datum were used in geo-referencing the images two land-use/cover classes were identified for image classification for all the imageries . A pixel based supervised image classification with maximum likelihood classification algorithm was used to map the land-use/cover classes.

At sampling site of around 80 reference points were randomly identified in May, 2016 using GPS receiver. In addition, photographs of different LU/LC were taken from the site which helped to support in the identification and quantifying of forest cover change and also for map making. These data have been used for designing final image classification and testing sample sites, which are used for land cover map **validation.** This research mainly applied change detection techniques and on its accuracy assessment in tabulating error matrix.

3.3. Sources of Data

For this study both primary and secondary data sources were applied and the data sources Are categorized in to spatial and socio economic data sources.

3.3.1. Spatial data sources

Satellite image of (Land sat TM 1994, Land sat ETM+ 2004 freely dawn load from GLCFwhereas Land sat ETM+ 2014 through purchase from EMA will be used for forest cover classification. In addition, GCP will be collected using GPS recorder for the accuracy assessment.

Table 3.1.Description of satellites used in the study

Image acquisition year	Land sat Sensor	Spatial Resolution	Others
1994	TM	30 meters	Path/Row:169/054
2004	ETM^+	30 meters	Path/Row:169/054
2014	ETM^+	30 meters	Path/Row:169/054

3.3.2. Socio –economic data sources

Socio economic data of both primary and secondary data were collected using questionnaire; which was translated into local language for simplicity and precision purposes, Key Informant Interviews (KIIs) and filed survey were applied. The research findings from the primary data were supplemented by secondary data sources such as published and unpublished materials (CSA, Internet, WFEDD, Agricultural office etc.).

3.4. Sampling and Sample size Determination

In the first stage, sample enumeration areas were selected purposively. Sample households were selected by using systematic random sampling from the list of the households in the second stage. Sample household heads were requested to fill in the questionnaire under a close supervision of the researcher and/or trained field assistants.

Sample size determination is not an easy task and influenced by a number of factors which include the purpose of the study, population size, the level of precision, the level of confidence or risk, and the degree of variability in the attributes being measured (Miaoulis and Michener, 1976).

Generally, two options are there to determine sample size. These are using formulas to calculate a sample size and using published tables**.** The following is sample size of the study area. The sample *kebele* has 2070 households and 334 of them were used as sample population of the area using sample size determination formula.

$$1+\frac{(n_0 - 1)}{N}$$

$$= \frac{(1.96)^2(0.5)(0.5)}{(0.05)^2}$$

$$=385$$

$$\frac{385}{1+\frac{(385-1)}{2070}}$$

$$=325$$

In the absence of previous data on the study population and to get the

Maximum sample size, p has taken to be 0.5 (50%).

Margin of error e = 5% = 0.05.

Level of confidence was taken to be 95% (z= 1.96).

Therefore, n=385

Adding 5% allowance for non-respondents, absenteeism and refusal to participate in the study was taken into account.

Hence, the final sample size N is,

N= n+5%*n = 325+19= 334.

Selection of sample households for the questionnaire-based survey follows a two-stage Sampling design. In the first stage, sample enumeration areas (SEAs) were selected purposively. The sample enumeration areas or clusters were demarcated following easily recognizable natural features. Then listing of households was done in their spatial order so as to represent each village adequately. Sample households were selected by using systematic random sampling from the list of the households in the second stage. Sample household heads were requested to fill in the questionnaire under a close supervision of the researcher and/or trained field assistants. Essentially, the questionnaire was translated into *Afan*Oromo (Oromo Language) and Amharic for simplicity and precision purposes. The agreement of each respondent were also sought and secured prior to the beginning of the actual survey processes.

3.5. Techniques of Data Analysis

A.Spatial data analysis

One of the main objectives of this study is to identify and quantify the changes in forest cover over the last 20 years. Land sat the unprocessed satellite images were processed by using GIS technology. The pre-processed images were classified into two land uses based on the supervised classification technique, Maximum likelihood algorithm (MLC) which is one of the most popular supervised classification methods used with remote sensing image data. This method is based on the probability that a pixel belongs to a particular class. The accuracy assessment was done by using the first-hand data collected by using GPS.A supervised image classification technique was applied using ENVI 4.2 software based on the ground truth taken during field work With the help of visual interpretation and the different reflectance characteristics of the features in the satellite images Land cover classes, namely; Forest land and non-forest land. This is because since the major objective of the study was focus on forest cover change analysis and the other land use land cover were categorized under non forest land. Since image classification needs accuracy assessment at last, it was done by using the first-hand data collected by using GPS. From different methods of classification accuracy assessments, the dominant and mostly used classification error matrix or a confusion matrix was produced. The overall classification accuracy and an overall Kappa statistics were calculated.

B. Socio- economic data analysis

In order to supplement the spatial data analysis, data related to socio economic condition of the *woreda* collected through different data collection techniques such as questionnaire, and key formant interview was analysed by using different statistical techniques. These include the analysis of those questions related to cause and consequences of forest cover change.

CHAPTER FOUR

4. DATA ANALYSIS, RESULT AND DISCUSSION

4.1 Data Analysis

4.1.1. Image processing

Practicing image analysis is an inevitable task to extract meaningful information from remotely sensed data. So, an effort wasdoneto use the remotely sensed data with different level of image pre-processing methods. The methods of image processing techniques used in the current study are image resembling and image enhancement and interpretation. Acquisition of best and available different dates of satellite image data is the initial stage for image processing and analysis in this study. In the meantime, multi-temporal Land sat images (it is already geo-referenced) were down loaded from 'Global Land Cover Facility website 'was used (table: 2).

Land sat satellite images of the year 1994, 2004 and2014having a map projection of UTM zone37 and datum WGS84 were re-sampled to UTM zone37.Satellite image contains a detailed record of features on the ground at the time of data acquisition. In relation to this (Lille sand and Kiefer, 2000) suggested that image interpreters should have good power of observations coupled with imagination and it is important that the interpreters have a thorough understanding of the phenomenon being studied as well as knowledge of the geographic region under study. To do so, digital image enhancement and interpretation techniques were used in this study.

The principle of image classification is that a pixel is assigned to a class based on its feature by comparing it to predefined clusters in the feature space. In this study, a supervised image classification was important step for digital image processing and to develop training samples. In addition to this, maximum likelihood image classification algorithm was utilized. Using the application of image classification methods, land cover and land use types are identified in order to perform forest cover change detection. Here since the focus of this research is identifying the rate of forest cover change those areas which are outside of forest are grouped under non forest whether they are settlement, agricultural land ,water bodied ,road or other land use land cover change.

