JIMMA UNIVERSITY

COLLEGE OF SOCIAL SCIENCES AND HUMANITIES

DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

GIS and Remote Sensing Based Analysis of Forest Cover Change Detection: a Case of Goma *Woreda*, Jimma Zone South West of Ethiopia

By

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We hereby certify that we have read and evaluate this Thesis entitled GIS and Remote Sensing Based Analysis of Forest Cover Change Detection: a Case of Goma *Woreda*, Jimma Zone South West of Ethiopia is my own work. Prepared under my guidance by Asefa Amare. I recommend that it be accepted as fulfilling the thesis requirement.

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Declaration

By signature below, I declare and confirm this thesis entitled GIS and Remote Sensing Based Analysis of Forest Cover Change Detection: a Case of Goma *Woreda*, Jimma Zone South West of Ethiopia is my own work. That all sources of material used for the thesis have been acknowledged in the citation.

Asefa Amare

Signature______________

Date ________________

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List of Acronyms

ADF	Africa Development Forum
CSA	Central Statistical Agency
DEM	Digital Elevation Model
ETM	Enhanced Thematic Mapper
FAO	Food and Agricultural Organization
FRA	Forest and Resources Assessment
GIS	Geographic information System
GPLWDPD	Goma pilot learning wereda diagnosis and program design
GPS	Global Positioning System
IPMS	Improving Productivity and Market Success
NDVI	Normalized Difference Vegetation Index
TM	Thematic Mapper
UNFCCC	United Nation Framework Conventions on Climate Change
WBISPP	Woody Biomass Inventory and Strategic Planning Project

Abstract

*Forest resources are useful material that covered 30 percent of the earth surface which provide valuable ecosystem services. The Rapid population growth of the world has exerted pressure on the earth's forest resources resulted in annual loss of 7.6 million ha between 2010 and 2015. Therefore the main focus of this study was to detect and analysis the magnitude and the rate of forest cover change of over last 32 years between 1985 1and 2017 with the integrated approach of GIS and remote sensing technologies. "Landsat TM (1985 and 2001), and ETM +) were used for land use and land cover analysis. A supervised classification was made using the maximum likelihood method in ERDAS Imagine". In order to examine the areal extent and rate of forest cover change post classification change comparisons method and NDVI image differencing change detection methods were employed with the arc GIS software. Land use land covers of the study area were classified in to forest, Shrub land, farmland, settlement, grazing land and fallow land. The finding of this study indicated one land use and land cover class changed to another land use and land cover classes during the study period. Because of this Forest resources of Goma woreda was decreased from 26649.99ha (30.73%) in 1985 to*11569.05 *(13.3%) in 2017 with the rate of change by* 471.27*ha per year. Based on key informant and field observation data identify the following causes of deforestation included Population growth, Expansion of agricultural land, fire wood and charcoal production, removal of tree for constructional materials and timber production and expansion of residential area. The impact of deforestation resulted for environmental problems include loss of biodiversity, soil erosion and land degradation. Depending the finding suggested that for the concerned bodies on creating awareness on forest conservation, implementation of different agricultural technological inputs, adapted alternative energy sources, reduced the growth through of family planning awareness*

Key words: Forest, Deforestation, GIS and remote sensing

CHAPTE ONE

1. INTRODUCTION

1.1 Background of the Study

Natural resources are useful materials of the earth surface. These resources include both renewable and non-renewable resources such as, soil, forests, vegetations, water (surface and ground water) wild animals, domestic animals, birds, climate, and minerals(Tesfaye, 2010).Forests are one of these natural resources that covered 30 percent or 4billion hectares of the Earth's land surface which provide valuable ecosystem services and goods, serve as a habitat for a wide range of flora and fauna and hold a significant standing stock of global carbon (UNFCCC, 2011).

Similarly, Forests are sources of food, shelter, wildlife habitat, fuel, and raw materials for medicinal ingredients and paper and play an important role in balancing the earth's CO_2 exchange (Hassan, 2010).In addition, they provide foundations for life on earth by regulating the climate and water resources and by serving as habitats for plants and animals, sources of essential goods such as wood for domestic and exports markets and recreational opportunities (Diarrassouba and Boubacar, 2009). However, due to Rapid population growth of the world has exerted pressure on the earth's natural resources in general and forest in particular. According to global forest resource assessment (FRA, 2015) report, between 2010 and 2015 there was an annual loss of 7.6 million ha and an annual gain of 4.3 million ha per year, resulting in a net annual decrease in forest area of 3.3 million ha per year.

Africa is endowed with diverse, rich natural and plantation forests which provide a wide range of goods and services that create development opportunities, and support the livelihoods of millions of people, living in and within forest boundary (ADF, 2012). According to Forest and Resource Assessment (FRA) (2010), the estimated forest area in Africa was close to 675 million hectares, accounting for about 17 percent of global forest area and 23 percent of the total land area in the region. Despite the importance forest ecosystems of the continent, it is at declining rate, from 2000 to 2010, Africa recorded an annual loss of about 3.4 million hectares making it second largest net forest loser in the world(ADF,2012).

It is clear that the global forest has been decreasing from time to time. As Genanaw (2008) suggested that Ethiopia is one of the countries in which its forest resources are highly depleted due to massive removal by its growing population. Ethiopia is the second-most populous country in Africa and endowed with diverse forest resources. About 40% of the country land area was covered with high-forests at the turn of 19 century. Yet, the country has lost much of these forest resources. These high-forests have declined from 40% of land cover to approximately 3.6% in 2013 and the remaining high forests are found in the southwest of the country; more than 60% of the original forest has been lost over the last 30 years, between 1970 and 2000(Maereg *etal*, 2013).

Globally, forest gains and losses occur continuously, and are very difficult to monitor. Knowing how and why forest area changes over time is important for managing forests sustainably because such changes may result in long-term deletions (e.g. forest conversion to agriculture) from the forest land base or additions (e.g. afforestation)(FAO, 2010).

Understanding forest patterns, changes and interactions between human activities and natural phenomenon are essential for proper forest management and decision improvement. Today, data from satellites are very applicable and useful for forest cover change detection studies. Monitoring of forest cover change is one of the main applications of remote sensing based change detection (Abyot *et al.*, 2014).

Therefore, this study focused on the detection of the forest cover change and mapping the rate of change in Goma District using the integrated techniques of remote sensing and GIS technology.

1.2 Statement of the Problem

Historically the problem of deforestation and forest degradation are occurred in Ethiopia. The consumption of forest and forest products has been shown to be higher than the incremental yield (forest gain) of forests leading to deforestation and forest degradation in the country (Bork &Assefa, 2014).

Goma woreda is one of the weredas found in jimma zone south west of the country where forest cover is relatively high. However, there is very fast encroachment of these forest areas due to high population pressure (GPLWDPD, 2007). The natural resources (vegetation, wildlife and soils) are facing indiscriminate depletion mainly due to expansion of croplands, expansion of residential area and cutting of forest trees for construction materials and timber production. In the district it is becoming difficult to find large areas under conserved natural forests. According to (IPMS, 2007) estimated the wereda has about 4505.3 ha or 4.8% of natural and manmade forest resources.

As Million (2011) noted that, there is a growing gap between demand and supply of forest products and services in Ethiopia. In order to narrow these huge gaps, forest resources of the study area was depleting and endemic tree species are destructed by various human activities. In the Goma woreda the majority of population is live near to the forest boundary. This population depleted these forest resources due to their livelihood is mainly dependent on the forest for fuel-wood, food, and timber and generates income from forest to fulfill their basic needs. Moreover, in the study area forest resource was declined from time to time due to cutting of tree for timber production, expansion of agricultural land by population pressure, constructional materials, and fuel wood. The problems were affects the forest coverage of the woreda. There are a few researchers who conducted their research on Goma woreda such as (Behailu and Meseret, 2010) mainly focused on agriculture, production and marketing of cash crops such as coffee, fruits. Beyond these research issue, forest resources of Goma woreda didn't have attention of any researchers and it is unexploited area of study in the wereda. This study has come up with application of GIS and remote sensing tools for the assessment of natural resources particularly forest cover change detection provides update and relevant information in decision making for concerned bodies.

1.3 Objectives of the Study

1.3.1 General Objectives

"The study aims at analyzing the historical forest cover changes and their underlying factors in Goma Wereda, South West Ethiopia".

1.3.2 Specific Objectives

- To analyze the land use and land cover of the study area for the last three decades.
- To analyze the spatio-temporal forest cover changes in the study area.
- To investigate the pattern and rate of forest cover changes in the study area.
- To identify main causes of forest cover changes in the study area.

1.4 Research Questions

- What was the area of land user and land cover of the study area for last three decades?
- What are the spatio-temporal forest cover changes in the study area?
- What was the pattern and rate of forest cover changes in the study area?
- What are the factors responsible in determining the forest cover Changes in the study area?

1.5 Significance of the Study

The final result of this study provide historical pattern of LULC change in the study area, to understand how land was used in the past and serve as an input especially for woreda administration office to take solution for problem of deforestation. It provides current information on the dynamics of forest cover change of the study area for different governmental sectors such as agricultural officers, forestry experts as well as other concerned bodies including NGOs and local population of the study area in the remedial action of intervention. For different researcher provide alternative sources of information on the problem of forest cover change in the study area for those are interested on the further research works.

1.6 Scope of the Study

This study has both theoretical and spatial scopes. Theoretically; it is delimited to analysis forest cover change detection and spatially the study was delimited to the boundary of Goma Woreda.

1.7 Limitation of the Study

Limitations encountered in this study are unable to use satellite imageries of high resolution like QuickBird due to its expensiveness, which leading to employed landsat images. Therefore, the difficulty to identify each land use/land cover category has resulted in misclassification of one land use/land cover into another. In order to overcome this problem, field observations were undertook to verify actual land use/land cover classes.

1.8 Organization of Paper

This study is composed of five chapters. The first chapter is an introduction part, which includes background of the study, statement of the problem, objectives of the study, basic research questions, and significance of the study, scope of the of the study. Chapter two provides a literature review with an over view of related studies conducted in other parts of the world with different authors. Description of the study area as well as the different data sets, materials and methodology which are employed in this research presented in the third chapter of this thesis. The analysis and final finding of with the various methods was presented in chapter four. Finally, the major findings and the conclusions drawn together with recommendations are presented in chapter five.

CHAPTER TWO

LITRATURE RIVIEW

2.1. Definition and Concepts of Key Terminologies

2.1.1. Forest

A forest is a complex ecosystem which is mostly composed of trees, shrubs and is usually a closed canopy and the storehouses of a large variety of life forms such as plants, mammals, birds, insects and reptiles (Amritkar, 2009). Forest is defined by international organizations, institutions and individual countries in order satisfy to their needs and specific interests. However, most countries, for purposes of international agreements, accept the FAO definition. In this, forests are defined on the basis of thresholds values for three quantitative criteria: canopy cover, area and height.FAO (2001) defined a forest as land with a tree canopy cover 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*.

2.1.2 Deforestation and Forest Degradation

Many people use the definitions of deforestation and forest degradation interchangeably to explain forest loss. However, their meanings are different. According to FAO (2001), deforestation is the conversion of forest to another land use such as agricultural land, urban use, logged area or wasteland or the long-term reduction of tree canopy cover below the 10% threshold. Besides to this, forest degradation is defined as the changes within the forest which negatively affect the structure or function of the site and lower the capacity to supply products and services (FAO, 2006).

2.1.3 Land use and land cover change

Land cover it refers to the bio-physical sate of the earth's land surface and immediate sub-surface including biota, soil, topography, surface and ground water, and human structures (Turner *et al*., 2001).Land use refers to the purposes for which humans exploit the land and its resources, whereas. Land cover change refers to modification of the existing land cover or complete conversion of the land cover to a new cover type (Lambin and Guest 2006).

Land use change is the conversion of land use due to human intervention for various purposes, such as for agriculture, settlement, transportation, infrastructure and manufacturing, parks, recreation uses, mining and fishery (Turner and Meyer, 2001) Conversion and modification are the two forms of land cover changes described by Meyer and Turner(1992) where the former is a change from one class of land cover to another (e.g from grassland to cultivated land). The latter is, however, a change within a land cover category (e.g thinning of a forest or a change in composition). Whatever the type of changes in land cover, they encompass changes in biotic diversity, actual and potential primary productivity, soil quality, runoff and sedimentation rates, and other such attributes of the terrestrial surface of the Earth (Steffen *et al*., 2004; DeFries*et al*., 2004; Lambin and Geist, 2006). Four aspects of change detection which are important when monitoring natural resources (Macleod and Congation, 1998 cited in Zabair, 2006):

LULC cause for loss of biological diversity, resulted for forest fragmentation, lead to soil erosion, affect ecosystem services, disturb socio-cultural practices, and increase natural disasters, such as flooding (Vitousek, 1997 and Mas, 2004).With an area of 1,130,000 km2, and as one of the most populous countries in Africa, Ethiopia is experiencing huge LULC dynamics from natural vegetation to farming practices and human settlement (Kidanu, 2004 and CSA, 2007).The problem of land cover dynamics is more severe in the highlands, which account nearly 44% of the country's landmass and have been cultivated for millennia (Eshetu and Högberg, 2000 and Hurni, *etal.*, 2005).

2.1.4 Descriptions of land covers

In this study, for the purpose of forest cover change detection and analysis of the land use/land cover categories are classified in to six classes, forest, shrub land, farm land, settlement, grazing land, fallow land. In the classification step that considered two things. Primarily the land use/land cover classification processes are determined based on the reality that exists on the ground. In the primary field observation the researcher with aid of agricultural and forestry officers identify six land use/land cover classes. Second these classes are having more direct or indirect relationship with the fluctuation of forest coverage the study area.

Forest: It represents both natural and fragmented plantation forest areas that are stocked

Tree Capable of producing timber or other wood products.

Shrub: supporting a combination of small trees and shrubs.

Grazing land: are those lands where small grasses are the predominantly natural Vegetation. It also includes land with scattered or patches of trees and it is used for Grazing and browsing.

Settlement: are those areas composed of intensive use with much of the land by rural villages, towns and roads.

Farmland: This area cover includes agricultural crops.

Fallow land: Are farmlands that has been but then left without crops being implanted on It, in order to allow essential chemical elements to increase in it

2.2 Global extents of forest cover change

Human being has taken the leading role in changing natural environment and there is increasing pressure on these nonrenewable natural resources. Human activities have a role in modification of physical or man-made environment, so making suitable or harshen is in its hands (Workaferahu, 2015). Historically, the state of the world's forests has strongly reflected the pattern and intensity of land use by societies. Demand for agricultural land, timber, and other forest products, as well as technological change in agriculture, significantly impacts the magnitude and rate of transformation of forested areas (Nzeh, etal, 2015). In the views of Kapos (2000), biophysical triggers may also play a role, such as fire dynamics, which are linked to agricultural activities or other natural phenomena. These demands are often linked to present-day developing countries experiencing deforestation.

Now aday, due to global increases in population and consumption, and changing diets; oil and gas extraction and mining; the development of roads and other infrastructure; smallholder agriculture; fuel wood collection and charcoal production; forest fires which are often a precursor to conversion; and legal and illegal logging (ISU, 2015). According to Adeofun (1991) the world's forest has reduced considerably from 4 to 5 million hectare over past one hundred years. As the Mathews (1983), finding indicated that, temperate closed forest experienced the highest rate of reduction about (32 to 35%), the subtropical woody savannas and deciduous forests diminished about 21 to 24% also the tropical declined to 15 to 20%. The 2010 FAO's report argues that, an estimated global forest cover was about 4 billion hectares which is 31% of total land area of the world. According to UNEP (2011) and FAO (2012) report indicated that, global population estimated to above 6.5 billion and this figure expected to double in the coming of 50 years.

As the Mathews (1983), finding indicated that, temperate closed forest experienced the highest rate of reduction about 32 to 35% of the subtropical woody savannas and deciduous forests diminished about 21 to 24% also the tropical declined to 15 to 20%. This estimation indicated that the tropical rain forest experienced minimum distraction from the anther regions over the period. However, Deforestation was intensified in the rain forest since the Second World War, because of the growing rural population invades the forests in search of land for their crops, fuel wood for cooking, and fodder for their animals. Also most tropical nations in an attempt to raise foreign exchange earnings to execute economic development programs turn to the forests as a readily exploitable resource (Nzeh, *et al*., 2015).

In most developing countries, deforestation is increasing highly at alarming rate. About 11 million hectares of forest are cleared for other uses annually in developing countries (Adeofun, 1991). Between 1950 and 1983, Melillo et al. (1985) reported that forest and woodland areas declined by about 38% in Central American and 24% in Africa. In addition to this, in the recent years as Adams (2013) report, Africa experienced extensive deforestation, which lost about 34 million hectares from 2000 to 2010. Brazil also lost 2.6 million hectares of forest between 2010 to 2012 each year.

2.3 The problem of Deforestation in Ethiopia

Ethiopia has diverse vegetation resources, from tropical rain and on the mountains to the desert scrubs in the east and north east and parkland agro forestry on the central plateau (Demel *et al*., 2010). The history of deforestation in Ethiopia, specifically in the long inhabited highland of the country had been severe and continuous process (Zewdu Eshetu and Hgbeg, 2000, Demel Teketay, 2001 and Derbyshire etal, 2003).Since the third and fourth millennium BC, the expansion of cultivable land was resulted in the higher rate of deforestation and forest degradation in northern highland of Tigray and wello (phillipson, 1990). Derbyshire etal (2003) suggest based on the review evidence from charcoal and pollen analysis of sediments, the forest coverage in the highland of wello was continuously cleared for the purpose of cultivation in the last 300 years.

According to Bekele (1992) suggested based on the review of historical documents that forest of central and northern highland completely convert for the cultivation before sixteenth century. In the time of the forest inventory of south west of Ethiopia, forest area of the region was clear for cultivation. In addition Reusing (1998) described that 50% of south west forest was removed for agriculture in less than 20 years. As the view of Mekuria (2005) after the resettlement of people from degraded and drought affected part of Ethiopia, large scale deforestation was continued in the south west of the due country.