4.1.2 Land use/ Land cover classification of 1994

The 1994 Land sat satellite image is the land sat image used as the starting point of the study. In the given year as of satellite image data nearly one fourth (24.9%) of the study area's land was covered by forest which was many times greater than the national average. On the other hand the non- forest parts which include pastureland, waterbodies, agricultural land and settlement totally constituted 75.1% of the total area of the *woreda*. It is not surprising that the study area is one of few areas that forest coverage is better than other areas since it is located in the south western part of Ethiopia where natural forests mostly found. The presence of such like coverage was or is also because of the presence of coffee which needs shade that is forest.

Table 4.1. Land use/ Land cover classification of 1994

LULC of 1994	Area in Hectare	Area in Percent (%)
forest	*62162.73*	24.9
Non forest	*186762.24*	75.1
Total	248924.97	100

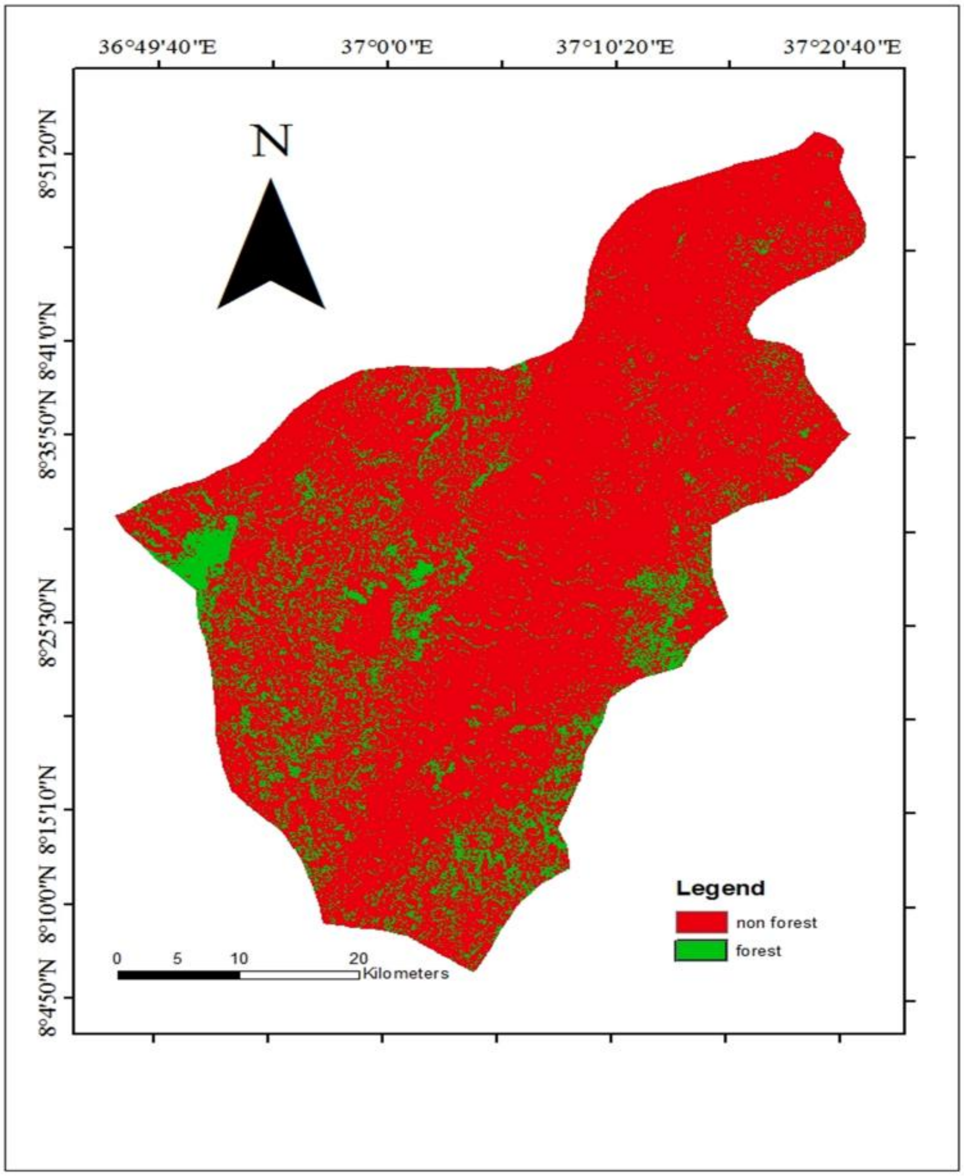

Fig .4.1. Map of Land use/ Land cover classification of 1994

4.1.3 Land use/ Land cover classification of 2004

Comparative to the 1994 land use land cover change map, the rate of forest cover change to other LULC was in a very fast rate that is as of satellite image of this year 7.3% reduction of forest was observed. This may be because of settlement in the in the study area, poor conservation of natural forest and population explosion and the dependency of the large majority of the people on the nearby forest for their energy source construction materials and income. Generally the forest coverage of the area was reduced from 24.5% to 17.6% and other land use land cover changed from 75% to 82.4% within the interval of ten years.

Table 4.2. Land use/ Land cover classification of 2004

LULC of 2004	Area in Hectare	Area in Percent (%)
forest	*43957.89*	17.6
Non forest	*204967.08*	82.4
Total	248924.97	100