In 2005, the forest cover had further declined and was estimated to cover 13.0 million ha the country. In other words, Ethiopia lost over 2 million ha of the forests, with an annual average loss of 140 000 ha between 1990 and 2005. In 2009, the area is estimated at 12.3 million ha, 11.9 % of the total land area. Of this, the remaining closed natural high forests are 4.12 million ha or 3.37% of Ethiopia's land (FAO, 2010). This indicates that the coverage of forest resource was declined in an alarming rate. The remaining forest area of the country unevenly distributed that 95 percent of the total forest area occupied in Oromia, Southern Nations and Nationalities Regional State and Gambella regions (WBISPP, 2004).

2.4 The causes of deforestation in Ethiopia

The causes of deforestation are very complex. Now a day's large amount of damages have been experienced on the forest resources of Ethiopia. A group of people can destroy dense forests so as to expand their farm lands or get fresh farm and grazing lands (Zemedie and Kedir, 1997). Higher rate of population increased over the decades is the major factor contributing to the accelerated rate of deforestation in Ethiopia. Population growth is leading to increase need for farming and grazing land, the demand for fuel wood and construction materials, repeated fire out breaks, and movement of political center (Berhan, 2007).

Similarly, in his finding Tigabu (2016) indicated that in higher population growth, low agricultural productivity, the poor economic performance of the country, shifting agriculture activities, livestock production and fuel wood consumption was the main causes of deforestation. The rural poor population living around forest area highly dependent on biodiversity to satisfy their basic needs such as food, water, housing and social services. This economic dependency of the people on the forest is main reasons for deforestation (Workaferahu, 2015).

In Ethiopia the remaining forest is confined to the southern part of the country. Land is publicly owned. This unrestricted access, land users tend to maximize land to enhance future harvest opportunities, and especially farmers operate agricultural sites with free access to any available land resource and abandon overharvested areas and seek to convert forests into new agricultural land. Werner A. Kurz, (2010) estimated that between 2000 and 2008, 80% of new agricultural land was converted from forests, woodlands or shrub lands. Fuel wood is also largely free access and a major source for household energy in Ethiopia. It is estimated that 90% of the country's total energy for household cooking is derived from biomass fuels, of which 78% come from fire wood. It is common Land is being converted for subsistence and commercial agriculture, timber, used for fuel wood and construction The loss of forests and other protected land is caused by a growing population, unsustainable harvest for timber and fuel wood extraction (EPA, 2012).

Table 1 Major drivers of deforestation and forest degradation

Direct drivers	Anthropogenic	• Small-scale agriculture • Large-scale agriculture • Fuel wood extraction • Charcoal production • Logging (legal and illegal, Construction wood extraction • Forest coffee planting • Livestock grazing • Mining (small artesian and large scale industrial) • Roads and infrastructure • Invasive alien species • Fires/human caused
	Natural	Wild Fire • Climate change/Droughts • Pests and diseases • Floods

2.5 Geographic information system (GIS)

GIS is defined with different individual authors from different point of view. According to Burrough(1986) define GIS is computer based power full tool for collecting, retrieving, transforming and displaying spatial data from the real world phenomenon for the specific purposes. In another hand, it is a form of management information system which allows displaying general information in the form of map (Devine and Field, 1986). Parker (1988) also defined GIS an information technology which stores, analysis and display both spatial; and non spatial data. According to Eastman(2001), defined GIS is the a specific information system which employed to geographic data and especially referred to as a system of hardware, soft ware and procedures designed to support the capture, management, manipulation, analysis, modeling and display of spatially-referenced data for solving complex planning and management problems". GIS is mostly used for data entry data, data display, data management, Information retrieval analysis. In this study the application of GIS is mapping location, quantify the rate of change, mapping and monitoring the change.

2.6 Remote sensing

Remote sensing is the science and art of collecting information about object, area or phenomenon of the earth without direct physical contact of the device with the object, area and phenomenon under investigation (Lillesand and kiefer, 2000) In this study the main role of remote sensing is provide the measurement of emitted or reflected electromagnetic radiation in the form of digital number from a target object or phenomenon of the earth's surface. Remote sensing satellite images are widely used in natural resource monitoring and management, to determine between different changes from repetitive coverage particularly in the forest cover change detection. The main focus of remote sensing in this study is to indicate the areal extent and the rate of forest cover change on map using different period Landsat resources.

2.7 The role of GIS and Remote Sensing on forest Management

Remote sensing together with GIS and computer simulation models contribute significantly with whole process of forest planning, operation and management. The information on the forest status such as quality, quantity, spatial distribution can be assessed by remote sensing data (Kandel, 2009). Remote sensing is a powerful technique for the purpose of surveying, mapping and monitoring of natural resources of the earth surface. This technology integrated with GIS which used in storage, manipulation and analysis for Geographic information and Socio-economic data. For land resource and environmental management and decision makers require statistical information on spatial and temporal as well as observed changes of land use types. Remote sensing provide together with multitude of tools in order to analyze the magnitude and rate of forest cover change. In change detection process Multi-date image data was provide and image of earlier years compared with image of recent to detect the magnitude, areal extent and rate of forest cover change of a particular area.

2.6 Change detection method

Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times (Singh, 1989). It is the application of multi date datasets in order to discriminate the areas of land cover change under investigation between deferent dates of imaging, and usually it includes the ability identify and quantify spatio– temporal phenomenon using multi –temporal datasets(Lillesand, (2004). In addition to this, Singh (1989) indicated that change detection is important and applicable in various area of scientific change analysis, such as, land use change analysis, monitoring of shifting cultivation, assessment of deforestation, seasonal changes in pasture production, damage assessment, disaster monitoring, day/night analysis of thermal characteristics as well as other environmental changes. According to Chen(2000) explain that there are different change detection methods have been developed which employed in different area applications, Such as there are post-classification comparison, image differencing, image rationing, image regression and principal component analysis. However, they can be broadly divided into: post classification and spectral change detection approaches (Singh, 1989).

2.6. 1 Post classification change detection method

Post classification is among the most widely applied techniques for change detection purpose. Numerous studies have been carried out using post-classification approach. In post classification change detection approach two images from different dates are classified and labeled. The area of change is then extracted through the direct comparison of the classification results (Lunetta and Evade, 1999). Chen (2000) forwards both advantages and disadvantages of post classification techniques. The main advantages of post-classification include: detailed “from- to” information. The main disadvantage of the post-classification approach is the dependency of the land cover change results on the individual classification accuracies (Chen, 2000).

2.6.2 Spectral change detection approach

According to Chen (2000), there are a number of spectral change detection methods. Spectral change detection techniques depend on the principle that land cover changes result in persistent changes in spectral signature of the affected land surface. In this change detection methods two original images were transformed into a new single band or multi-band image, in which the area of spectral change is highlighted. In addition Singh (1989) have identified image differencing as the most accurate change detection technique. This technique is performed by subtracting images from two dates pixel by pixel. Then threshold boundaries between change and no-change pixels are determined for the difference image to produce the change map. The vegetation indices are the most widely used among spectral change detection techniques which have reliable in monitoring vegetation change.

One of the most widely used indices for vegetation monitoring is the Normalised Difference Vegetation Index (NDVI), because vegetation differential absorbs visible incident solar radiant and reflects much of the infrared (NIR), data on vegetation biophysical characteristics can be derived from visible and NIR and mid-infrared portions of the electromagnetic spectrum (EMS).

The NDVI approach is based on the fact that healthy vegetation has low reflectance in the visible portion of the EMS due to chlorophyll and other pigment absorption and has high reflectance in the NIR because of the internal reflectance by the mesophyll spongy tissue of green leaf (Lunetta and Elvidge, 1999).NDVI can be calculated as a ratio of Red and the NIR bands of a sensor system. NDVI values range from -1 to +1, because of high reflectance in the NIR portion of the EMS, healthy vegetation is represented by high NDVI values between 0.1 and 1.

Conversely, non vegetated surfaces such as water bodies yield negative values of NDVI because of the electromagnetic absorption quality of water. Bare soil areas represent NDVI values which are closest to 0 due to high reflectance in both the visible and NIR portions of the EMS. NDVI is related to the absorption of active radiation and basically measures the photosynthetic capability of leaves, which is related to vegetative canopy resistance and water vapour transfer (Lillesand and Kiefer, 2000).

A large number of comparative studies on different change detection methods including NDVI image differencing have been employed. Most of the studies have concluded that NDVI image differencing method yields highest accuracy. The main advantage of spectral change detection techniques is that they are based on the detection of physical changes between image different dates. This avoids the errors introduced in post classification change detection where inaccuracies in the land cover classification are propagated into land cover change analysis. However, the greatest challenge to the successful application of these techniques is the discrimination of “change” and “no change” pixels. For spectral change detection, an accurate image co-registration is crucial.

CHAPTER THRE

3. Materials and Methods

3.1 Description of the Study Area

3.1.1 Location

Goma woreda is found in Oromia region, Jimma zone south west of Ethiopia. It is located 390 km south west of Addis Ababa and about 50 km west of the Jimma town. It is located from7º39'43"N to 8º41'7"N latitude and 36º28'54"to 36º 39'00" E longitude. Relatively, Goma is found south of Seka Chekorsa, Southwest of Gera, Northwest of Sentema, North of the Didessa River,whichseparates it from the Illubabor Zone, Northeast of Limmu Kosa, and East of Mana woreda. The total area of the Wereda is 86731.74 ha (IPMS, 2007).