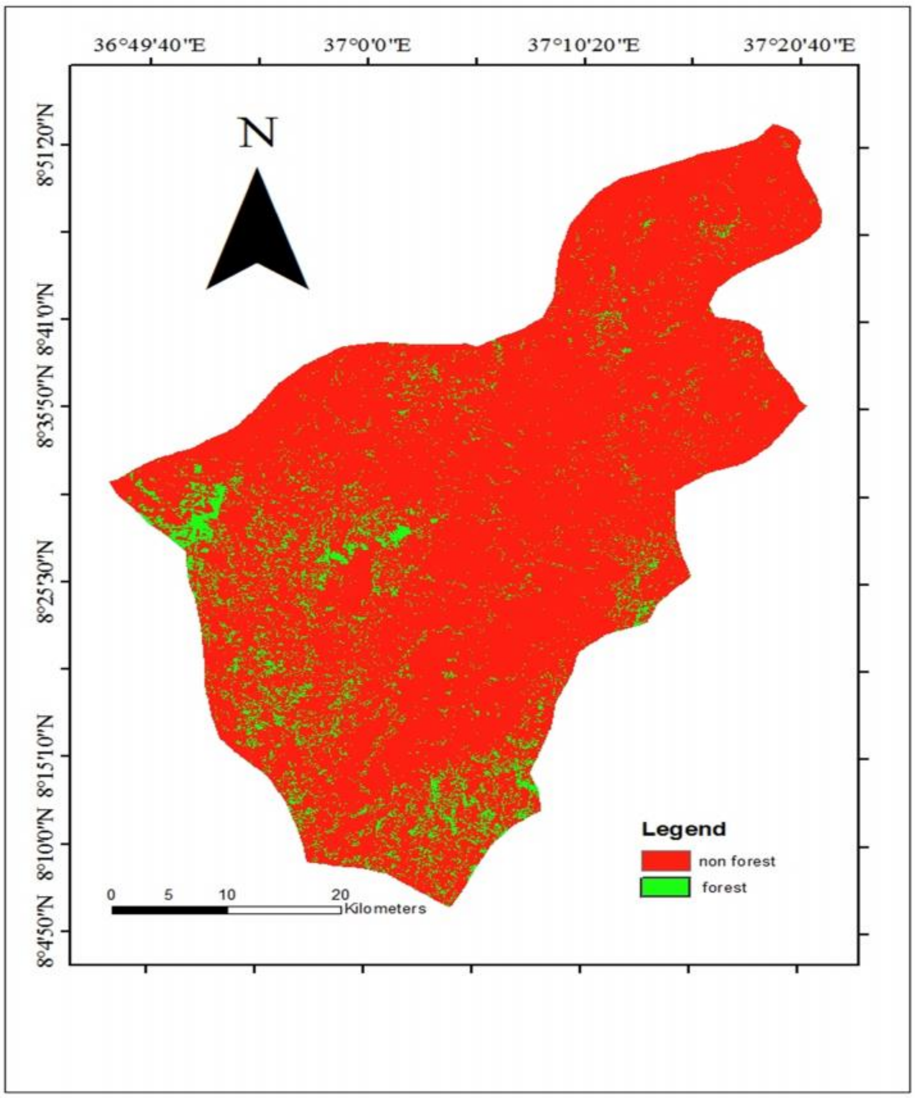

Fig.4.2.Map of Land use/ Land covers classification of 2004

4.1.4 Land use/ Land cover classification of 2014

Comparative to the year 1994 and 2004, the year 2014 was the time when low rate of forest cover change was observed. From the total of 17.6 % in the year 2004 there was a reduction of only 1.7 %.in the year2014. But still forest cover change was observed and only 15.9% of the *woreda's* land is occupied by forest. Generally comparative to the initial year (1994) there was a reduction of 9% forest cover land. Here the relative reduction of forest cover change was related to strict enforcement of law on forest of the *woreda*, millennium afforestation and reforestation program at the national level. But still the dependency of the people on the forest continues. Forest proclamation by the government has its own contribution on the reduction of deforestation rate in the study area.

Table 4.3. Land use/ Land cover classification of 2014

LULC of 2014	Area in Hectare	Area in Percent (%)
forest	39733.03	15.9
Non forest	209,191.94	84.1
Total	248924.97	100

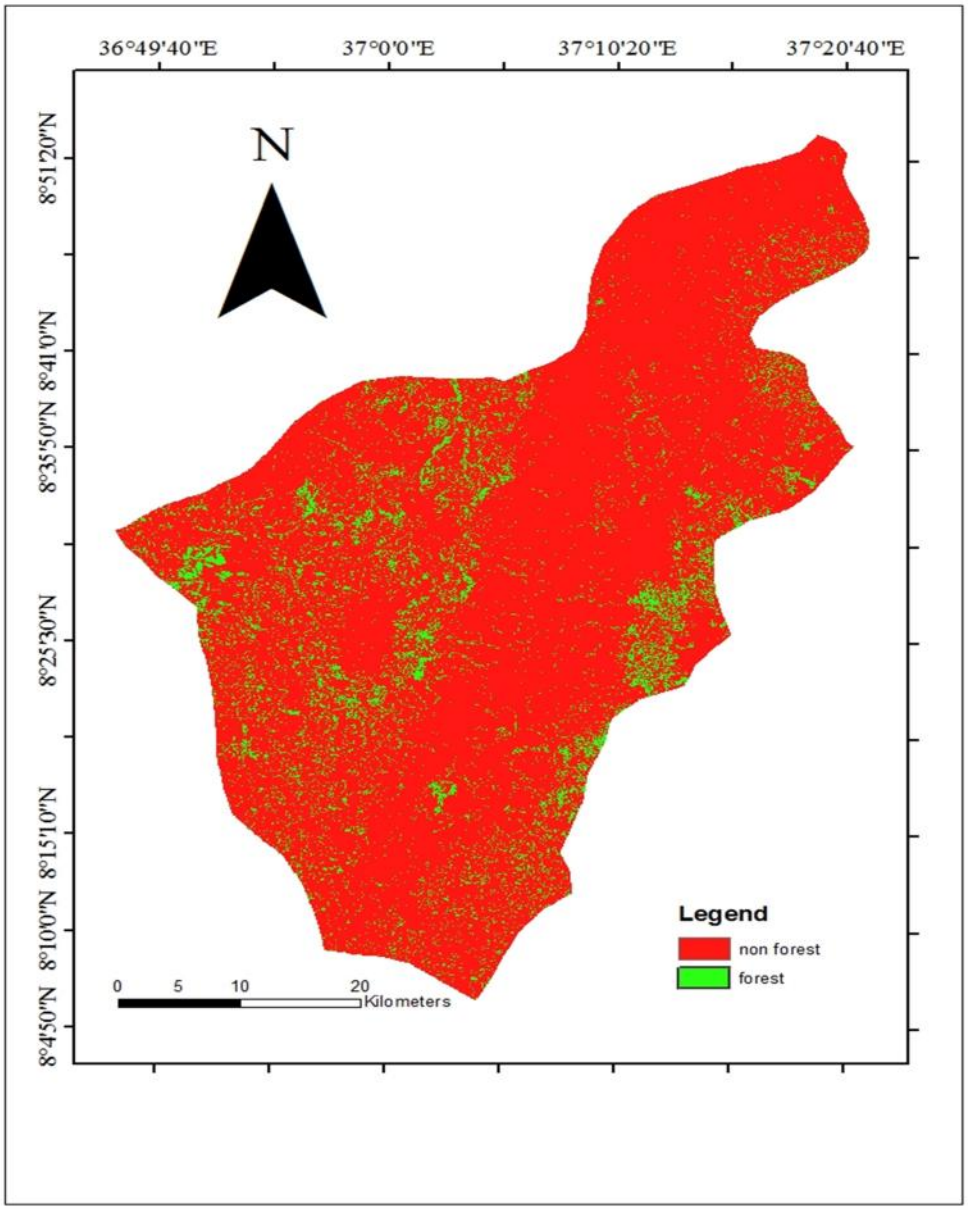

Fig.4 .3 Map of Land use/ Land cover classification of 2014

4.2.1 Accuracy Assessment for Image Classification

One of the most important that has taken in to account is accuracy assessment. This is because Land cover maps derived from remote sensing always contain some sort of errors due to several factors which range from classification technique to method of satellite data capture. Following classification process the accuracy assessment of each land-cover/land-use has been conducted to assure the classification result was accurate for further use.