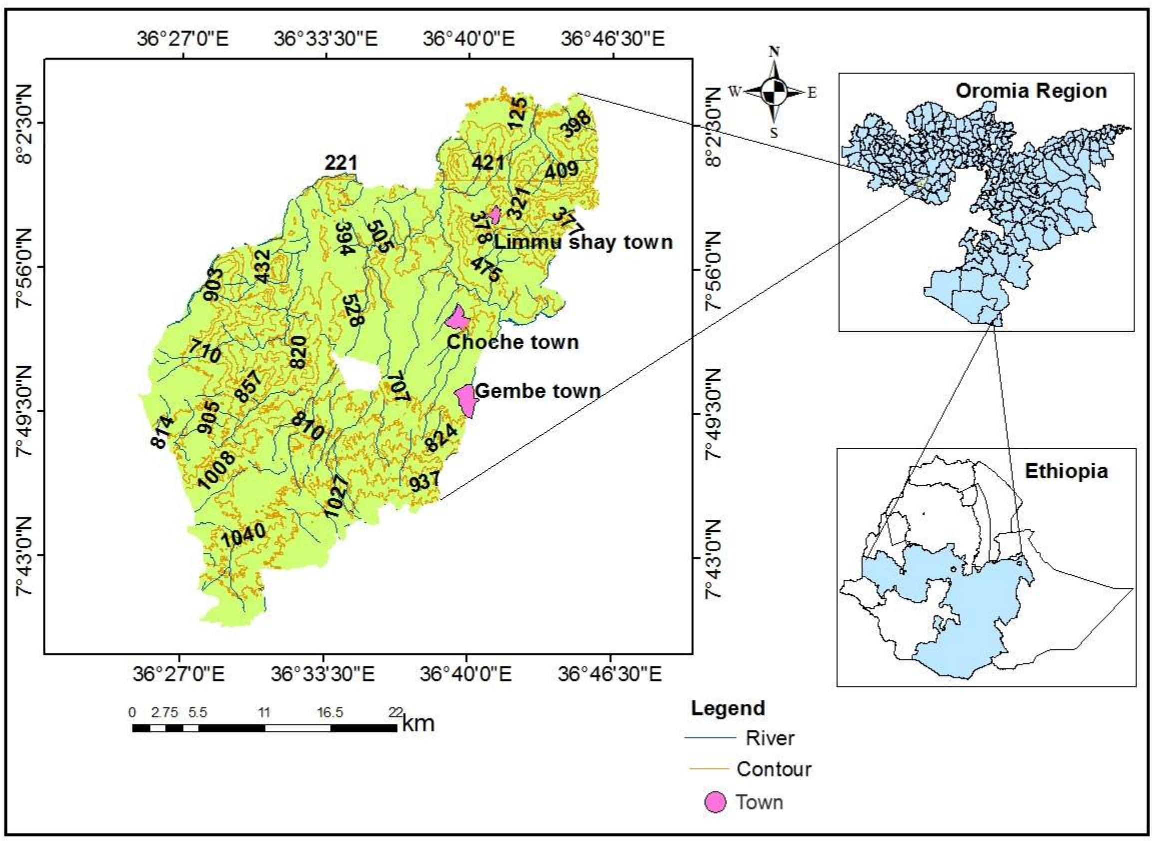

Figure 1 Location map of study area

3.1.2 Population

According to the CSA (2007) report, the total population of this woreda was 213,023, from this population 108,637 were male and 104,386 were female. From this number of population 12,769 or 5.99% was urban dwellers and the remaining population of the woreda was rural dwellers.

3.1.3 Climate and topography

The south and southwestern parts of the country receives reliable rainfall. Goma wereda is one of these areas that enjoy well distributed annual rainfall. Its average annual rainfall is 1524 mm. The annual rainfall variability of the area is very low. There are about 7 rainfall months in the woreda. The main rainy season from June to October and the small rains are from March to April. However, rainfall is sometimes received even during the other months. The average mean annual temperature of the area is 20.8ºC. Agro ecologically; Goma wereda is classified as 96% wet Weina Dega (wet midland) and 4% kolla (lowland). Altitude ranges from 1387 to 2870 meters above sea level. Most parts of the wereda lay between 1387 and 1643; and 1849 and 2067meter above sea level. However, few of the areas in the wereda have altitudes ranging from 2229 to 2870 meter above sea level (IPMS, 2007).

3.1.4 Soils

The three dominant soil types are Eutric Vertisols, Humic alisols and Humic Nitosols. Among these soil types, Nitosols is the most abundant covering about 90% of the wereda. These soils are young soils and are generally acidic soils. However, farmers grow crops that are acid tolerant. The pH of the soils in Goma ranges between 4.5 and 5.5. However, the commonly observed problem related to aluminum and magnesium toxicity as a result of low pH is minimal (GPLWDPD, 2007)

3.1.5 Vegetation

The major forest tree species in Goma Wereda include *Acacia abyssinica, Albizia gummifera, Albizia schimperiana, Brucea antidysentrica*, *Cordia africana, Croton macrostachyus, Ficus*species, *Millettia ferruginea*, *Sapium ellipticum, Syzygium guineense, Vernonia* species, and different shrubs and herbs (Regional Government of Oromia, 2003).

3.1.6 Drainage

The topography, vegetation and rainfall pattern in the Wereda encourages the existence of many perennial rivers. The rivers drain to Ghibe/Omo to the east and Dedesa River in the north. Currently there are many small rivers (Didesa, Awetu, Temsa, Colombos, Naso, Dogaja, Melkayida, Chiseche, Loga,) that have been providing an irrigational function under traditional system (ILRI, 2007).

3.2 Data and Materials

In this study, in order to execute the intended objectives Landsat TM and ETM+ satellite imageries were selected for forest cover change analysis of Goma woreda during a period of 32 years (1985-2017).The selection of landsat imagers are based on their accessibility, spatial and spectral resolutions and relevancy in order to address the intended objectives of the study**.** The main data used in this study included three Landsat satellite images for years of 1985(TM), 2001(TM) and 2017(ETM+) images were downloaded from USGS.

Table 2 Summary of sources of data and materials

Satellite images					
Sensor	Path	Raw	Resolution	Date of capture	Source
Landsat TM	170	55/54	30m	17/02/1985	USGS
Landsat TM	170	55/54	30m	05/02/2001	USGS
Landsat ETM+	170	55/54	30m	08/01/2017	USGS
Shape file					CSA
Software's and instruments					
ArcGIS 10.4					
ERDAS IMAGINE 2014					
GARMIN72 Global position systems					

3.3 Research Design

This study was employed a cross-sectional survey approach in GIS and remote sensing based analysis of forest cover change in Goma wereda. Descriptive cross-sectional study design was used to identify the major causes of deforestation in the study area. The target populations were key informants of agricultural and land administration officers, forest experts and elders from local community. The researcher also employed qualitative types of data. It was a qualitative data that the researcher gathered information about the underlying factors and the impact of forest cover change.

3.4 Method of data collection

3.4.1 Interview

In this study, for investigation three kebeles were selected randomly. The researcher was used semi structure interview to collect relevant data. Interviews were made with key informants who were purposively selected from concerned officials and elders of community representatives in order to generate reliable information. It is conducted on one to one basis between respondent and an interviewer. Accordingly seventeen (17) key informants were selected for the interview to collect qualitative data. The main purpose of conducting an interview on concerned officials is to make an in-depth investigation on the main factors and impacts of deforestation. Key informants were including Wereda administration office, Agricultural and Land administration officers, forest experts, and elders from local community and kebele leaders.

Table 3 sample respondents for interviews

No	Respondents	Number of interviewee
1	Wereda administration office	1
2	Agricultural officers	3
3	Land administration officers	3
4	Forest experts expert	1
5	elders from local community	6
6	kebele leaders	3
Total	-	17

3.4.2 Observation

Personal physical observation of the study area was made by the researcher. This helped to gather first hand primary information. Furthermore, it enhanced the validity and reliability of the collected data. Finally the data collected from, Key Informants and researcher's physical observations were analyzed qualitatively

3.4.3 Ground truth survey

From the sampled kebeles the researcher (Didessa deco, Meti koticha and Limu sapa) selected 85 reference points were randomly identified during March 2017 using Garmin72 GPS receiver instrument. In addition, photographs were taken from forest, settlement around forest, farm land and other essential information were generated, which helped to support in the identification and quantifying of forest cover change.

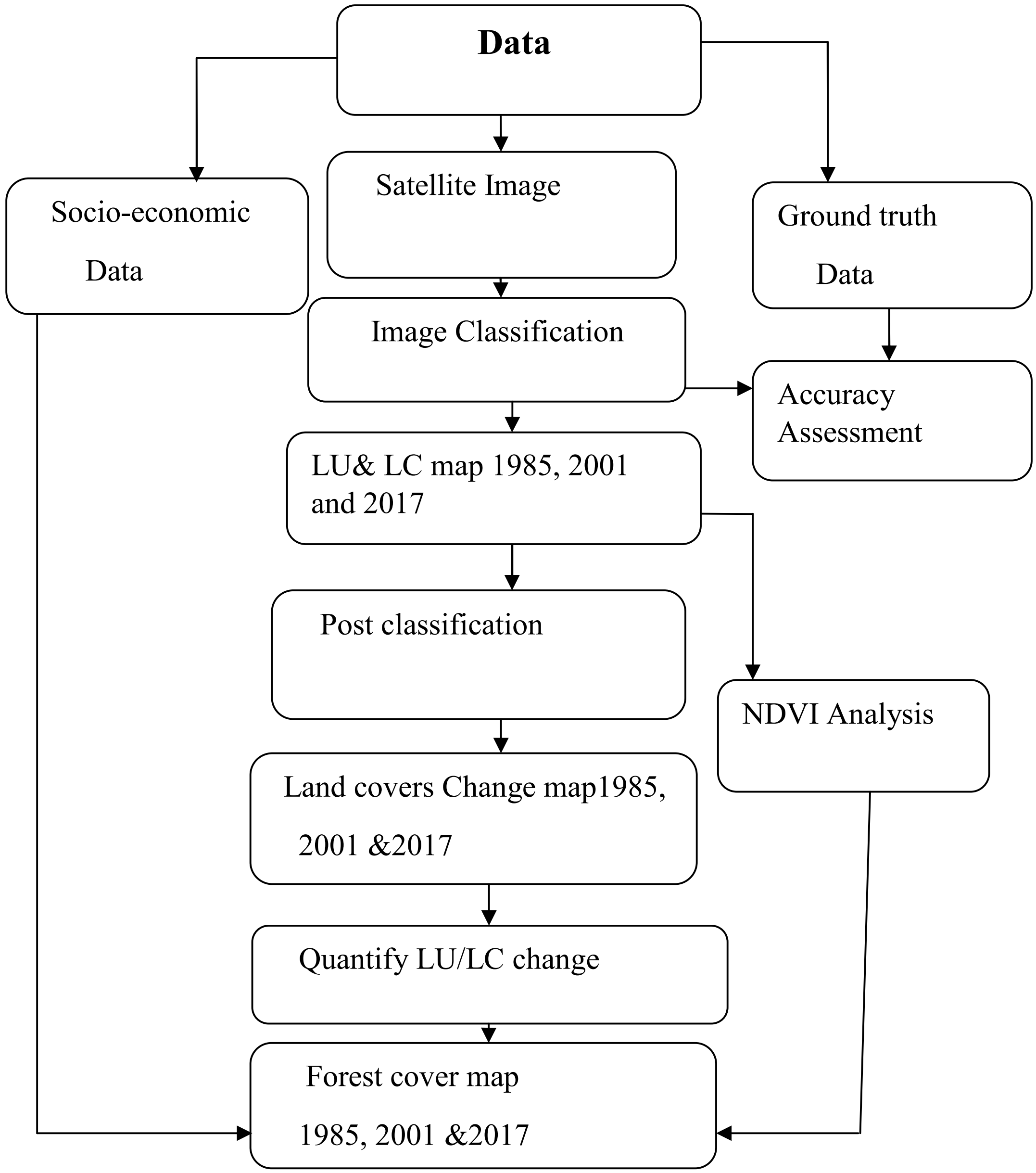

Figure 2 Methodology of flow chart

3.5 Method of data analysis

3.5.1 Supervised classification

The process of using samples of known classes (i.e. pixels already assigned to informational classes) to classify pixels of unknown classes (i.e. to assign unclassified pixels to one of the several informational classes) (Campbell, 2002).

Supervised classification is the process of using a known identity of specific sites in the remotely sensed data, which represent homogenous examples of land cover types to classify the remainder of the image. These areas are commonly referred to as training sites (Jensen, 1996).In this study, TM1985, TM2001 and ETM+ 2017 satellite image were classified under six land use land cover categories using supervised classification maximum Likelihood method based on sample training signature using ERDAS IMAGINE 2014.Training areas for the supervised classification were taken from the following land use land cover types categories were Forest, Shrub land, Farm land, Settlement, Grazing land and Fallow land. After operation of succefull classification the Landsat images, land use land cover map of 1985, 2001 and 2017 were produced.

3.5.3 Accuracy assessment

In the change detection process land use land cover classification was performed based on the supervised classification method. Evaluation of classification result was must be necessary step for testing the accuracy of classification to insure the existence of result of the reality on the ground. Kappa value was computed using the following formula.

$$K = \frac{N \sum_{i=1}^{r} xii - \sum_{i=1}^{r} (xi + \times x + i)}{\mathrm{N2} \sum_{i=1}^{r} (\mathrm{xii} \times \mathrm{x} + \mathrm{i})}$$

Where:

r =Number of rows in the error matrix;

xii= Number of observations in row I and column i;

xi+ =Total of observations in row i;

x+i =Total of observations in column i;

N =Total number of observations included in matrix.

Kappa value is the measurement of agreement between classification and reference data. As Landis and Koch(1977) indicate that kappa value ranged in to three categories .1) values greater than 0.80 represented strong agreement and good accuracy,2) these values range between 0.40 to 0.80 represented moderate agreement:3) finally these value less than 0.40 represented as poor agreement

3.5.4 Post classification change detection

In this change detection method, 1985, 2001 and 2017 land use land cover classified images were used and reclassified these land use land cover with spatial analyst of ArcGIS 10.4.1 software. Extracted the area of changes through direct comparison of the individual classified imagery and compared based on statistical data that derived from each individual images. Besides to this, land use/land cover change detection matrix had generated to examine the trends and pattern of land use/land cover change of an area as well as specifically forest cover change detection. Finally, four aspect of forest cover change detection characteristics such as detecting the change that have occurred, quantify the areal coverage of the change, assessing temporal pattern of change are investigated and maps ,table and graphical of summery statistics were produced.

The rate of forest cover change also computed using equation developed from (Berhan, 2007).

r = Q2-Q1 / t ------------------------------*Equation (2)*

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

In the mean time, from the land use/ land cover map images, 1985, 2001 and 2017 forest cover map of the study area were generated.

3.5.5 Spectral change detection methods

Spectral change detection methods are the numerical indicator, which used in the visible and near infrared electromagnetic spectrum of an image which is applied for the analysis of remotely sensed satellite images on an area and assess the presence and the absence of green live vegetation. The ratio is differenced with the division of digital number of one band by the corresponding digital number of another band of an image. Therefore, depending on the reflectance characteristics of vegetation which can be explain the healthiness and identify of the level of vegetation cover of an area. NDVI is the most common and widely applicable that used index for the forest cover change detection. The value of NDVI in vegetation change analysis is between -1 and +1. In this -1 value is indicated low vegetation content and +1value indicated high vegetation content. The NDVI is calculated from reflectance measurements in the red and near infrared (NIR) portion of the spectrum. The NDVI empirical analysis computed using the formula developed from (Berhan, 2007).

$$NDVI = \frac{NIR\ (Band\ 4 - R\ (\text{Band3})}{NIR\ (Band4 + R\ (\text{band 3})}$$

Where RNIR = the reflectance of NIR radiation and

Red = the reflectance of visible red radiation

The vegetation condition is explain with the NDVI values of -1 and +1 which is the green healthy or high amount of vegetation cover have the positive portion of NDVI values. In this study NDVI analysis was computed with Arc GIS 10.4 software and automatically calculated the Maximum, Minimum, mean and standard deviation values are derived and summarized the trend of forest cover changes of the study area**.**

3.5.6 Socio economic data analysis

Qualitative data was used in the study**.** Qualitative data was analyzed through direct writing of the answer of key informant participants based on their understanding on the cause and impact of forest cover change, narration and description of the interview.

CHAPTER FOUR

4. RESULTS AND DISCUSION

4.1 Land use land cover of Goma wereda-1985

From the TM 1985 Landsat image, land use land cover of Goma woreda was classified in to six main classes. These classes categorized in to forest, shrub land, farm land, settlement, Grazing land and fallow land. The 1985 land cover and land use map classification result indicated that 26649.99 ha (30.73%) of the study areas were covered with forest. The land use land cover percentage share of fallow land and grazing land were accounted about 21802.05 25.13% and 18394.74ha (21.2 %) of the study area respectively. Besides, to the above land cover shrub land, farmland and settlement occupied about 12645.75ha (14.6 %,) 6341.4 ha (7.3%) and 897.8 ha (1.035 %) of total land area respectively.