Currently, accuracy assessment is considered as an integral part of any image classification process because of the fact that image classification using different classification algorithms may classify pixels or group of pixels to wrong classes. Furthermore it helps in order to identify the problem of commission and omission error during the process of classification Accuracy assessment allows a researcher to compare certain pixel values in the thematic raster layer (original image) to the reference pixels, for which the class is known. This is an organized way of comparing the classification with ground-truth data, a previously tested map, aerial photos, or other data of the study area. Accuracy assessment is therefore important for understanding the developed results and employing these results for decision making.

The most common accuracy assessment method is the preparation of a classification error matrix (or confusion matrix). Error matrix compares, on a category-by-category basis, the relationship between known pixel reference data and corresponding results of an automated classification. The most common elements of the error matrix accuracy assessment include overall accuracy, producer's accuracy, user's accuracy and kappa coefficient (Lilles and Kiefer, 2000).

Moreover, the land cover types were in the process of dynamic change spatially as well as temporally increases from time to time due to human interfere in the study area but, all other classes were relatively correctly classified. Therefore, the Overall percentage classification accuracy of 1994, 2004 and 2014 LC/LU classification was respectively 98.04% 98.65%and100%. This is because unlike the other land use land change classification, the land use land cover classification for this research only depends on two land cover land use categories. These are those areas which are covered with forests and those areas generally converted from forest to other land use land cover types. So the classification is only forest and non-forest areas. The user and producer accuracy and as well as the Kappa Coefficient were explained in (Table4.4.).

The kappa value is a measure of the agreement between classification and reference data with the agreement due to chance removed. None of the kappa values in any of the images were very high. The ranked the kappa values, ranging from -1 to 1, into 3 groups: 1) those greater than 0.80 represented as strong agreement between the classification and reference data; 2) those between 0.40 and 0.80 represented as moderate agreement; and 3) those less than 0.40 represented as poor agreement (Landis and Koch, 1977).

The Kappa coefficient lies typically on a scale between 0 and 1, where the latter indicates complete agreement, and is often multiplied by 100 to give a percentage measure of classification accuracy. This implies that the Kappa value of 0.84 represents a probable 84% better accuracy than if the classification resulted from a random assignment.

In general, the overall accuracy of 82% was achieved with a Kappa coefficient of 0.84 (See table 4.4).

Kappa value was calculated using the following formula (Developed from Stephen V. S., 2004)

K = r0i-ei   2/1-rei……………………equation 1

K= kappa coefficient

= Summation

r = relative

Oi = Observed value GPS value on the ground

Ei=expected value during supervised classification

Table 4.4 assessment of LU/LCC

Class Name	1994Accuracy assessment%		2004Accuracy assessment%		2014 accuracy assessment%	
	pro	user	pro	user	pro	user
forest	97.2	99.1	100.	100	100	100
Non forest	98.1	98.2	100	100	100	100
Overall classification accuracy	98.04%		98.65%		100%	
Kappa Coefficient	0.95		0.97		1	

Source: computed from ENVI image software

Additionally, change detection matrix had been generated to investigate the trends and patterns of land cover change in general and forest cover change in particular.

R=Q2-Q1/t……………………………….equation (2)

Or r=q1*100+q2…………………………. (equation3)

Where, r= Rate of forest Cover Change

Q2= Recent year forest cover in ha

Q1= Initial Year forest cover in ha and

t= Interval year between Initial year and Recent year

100= Initial change in percent

4.2.2. Forest cover change between 1994and 2004

The forest cover change matrix between 1994 and2004 results indicated that there was a forest cover changes within the specified years of the study area. About 4190ha, forestland was converted in to different LU/LC types which include vegetation, agriculture, and settlement areas and finally classified as non-forest. Table.4.5).

Table 4.5. Land use/Land cover change matrix between 1994-2004

Final year 2004	categories	Initial year 1994					
		forest		Non-forest		total	
		Ha	%	Ha	%	Ha	%
	forest	**(22,579.84)**	51.4	4189.52	2	26,769.36	100
	Non-forest	21,378.04	48.6	**(200,777.55)**	98	222,155.6	100
	total	43,957.88	100	204,967.1	100	248,925	100

Source: Computed from Arc GIS software

4.2.3. Forest cover change between 2004 and 2014

The forest cover change matrix between 2004 and2014 results indicated that there was a forest cover changes within the specified years of the study area. About 1924 ha forestland was converted in to different LU/LC types which include vegetation, agriculture, and settlement areas and finally classified as non-forest. Table.4.6).

Table 4.6. Land use/Land cover change matrix between 2004 and 2014

Final year 2014	categories	Initial year 2004					
		forest		Non-forest		total	
		Ha	%	Ha	%	Ha	%
	forest	**(3463.00)**	8	1924.64	1	5387.64	100
	Non-forest	40494.88	92	**(203042.43)**	99	243537.3	100
	total	43957.88	100	204967.1	100	248925	100

Source: Computed from Arc GIS software

4.2.4. Forest cover change between 1994 and 2014

The forest cover change matrix between 1994 and2014 results indicated that there was a forest cover changes within the specified years of the study area. About 318.24ha, forestland was converted in to different LU/LC types which include vegetation, agriculture, and settlement areas and finally classified as non-forest. Table.4.7).

Table 4.7.Land use/Land cover change matrix between 1994-2014

Final year 2014	categories	Initial year 1994					
		forest		Non-forest		total	
		Ha	%	Ha	%	Ha	%
	forest	**(4074.76)**	6.5	318.24	0.17	4393	100
	Non-forest	58087.96	93.5	**(183579.81)**	99.82	241667.8	100
	total	62162.72	100	183898.1	100	248925	100

Source: Computed from Arc GIS software

4.2.5. Areal Extent and Rate of Forest Cover Change

Assessment of forest cover change was done using remote sensing and GIS techniques with the integration of field survey. In this study, three Landsat satellite images (see table4.8.) were used to monitor the areal extent and rate of forest cover change with in time sequence. During the analysis stage, digital image interpretations of forest cover area for each year was performed and total area of the forest cover in terms of ha and its percentage from each date of satellite interpretations were computed and summarized. Figure 4.8.revealed the pattern of forest cover changes between 1994 and 2014.