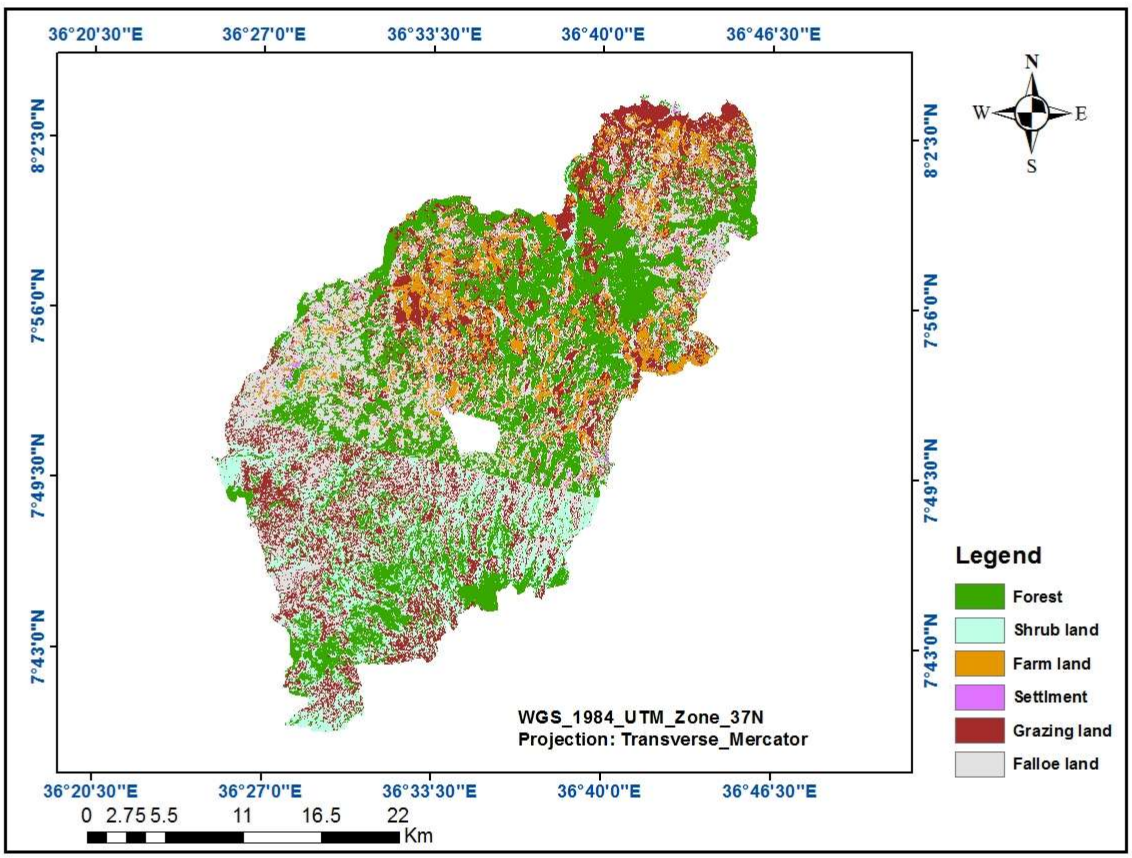

Figure 3 Land / land cover map of 1985 image

4.2 Land use land cover of Goma wereda-2001

The results extracted from land use/land cover classification of TM 2001 Landsat image shows that forest cover accounts 26062.56ha(30%)of the study area. In addition to this, the land cover of the woreda was covered with fallow land was 23062.56ha (26.6%) of total land area and 23181.57ha (26.7%) from total land area was covered under Grazing land. In addition, the remaining area of Goma woreda was occupied by shrub land, farmland and settlement that accounted 6442.02ha (7.4%), 8224.68ha (9.5%) and2428.02ha (2.79%) of Goma woreda respectively. In 2001 except forest and shrub land the remaining land use land cover classes were increase from previous year. This figure indicated the conversion of forest and shrub land in to another land use class of the area.

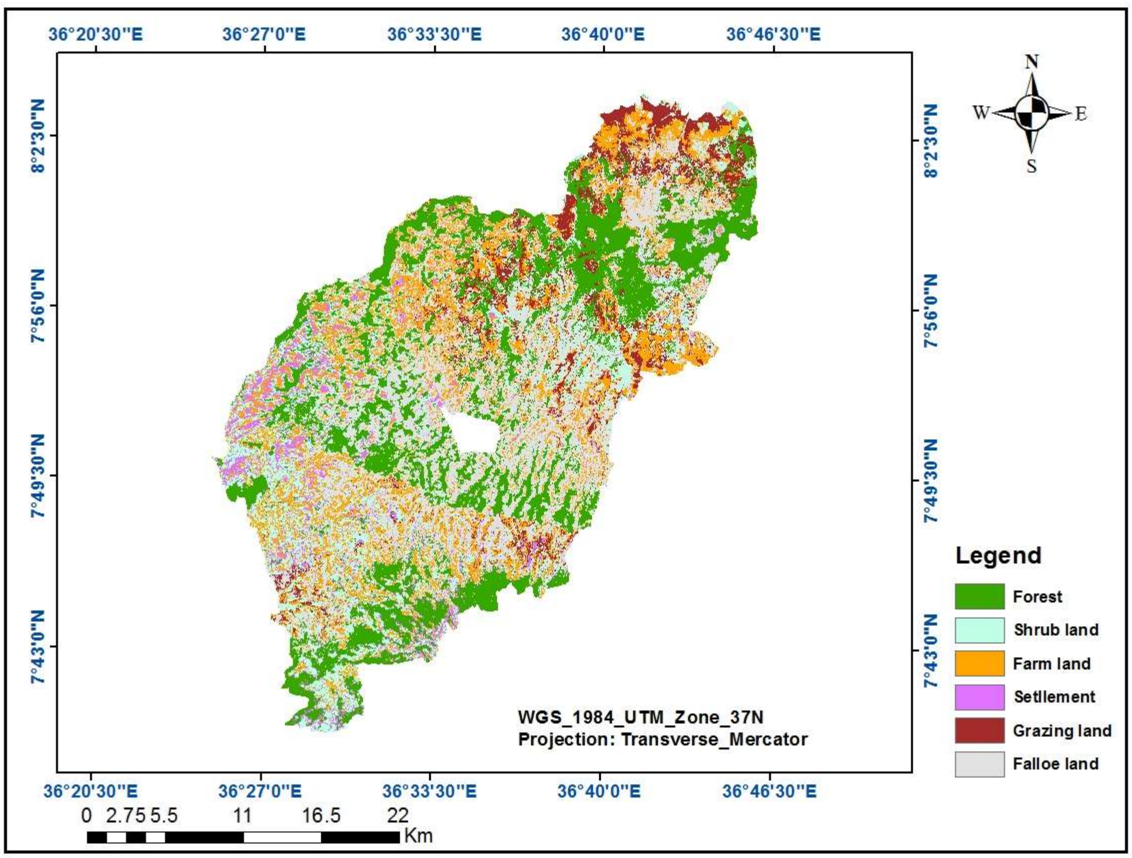

Figure 4 Land / land cover map of 2001

4.3 Land use land cover of Goma wereda- 2017

Based on the result extracted from 2017 raw land sat image shows that farm land is the dominate land use /land cover class which covered 30.78 % of the total land of the study area. At the same year 18.12%, 15.73% and 13.33 % from the total land area of the woreda was covered under shrub land, settlement and forest respectively. Besides to this, Grazing land and fallow land occupied the remaining land of the study area. Generally, based on the extracted result can be understand that farm land and settlement are increase from previous years, opposite was happened in forest area the decrease as a result of population pressure.