Table 4.8.Land use land cover and their extent between 1994 and 2014

	1994		2004		2014	
Class Name	Area in hectare	Area in percent	Area in hectare	Area in percent	Area in hectare	Area in percent
forest	*62162.73*	24.9	*43957.89*	17.6	39733.03	15.9

As can be clearly indicated on the table within an interval of 10 years (1994-2004) there was a reduction of 7.3% % of forest in to another LU/LC, but the rate of forest cover change show reduction in the second 10 years (2004 -2014) .only 1.7% of forest land was converted to other LULC.This does not mean that forest reduction stops .Generally, in the last 20 years 9% of forest land was changed to other LU/LC which is very high.

4.2.6. Spatio- temporal changes of forestlands

In order to assess forest cover change in the study area, Land sat images of 1994, 2004 and 2014 were classified and analysed by using ENVI4.7 and Arc GIS 10.1 software techniques. As an image analysis result show that in 1994forest coverage of the study area was 62162.73ha (24.9) but gradually decreased to*43957.89*ha in 2004(17.6) It then finally reduced to39733.03 (15.9) in 2014.

Table4.9. Spatio temporal change of LULC between 1994and 2014

	1994_2004		2004_2014		1994_2014	
Class Name	Area in hectare	Area in percent	Area in hectare	Area in percent	Area in hectare	Area in percent
forest	-22204.08	-10.8	-4224.86	-2	-17979.22	-8.6
Non-forest	204967.08	91.1	209191.94	98	231621.64	93.4

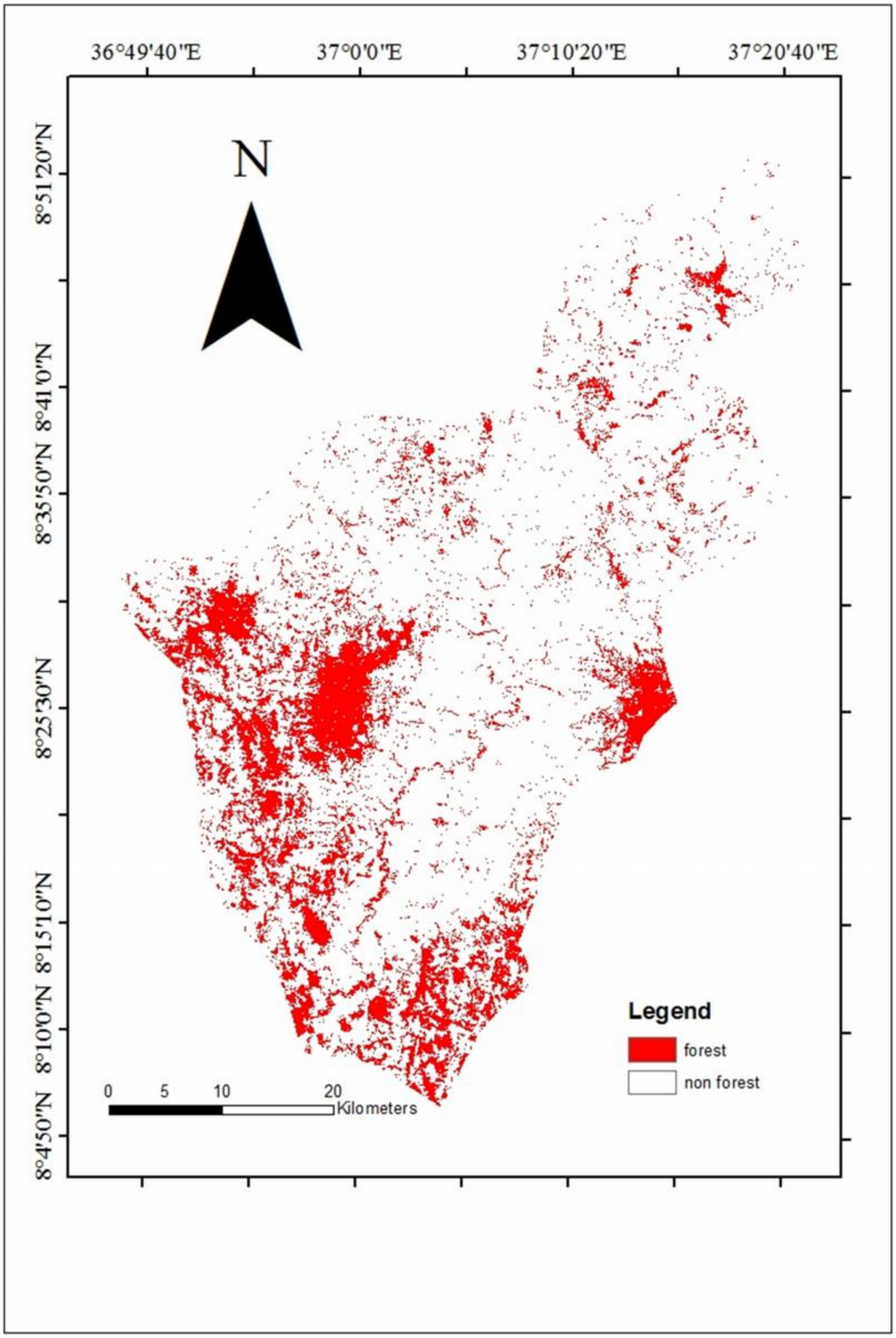

Fig4 .4.Map of forest cover change between 1994and 2014

4.7. Analysis of Socio-Economic Survey

A socio-economic survey was conducted and it involved interview of selected households and focus group discussion to generate information on household level change in forest cover, and to get an insight into various socio-economic, environmental and cultural factors that influence decision on land use and land cover at household and landscape level. The time horizon considered for the trend analysis using the socioeconomic study corresponded with the time horizon considered above for the remote sensing analysis.

4.7.4. Causes of Land use land cover change

Respondents were asked to identify the causes of this land use land cover change, accordingly,62.8percent of the respondents confirmed that population increase in Search for agricultural land is the major cause for forest cover change followed by Settlement which constituted 30 percent of the total respondents. Charcoal production and investment activities in the study area respectively occupy the rest. So, the high population of the farming community has also resulted in a shortage of land which indirectly leads to repeated use of the same land from year to year. Furthermore, the demand for land has led to the expansion of farmlands into forest areas. Not only shortage of land, but very poor soil productivity and not using the recommended amounts of external inputs on the farm, either because of their high costs or lack of knowledge, have reduced production per unit area and forced farmers to look for further farming land which finally led to deforestation of the remaining forest.

4.7.4.1. Causes of Forest Cover Change

Forest cover change is triggered by various factors that undermine the forest cover potential and its productivity and leading to irreversible deterioration. Besides, forest cover change is the direct reflection of the dynamics of socio-economic development. Regarding this, Burton, (1994:288) states that the complex nature of human activities has had a tremendous impact on modern forests and large forest areas have been cleared for various reasons since agriculture began about 11,000 years ago. Likewise, several factors stimulated by the activity of man are responsible for massive conversion of forest cover land into other land cover and land use units in Limmuseka*woreda*. For the purpose of clarity in the present study, the factors have been grouped into population growth and its resultant effects such as the prevalence of various types of agricultural activities, firewood and charcoal production, cutting trees to fulfil the demand of constructional materials, settlement expansion and income generation and grazing.

I. Population Growth

As it has been indicated in chapter three, limmu seka *woreda* is attracting a lot of people because of its favourable climatic condition, ample agricultural land. Job opportunity for thousands of daily labourers especially during coffee harvest time. The population is almost enlarged from152, 985 (1994) to 256,896 (2007). Population growth is the major factor which affects forest resources in the study area. Population increment and agricultural land expansion is directly proportional to each other. The forces behind in the forest cover change problem are partly population pressure as well as increased demand of various types of forest product such as fuel wood, building poles and making furniture as well as to obtain adequate agricultural lands.

Based on the view of informants and field observation data, due to the alarming increase of the demand of forest products, both the natural as well as plantation forests which are grown in the *woreda* have been seriously depleted. Coupled with population resettlement in the *Woreda* it also experiences alarming population growth because of its relative location, that is the woreda shares boundary with three zones and there is an influx of people from these areas.in addition the socio cultural practices of the society in the *woreda* encourage polygamy the area has been experiencing population explosion.

Discussion with Agricultural officers, developmental agents and Household Heads) summary report, revealed that the leading causes of forest cover change in the woreda is expansion of agricultural activities and followed by fire wood and charcoal production, demands of constructional materials, settlement expansion and income generation which has been observed in the area in the last few decades.

II, Agriculture Land Expansion

Knowingly or unknowingly human beings habitual abuse of the precious forest resource for immediate economic use (mainly to secure ample cultivated lands) by ignoring the facts of their ecological as well as environmental values is the major causes of forest cover change. This is manifested over exploitation of forest resources through the process of deforestation. As discussed in the previous sections, the agro-ecological conditions of the *Woreda* are convenient for agriculture.

It has also been noted that agriculture is the major livelihood of the study area population. Due to this, crop production including coffee and livestock rearing is the basic elements of the subsistence production system and the products obtained used as supplementary food sources for peasants who are inhabited in the *woreda.* Most of the farmers in the *woreda*rear livestock and want to maintain larger numbers with little care for their quality. According to the informants, the larger number of cattle population in a given family is both a source of wealth and status. Indeed, this mental attitude is not limited to the study area and is prevalent throughout Ethiopia. There is an increasing of non-forest land in which agricultural land is included for *62162.73* ha in 1994 to 39733.03 in the year 2014. The implication of increased cultivated land in terms of areal coverage means other land cover/land use units have been converted into cultivated lands which are the clear indicator of population in one way and lack of fertility of the land. In addition to this, according to the views of respondents the expansion of various types of agricultural activities is the major causes of forest cover change in the study area. Therefore, the presence of peasants with their various types of agricultural activities(both crop production and livestock rearing) inside and along the margin of the district's forest cover land is considered to be the major factor for forest cover change in the study area.

Fig.4.5.forestland changed to agricultural land

III. Fire wood and Charcoal Production

As indicated in the literature review part, as much as 93% of Ethiopian energy supply comes from biomass, with one–thirds of all the energy being derived from wood and charcoal. In this regarded, the Ethiopian Forestry Action Program (1994) estimated that in 1990/91 Ethiopia consumed about 15 million tons of energy, of which 95% was wood, dung, crop residue and charcoal. More specifically, the majority of the people in limmu Seka *woreda* are also depending on fuel wood as a source of energy

In the rural areas fire wood (collected from the nearby forest areas) is the most important sources of energy. According to the informants in the recent years fire wood is commercialized as its demand has increased illegal charcoal makers. Moreover, 28% of the respondents identified fire wood and charcoal productions are one of the major causes of forest cover change. Hence, the increasing demand of forest products, in the form of fire wood and charcoal within and outside the district has been causes of deforestation in the *woreda.*

IV. Cutting Trees for Constructional Materials

The demand of forest products for the construction of house and fence has been aggravated the destruction of forest in Limmu Seka *woreda*. As another rural Ethiopia forests are the only source of construction materials and different locally made utensils and from the respondent s' point of view about (8 %,); it was evident that cutting trees to fulfil the demand of constructional material is considered to be the causes of deforestation in the district. Field Observation data also indicated that woody biomass was found to be the single most important house construction material in the *woreda.*

V. Income Generation

According to, the view of developmental agents of the respective *kebeles* a number of people of *woreda* are poor and exposed for lack of adequate access to basic needs (such as food, clothing and shelter). However, huge proportions of limmuseka*woreda*dwellers are engaged in different activities to supplement their living condition. This is true for those people who do not have sufficient agricultural land and coffee land. Selling of wood products are traditional way of working activity for the poorest people such as jobless youths and women fuel wood carriers who are living in the *woreda* as well as inside the forest area. Referring to this, agricultural officers and forestry experts argue that these groups of people illegally cut down the trees from the forest area so as to supply a large quantity of forest products for urban dwellers and they sell it in small markets.

V. Settlement Expansions

Since the*woreda* is one of the areas where coffee is the major source income for large majority of the people and the influx of large number of people from other areas before and during coffee harvest there has been increment of people to the area .most of the newcomers prefer to settle permanently in the*woreda* which finally aggravates the need of land for settlement. Hence, settlement expansion is considered to be one cause of forest cover changes in the*woreda*.

Fig. 4.6.population settlement near forest

VI. **Free grazing**

Since the majority of the population of the *woreda* engaged in agriculture in which cattle are the means and mode of production in addition to cultivation of crops animal rearing is the common practice .because of the scarcity of sufficient grazing land ,people are forced to graze their cattle near and in the forest which facilitates deforestation.in addition lumbering, fire and investment are also some of the causes.

Fig. 4.7.cattle grazing near and in the forest

Table 4.10.Percentage Distribution of Respondents on the cause of forest destruction.