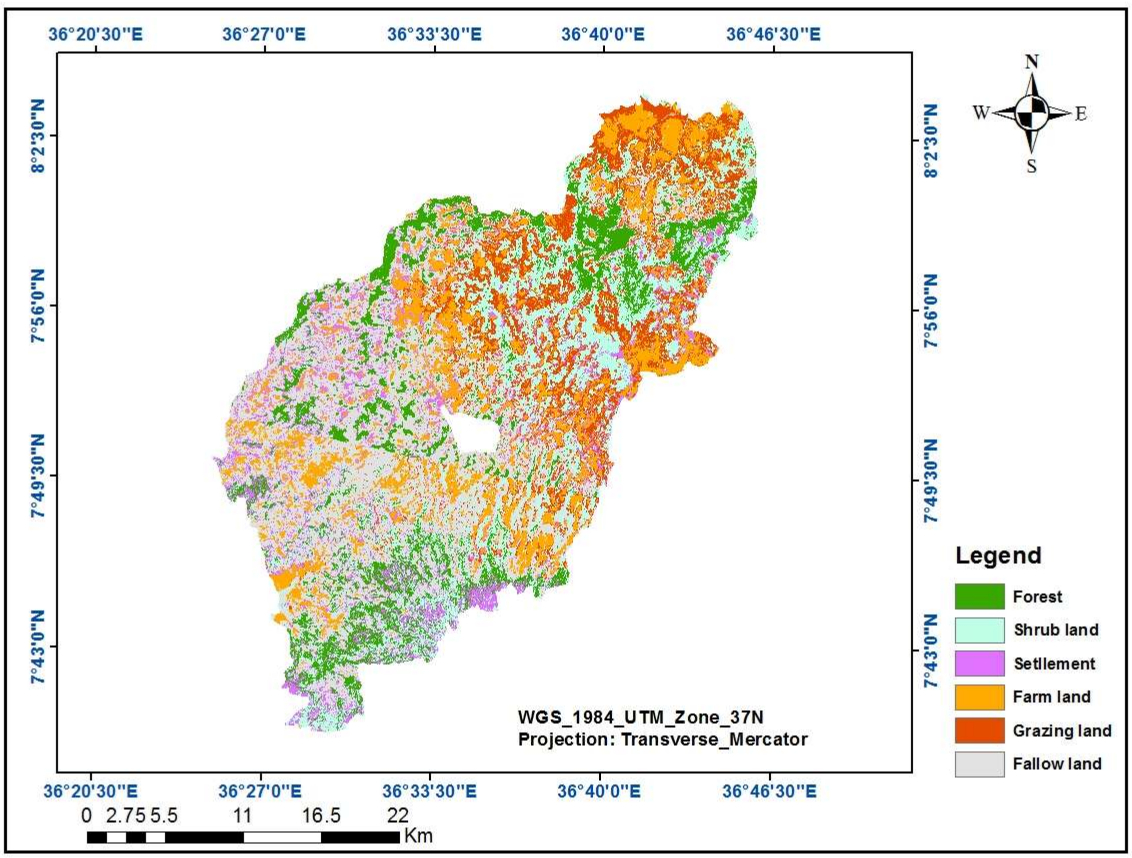

Figure 5 land use land cover map of 2017

Table 4 summery statistics of land use/cover map of 1985, 2001 and 201

LU/LC Classes	Areal coverage					
	1985		2001		2017	
	Ha	%	ha	%	ha	%
Forest	26649.99	30.73	26062.56	30%	11569.05	13.33%
Shrub land	12645.75	14.58	6442.02	7.4%	15724.26	18.12%
Farm land	6341.4	7.3	8224.68	9.5%	26700.3	30.78%
Settlement	897.8	1.035	2428.02	2.79%	13644.54	15.73%
Grazing land	18394.74	21.2	23181.57	26.7%	10811.43	12.5%
Fallow land	21802.05	25.14	23062.56	26.6%	8282.16	9.55%
Total	86731.74		86731.74	100.00	86731.74	100.00

Source: computed from satellite image classification

4.4 Accuracy assessment

The evaluation of classification accuracy it must be formulation of confusion matrix is the common means of expressing accuracy assessment. In this study, confusion matrix was generated based on the years of 2017 forest cover map and 85 ground truth data. The confusion or error matrix included the percentage which is the report of overall proportion of correctly classified pixels of data in each land cover units.

Table 2 Confusion matrix of image of 2017

Class name	Supervised Classification						
	Forest	Shrub Land	Farm Land	Settlement	Grazing Land	Fallow land	Raw total
Forest	15	1	0	0	0	0	17
Shrub land	1	9	0	0	1	1	12
Farm land	0	1	10	2	1	1	14
Settlement	1	0	3	9	0	0	13
Grazing Land	1	1	2	1	11	0	14
Fallow land	0	1	2	0	1	12	15
Column total	17	12	17	11	14	14	85

User accuracy	88%	83%	70.6%	90%	85%	85%	
Prod. accuracy	88%	83%	85.7%	76.9%	85%	80%	
Overall accuracy	83.5%						
Kappa	80.8%						

As indicated in the table overall accuracy and kappa coefficient were applied to evaluated classification accuracy assessment. Therefore, over all accuracy of the classification is 83.5% and kappa coefficients were achieved 80.8%.

4.5 Land use/ land cover change

According to (Bireda,2005) the important concept of change detection is to identify the actual changes what change to what, in another way which land cover classes changes in to another land cover classes overtime. Such types of information provides reduction and addition as well as land cover classes relatively remain unchanged with in a time period and used in management of decision.As Meshesha et al (2012) explain that both human activities and natural phenomena are the major driven forces of land use and land cover change.

4.5.1 Land use/ land cover change between 1985 an 2001

Table 3 Land use/land cover change matrix between 1985 and 2001

	Land cover categories(ha)	(1985) Initial						
		Forest	Shrub land	Farm Land	Settlement	Grazing land	Fallow land	Total
Final state 2001	Forest	5637.6	1699.4	2938	16.38	379.5	979.02	26649.99
	Shrub land	4761.4	2496.4	2298.7	137	1428.4	1523.79	12645.72
	Farm land	958	133.6	14.3	1028	415.6	3791.52	6341.4
	Settlement	285.7	53.3	7.74	79.4	130.4	341.1	897.54
	Grazing land	4864.7	1618.9	746	493.9	880.7	9790.56	18394.74
	Fallow land	9555.3	2391.3	437	672.8	1989.8	6755.58	21802.05
	Total	26062.6	23392.9	8224.7	2428	5223.6	23181.57	

Source, computed from reclassified image of 1985 &2001

In the land use and land cover change matrix indicated there is conversion of land use /land cover to another land use/ land cover types. Between 1985and 2001 the highest changes were observed which forest to farm land 2938ha and shrub land1699.4, shrub land to farmland, farm land to fallow land3791.52ha, Grazing land to forest4864.7ha and fallow land9790.56ha and fallow land to forest9555.3ha and shrub land2391.3ha as well as 1989.8ha was convert in to Grazing land.

4.5.2 Land use/ land cover change between 2001 an 2017

Table 4 Land use/land cover change matrix between 2001 and 2017

	Class	2001						
		Forest	Shrub land	Farm Land	Settlement	Grazing land	Fallow land	Class total
		Ha	ha	ha	ha	ha	ha	
2017	Forest	**268.**	3961.2	3830.5	1573.2	2747.2	13682.5	26062.56
	Shrub land	9602.82	**6516.6**	1758.9	53.55	113	5347.71	23392.89
	Farm land	1673.55	3259.6	**741.7**	3.96	12.2	751.14	8224.68
	Settlement	0	0.45	36.5	**2267.2**	122	1.98	2426.04
	Grazing land	20.52	844.7	1585.2	1288.4	**55**	1430.91	5224.68
	Fallow land	4.14	1141.7	329.5	8458.3	7761.9	**5486.04**	23181.57
	Class total	11569.05	15724.3	8282.2	13644.5	10811	26700.3	

Source, computed from reclassified image of 2001 &2017

Note: the number of the class totals in raw shows the final state (2017) and the class total in column Indicate the initial state (2001). The diagonal also indicate land of class remain unchanged.

Between 2001 and 2017 3961.2 ha, 3830.5ha, 1573.2ha, 2747.2ha and13682.5 ha of forest area convert in to shrub land, farm land, settlement, Grazing land and fallow land respectively. 9602.82ha and 5347.71ha of shrub land change in to forest and fallow land. In addition to this, 3259.6ha of farmland in to shrub land, 1585.2ha of grazing land in to farmland was among highest land use and land cover changes of the study period.

4.5.3 Land use/ land cover change between 2001 an 2017

Table 5 Land use/land cover change matrix between 1985 and 2017

	Land cover Types	(1985) Initial						
		Forest	Shrub land	Farm Land	Settlement	Grazing land	Fallow land	Class total
2017	Forest	**9374**	8595.8	1945.44	114.7	920.9	5699.3	26649.99
	Shrub land	911.5	**3105**	1887.93	822.7	427.7	5490.9	12645.72
	Farm land	31.8	267.4	**374.85**	3365	1746.7	555.7	6341.43
	Settlement	10.4	61.3	161.91	**316**	183.7	164.6	897.84
	Grazing land	653	1686	1575	4308.4	**4270**	5901.8	18394.74
	Fallow land	588	2008.4	2337.03	4717.7	3262	**8888**	21802.05
	Class total	11569	15724.3	8282.16	13644.5	10811.5	26700.3	

Source, computed from reclassified image of 1985 &2017

Note: the number of the class total shows the final state (1985) and the class total in column the initial state (2017). The diagonal also indicate land of class remain unchanged.

In the first period between 1985 and 2017 the highest percentage of forest area was converted in fallow in by 5699.3ha, Shrub land with 8595.8ha and 1945.44ha in to farm land. Shrub lands also converted in to fallow land and farmland in the amount of1945.44ha and 1887.93ha respectively. 5901.8ha and 4308.4 ha of Grazing land changes in to fallow land and settlement respectively. Besides to this, 4717.7ha, 3262ha, 2337.03ha and2008.4ha of fallow land changed in to settlement, grazing land, Farm Land and Shrub land respectively.

4.5.4 Detected land use/land cover change by post classification between1985 and 2017

Table 6 Summery on the existed land use land cover change of Goma wereda 1985-2017

LC classes	Year			LU/LC change		
	1985	2001	2017	1985-2001	2001-2017	1985-2017
	Ha	Ha	ha	ha	ha	ha
Forest	26650	26062.6	11569	-587.4	-11493.5	-15080.9
Shrub land	12645.8	6442	15724.3	+10747.2	-7668.6	+3078.5
Farmland	6341.4	8224.7	26700.3	+100.6	+1840.4	+1940.7
Settlement	897.8	2428	13644.5	+1530.5	+11218.5	+12746.7
Grass land	18394.7	23181.6	10811.4	-13171	+5586.8	-7583
Fallow land	21802.05	23062.6	8282.2	+1379.5	+3518.8	+4897.9

Source: computed from confusion matrix table of 1985-2001, 2001-2017 and 1985-2017

N.B: -ve indicate decrease

+ve indicate increase

4.5.5 Farm Land

Areal coverage of farm land was consisted 6341.4ha and 8224.68 ha and 8282.16ha in the years of 1985 2001 and 2017 respectively. An increasing trend of farm land in the Goma wereda similar with finding of Zeleke (2005) in Fincha valley of east wellega and also there is an increasing trend indicated in the same year finding of Solomon (2005) in the headstream of Abay watershed.