Cause of forest destruction	number	percent
Search for agricultural land	201	62.81
Investment activities	5	1.56
Settlement	96	30.00
Fuel wood demand and other	18	5.62
total	320	100

Source: field survey (2016)

As it is true in most developing countries including Ethiopia, the most dominant factor for the destruction of forest was expansion of agricultural land and responded by 62% of the total respondents followed by settlement which constituted 30%of the respondents.

Table 4.11.Percentage Distribution of Respondents on the effect of forest covers change.

Effect of forest cover change	Number	Percent
Soil erosion	102	31.87
Degradation of water shade	59	18.43
Increase waste land	33	10.31
Low productivity of the soil	96	30.00
total	320	100

Source: field survey (2016)

The respondents were asked to identify the causes separately for their choice on the effects of the land use/land cover change. Accordingly Table 17indicates that out of the total respondents who stated that soil erosion is the main consequence of land use land cover change and constitute 31.7 percent followed by those who responded low productivity of the soil ,degradation of water shade and low productivity of the soil respectively constitute-18and30percent. Farmers depend largely on cultivating different crops for their livelihood. Most of the crops under production are sensitive to soil fertility and productivity.

Soil erosion is the most serious problem in the area. Agricultural lands are located on very steep slopes (with gradients of about 30-40%). There is a lack of sufficient land areas with gentle slopes. In most land areas, soil conservation structures have not been constructed. Drought is what has been prevailing in recent years. Climate variability, late onset and early cessation of rainfall and vice versa, is clearly observed in the *kebele*. Given this, insect pests which were previously uncommon in the area are breaking out and damaging crops.

As most of the respondents mentioned, soil fertility in the area is very poor and farmers have been using farmyard manure and commercial fertilisers for maintaining fertility and increasing production and productivity. In some cases crop rotation was practised even though there was a shortage of cultivable land which prohibited farmers from rotating crops from year to year.

Table 4.12. Major Household source of energy

Source of energy	Number	Percent
Biomass fuel wood	297	92.81
kerosene	-	-
biogas	11	3.43
other	12	3.75
total	320	100

Source: field survey (2016)

The above table clearly indicate that almost all of the household energy source is biomass fuel wood mostly emanates from the nearby forest lands and only3percent of the households energy source is biogas which is introduced recently in the*woreda* generally and sample *kebeles* in particular.

Table 4.13.Approximate amount of Households fuel wood consumption per month

Fuel wood consumption per month	number	percent
2-3backload/head load	152	47.5
3-5backload/head load	157	49.06
>5backload/head load	11	3.43
total	320	100

Source: field survey (2016)

Since the large majority of the people in the *woreda* live in rural areas which is even above the average of the zone and have no another option of energy source than biomass fuel and the introduction of simple power efficient equipment almost all of the study areas source of energy mostly depends on fuel wood from the nearby forests. Accordingly half of the respondents consumed 3-5 back loads of wood per month and followed by those who consumed 2-3 backloads per month and constituted 47.5% of the sample population. This indicates that the dependency of the people on the scarce natural resource.

Table 4.14.Change observed in the last 20 years

Changes observed	Number	Percent
There is change	194	60.62
There is no change	78	24.37
uncertain	48	15
total	320	100

Source: field survey (2016)

As can be seen from the table above (table 20) greater than half of the respondents (60.62%) replied that there was a change in forest cover in the last 20 years. the rest who responded no change and uncertain constituted 24 and 15 percent respectively. Since the area is one of the *woredas* of Jimma zone where coffee is produced and coffee plantation is under the shade of forests, observing forest destruction or forest cover change is very difficult. Here what we have to know is that the presence of coffee means does not mean that the conservation of all of the original forest .this is because in order to plant tree there is a need of space, so in order to get space to plant coffee most of the trees must be removed.

Table 4.15.Distribution of Respondents on measures to be taken

Measures to be taken	number	percent
Strong enforcement of law on available forest protection	55	17.18
Proper resettlement	36	11.25
aforestationand reforestation	128	40.00
Applying community participation	111	34.68
other	10	3.12
total	320	100

Source: field survey (2016)

As can be seen from the table 40 percent of the respondents replied that a forestation and reforestation must be one of the measures to be taken to minimize the problem. Applying community participation is also one of the measures to be taken and responded by 34.68 percent of the total sample population. Strong enforcement of the law and proper resettlement respectively responded by 17 and 11 percent of the respondents.so, the response shows that the coordination of the key stake holders and active community participation constitutes the most important measures to be taken.

Fig.4.8. sample coffee and protected forest of the study area

Fig.4.9. Reforestation going on

4.7.5. Result of Socio-Economic Survey

The land use and land cover changes in general and forest cover change in particular was facilitated by different causative factors which may lead to complex environmental problems and natural resources degradation. In one way or another, the change in land use and land cover is the reflection of socioeconomic condition of the surrounding community. Mostly human activities and to some extent natural processes are the responsible factors for forest cover change in the study area. Forest cover change is mostly caused by multiple interacting factors.

The combination of driving forces of land-use change varies in time and space according to specific human environment conditions. Accordingly the underlying causes operate at the local level were identified from the household survey conducted in the sample *Kebeles*.There are conditions which were identified as important points before discussing the results of the underlying causes of forest cover change to link the result with the underlying facts. Since the majority of them were in the age group 31-50(74%) these groups can actually have a good understanding of the change in their localities and it is sounding to consider the responses for the identification of the underlying causes.

The analysis of the result shows that there is more dependency of the people on agriculture since they don't have any source of income other than agriculture. All of the respondents agreed that land is becoming scarce and they were asked to reason out the cause for the scarcity. As per the response of the respondents population growth in the study area because of the influx of people in search of agricultural land and poor family planning related to the culture of the society is in an alarming rate .All the above stated facts indicate that there is a need for the farmers in the study area to look for another land to feed their increasing population which may lead to land use land cover change especially which focus on the available forest land of the area. The nearby forests to pasture lands are gradually affected by cattle.

More than 60.6% of the respondents believe that there was a forest cover change in their localities. soil erosion and low productivity of the of the land were the major effects of the change inland use land cover according to the socio economic survey conducted in the study area and respectively constituted 31% and 30%.A focus group discussion was also employed to get insight of the underlying causes of land use / land cover change in the study area. Accordingly the members of the focus group discussion underlined that generally there is a decrease in forest land and water regimes while increase in crop land and settlement. This discussion result also supports the LU/LC change analysis. The group also discusses the cause for the change and underlined that population growth is the major factor for the change but there are some who argued that it is mismanagement and poor agricultural practices which were responsible for the change.

Population growth is the major reason in that since the *woreda* share boundaries with three zones there is an influx of people to the *woreda*i n search of agricultural land and settlement. The last issue discussed was community participation in conservation activity and they replied that the populations of the *wereda* are actively participating in conservation activities having the *kebele* officials in front line as their day to day activity with support from the *wereda* administration as one of their priority areas. This result also reveals similarity with the image analysis result in that the small rate in the last ten years change in forest classes could be a result of these activities. It is also supported by satellite image evidence .Rate of forest cover change decreases in the last decade.

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Forest cover change in the form of deforestation is a major environmental problem manifested at Limmu Seka *woreda*. The case study as presented in the current research is an indicator of how rapidly the forests are disappearing in the study area although its rate of change fluctuates. Now days, the situation at Limmu Seka *woreda* shows that extensive areas of forestland have been completely deforested while some areas of the forest cover land has been considerably degraded. As the satellite images show many of the forestland areas have been converted into cultivated land or grassland with a few scattered trees and shrubs. With the rapid population growth and need of extra land for these ever increasing population areas which were covered by dense forest lands in the late 1990s are now changed to other land use land cover.

From the analysed results, the magnitude of land use and land cover in general and forest cover change in particular was drastically changed between 1994 and 2014 at Limmu Seka *woreda*. Particularly, expansion of cultivated land and decline of forest cover was observed. In relation to this, currently, the overall condition of the forest cover land of the *woreda* shows change. Besides, the areal extent of forest cover land is reduced from time to time. As findings indicated that from the total area of the *woreda* about *62162.73* ha of land was covered with forest in 1994. But, this figure is declined to 39733.03ha in the year 2014. On top of this, considering the annual rate of forest cover change between1994 and 2014, the computed result indicated that about 22427.7 ha of forest land is changed in to other land use land cover in the last 20 years.

Finally, the socio-economic data were identified as major causes and consequences of forest cover change in Limmu Seka *woreda*. This resource has been utilized in unsustainable manner due to population growth (with other variables) such as demand of forest products for construction, fire wood and Charcoal production, income generation and expansion of various types of agricultural activities and built up areas along the margin and even inside the forest areas. The degradation can be attributed to the pressure of urbanization, poor management of the forest reserve and increasing human activities in the area this circumstances leads to further depletion of forest resources in the study area. As a result, the problem of forest degradation as well as deforestation with other related factors has aggravated land degradation with soil erosion and deterioration of biodiversity in LimmuSeka*woreda*. Hence, this type of data is very useful for the concerned bodies in protecting the remaining forest resources from distraction.

5.2. Recommendations

From the whole study, GIS and Remote sensing tools are important tools for forest cover change detection. It had been recognized that the forest cover land of Limmu Seka *woreda* has declined though; the rate was different in different period. For future application of this tools for multi-purpose including forest cover change detection in general and to protect the forest resources of the study area from further depletion in particular, and to use these precious resources in a sustainable basis, the following feasible suggestions are forwarded based on the findings and the conclusions drawn.

- To protect the forest resources from further destruction, to realize the impact of deforestation as well as how to use this precious resource with a sustainable manner, awareness creation campaigns especially for the farmers who are dwelling along the margin and inside the forest areas should be an indispensable phenomenon.

- Investment projects already licensed should be assessed, their impacts on biodiversity and local livelihood evaluated, and corrective measures should be applied to avoid further damages.

- Give priority to investments that are environmental friendly and socially acceptable such as ecotourism, honey and spices production.

- Forest cover mapping and detection of changes shown here may not provide the real figure of classes due to low resolution of the imagery but it serves as a base to understand the patterns and magnitude of land use/land cover changes in the area.so the application of high resolution satellite image will minimize the errors.

- Continuing the efforts of introducing family planning to make the people aware of consequences of population pressure on land resources should be carried out intensively.

- To minimize if not stop the degradation process and rehabilitate the situation, the on-going integrated watershed management works should have to be intensified in the study area.

- ❖ Participatory forest management should be also implemented. Without active participation of the local community it is difficult to think about conservation of natural resources in general and forest resource in particular, so community participation in forest management should be implemented.

- ❖ Forest degradation is believed to be an important source of emissions by Ethiopia and several measures are being put in place to reduce emissions from forest degradation (e.g. the promotion of energy efficient cooking stoves, planting trees on-farm boundaries for fuel wood and the provision of non-wood and alternative energy sources).

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JIMMA UNIVERSITY

COLLEGE OF SOCIAL SCIENCES AND HUMANITIES

DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

Questionnaire filled by sample households of the *woreda*

Dear respondents, the main purpose of this questionnaire is to collect primary and relevant data on the topic GIS based analysis of forest cover change. Thus you are kindly requested to give the necessary information on issue related to the study. The student researcher believes that the success of this study depends on your honest and genuine response to the question. Please, feel confident that your response will be kept confidential and the information you provide will be used for academic purpose only.

Thank you in advance for your cooperation!

Personal information

1. Age ----------------------------

2. Sex: Male ☐ Female ☐

3. Educational level: Illiterate ☐

Literate ☐

If literate, grade attended: ☐

Primary ☐ Secondary ☐

Diploma holder ☐ Degree holder ☐

Other ☐

4. marital status: Single ☐ Married ☐

Divorced ☐ Widowed ☐

5. Family size: Male ☐ Female ☐

6. Occupation of household head

Merchant ☐ Farmer ☐ Government employee ☐ other ☐

Questionnaire related to forest cover change

7. what is your major energy source?

Fuel wood ☐ charcoal ☐

Kerosene ☐ Electricity ☐ other ☐

If your answer for question No. 7 is fuel wood from where did you collect it?

Forest ☐ Garden ☐ other ☐

8. How long have you been living here?

1-5 years ☐ 6-10 years ☐ 11-15 years ☐ >16 years ☐

9. Did you observe any change in forest cover in the last 20 years?

If your answer for question is yes, what do you think the reason?

Search of agricultural land ☐

Clearing the forest for other investment activities ☐

Settlement ☐

For charcoal production ☐

Other ☐

9. What amount fuel wood did you consume per month?

2-3 head load/back load ☐

3-5 head load /back load ☐

Greater than 5 back load/head load ☐

10. what changes did you observe in the past few years in connection with forest destruction?

Migration of wild animals ☐

Land degradation ☐

Absence of fuel wood in a nearby area ☐

Reduction of the size of streams ☐

11. Are there reforestation and a forestation program in your *kebele?*

Yes ☐ No ☐

If yes do the afforested and reforested areas are properly conserved?

Yes ☐ No ☐

11. What measures do you think should be implemented to combat forest encroachment?

Strong enforcement of law ☐

Proper resettlement ☐

Coordination between key stakeholders ☐

Applying community participation of forest management ☐

Other ☐