In the first period of interval between 1985 and 2001 farm land increase by 100.62 hectars the same is true between 2001 and 2017 it was increased by 1840.7ha and also increased by increasing rate 1940.7ha between 1985 and 2017 respectively. Beyond the increasing trend there is also the conversion form land in to another land cover classes, proportionally in the first period of the study between 1985 and 2001 about 3791.52ha of farm land was converted in to the fallow land and 1028.43ha also converted in to settlement. Between 2001 and 2017 3259.53ha was converted in to shrub land and 1673.55ha in to forest land.

4.5.6 Grazing land

In the period of 32 years, 18394.74 ha of total land area of Goma wereda is occupied with grazing land in the base year of 1985 of this study. 1n 2001 this land use land cover categories were decreased in to5223.59 ha which decreased dramatically by 13171.2ha between 1985 and 2001 years respectively. This indicated that there is a conversion of grazing land and in to farm land and settlement area due to high rate of population growth. Opposite to the first result grazing land was increased from 5224.68 ha to 10811.68ha between 2001and 2017 by 5586.75 respectively. In this finding agree with the finding of Bireda (2005) in Fagita Lekoma wereda, Awi Zone, North Western Ethiopia, Gete and Hurni (2001), Solomon (2005), revealed an increased trend of grazing land in both Anjeni area and head stream of Abay Watershed respectively, both in northwest Ethiopia.

4.5.7 Fallow Land

Fallow land constituted 21802.05ha, 23181.57ha and 26700.3 ha in the years of 1985, 2001 and 2017 respectively. The predominance of fallow land in the study area was similar with the finding of Netsanet (2007) in the first period of his study between 1973 and 1986 in Herena forest and srounding area, Bale Mountains of national park and also this result completely agree with finding of Alelign (2009) and Daniel and salami (2007) in over all year increasing of fallow land in Borena District in North central Ethiopia and in part of south western Nigeria.. In the first period of his study, between 1985 and 2001 fallow land increased by 1379.52 ha. Besides to this, in the second period of wereda between 2001 and 2107 it was increased by3518.73 ha.

4.5.8 Settlement

The total area under settlement was the smallest among land cover types of the area which constituted about 897.54ha and 2428ha in the years of 1985 and 2001 respectively. In 2017 it was increased in to 13644.54ha. In recent years settlement is among the dominance land use land cover classes of the area which highly increased land cover types next to farm land during the study period. This increased pattern was similar and agrees with finding of Mengistu, *et al.,* (2013) in Munessa-Shashemane landscape of the

Ethiopian highland. The large conversion of fallow land, forest area and Grazing land was contributed for increasing trends of settlement by 8458.3ha, 1573.2ha and1288ha respectively.

4.5.9 Shrub land

The areal extent of shrub land was constitute 12645.8 ha, 6442ha and 15724.3ha in the years of 1985, 2001 and 2017 respectively. This figure reveals that shrub land was increased by10747.2ha between 1985 and 2001, but it was decreased (-7668.6ha) between 2001 and 2017, because of higher conversion of shrub land in to fallow land and farm land that accounted 5347.7 ha and 1758.8 ha respectively. This finding similar with the study of Oumar (2009) shows that shrub land decreased 9% in 1973 to 6% in 1985, in A cooperative study from Kuhar Michael and Linche Dima of Blue Nile and A wash basins of Ethiopia and also agree with finding of Emias, *et al,* .(2012)in the source region of the upper Blue Nile Ethiopia.

4.6 Forest cover analysis

In order to determine forest land of an area that subjected to various changes extracted from forest the land use land cover maps which required extracted polygons represented the forest areas in each year of images. This was done by converting the classified forest area raster in to vector.

The main focus of the present study was relay on perspective of spatial and temporal distribution, historical pattern, past and current ongoing process of deforestation of Goma wereda. Based on different data types and sources with integrated of different methodological approach and application of various tools that attempted to described the magnitude of forest change and identifying the major underlying factor of deforestation as well provide tangible picture of past and current situation of forest resource of the study area through map, and quantitative and qualitative statistical results

The land use land cover matrix shows that the pattern of forest area was decreased from 26649.99 ha to 26602.56 ha between the year of 1985 and 2001 as well as it was diminished in to 11569.05 ha in 2017 in the study area respectively. This figure indicated the decline of forest area by 587.8 ha and 11493.5 ha in interval of the 16 years. This is

Agree with study of Bireda (2005) in Fagita Lekoma wereda, Awi Zone, North Western Ethiopia between the year of 1973 and 2015.

Between the year of 1985 and 2001 2938.05 ha was changed in to farm land and 1699.41ha in to shrub land. The significance change was occurred in the second period of the study there was large amount forest converted in to all land cover class, 3961.17ha in to shrub land, 3830.49h farm land, 1573.2ha settlement, 2747.16ha in to Grazing land and13682.5ha in to fallow land.

Between 1985 and 2017 among land cover classes largest proportion of forest was converted in to shrub land and farm land in 2938ha and 8595.8ha respectively, similar with the finding of Abyot, *et al*,.(2014) in Banja District, Amhara region, Ethiopia.

4.6.1 Forest cover distribution

Forest cover change analysis was done with integration of GIS and remote sensing techniques as well as field survey to identify major factors responsible for the forest cover change of the area. In this study, 32 years coverage of three raw land sat image were used in time sequences as input for the detection of the spatial pattern and rate of forest cover change. During analysis stage, digital image interpretation of an area for each year was performed and its areal extent for each year ware computed and summarized in table form as well as expressed in units of hectares and percent.

Table 7 Land use/land cover change matrix between 1985 and 2017

Years	Forest coverage (ha)	Forest coverage (%)
1985	26649.99	30.73
2001	26062.56	30
2017	11569.05	13.33

From this result, about 26649.99ha (30.73%) of the district were covered with forest resource in the year 1985. Meanwhile, the forest cover land of the district was accounted for 26062.56 ha (30%) and11569.05 ha (13.3) in the year 2001 and 2017 respectively. The percentage share of each year forest cover value was at diminishing trend

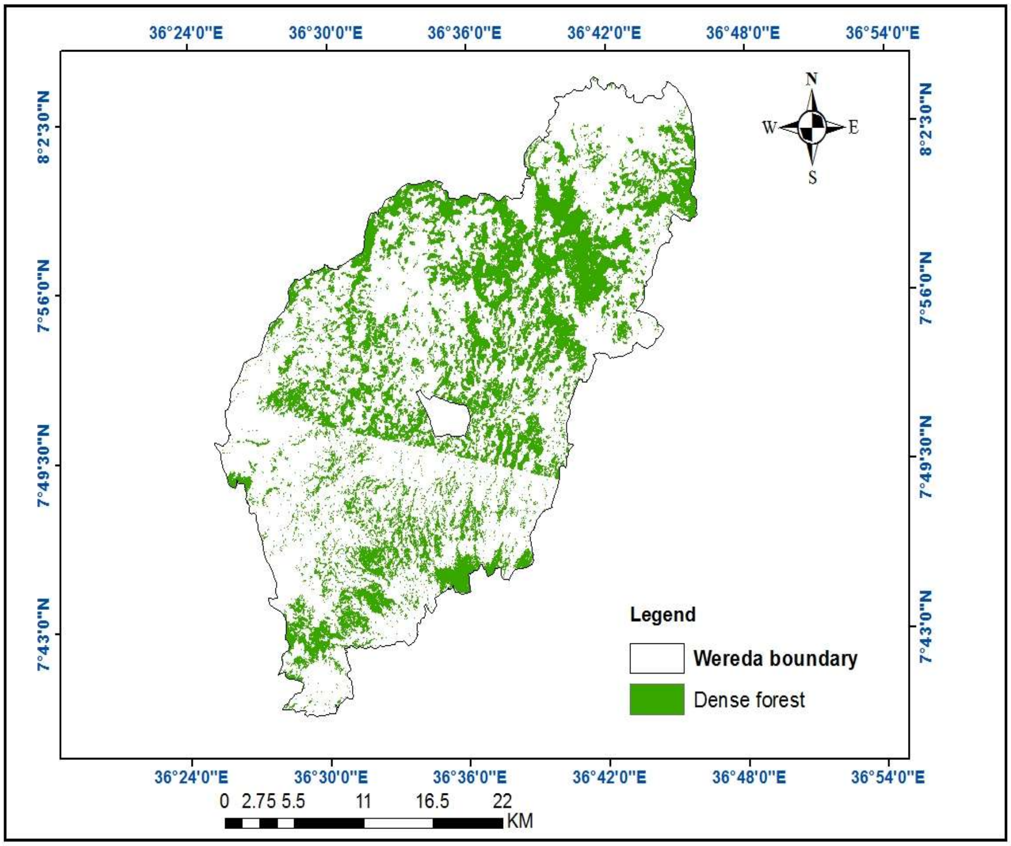

Figure 6 forest cover map of 1985

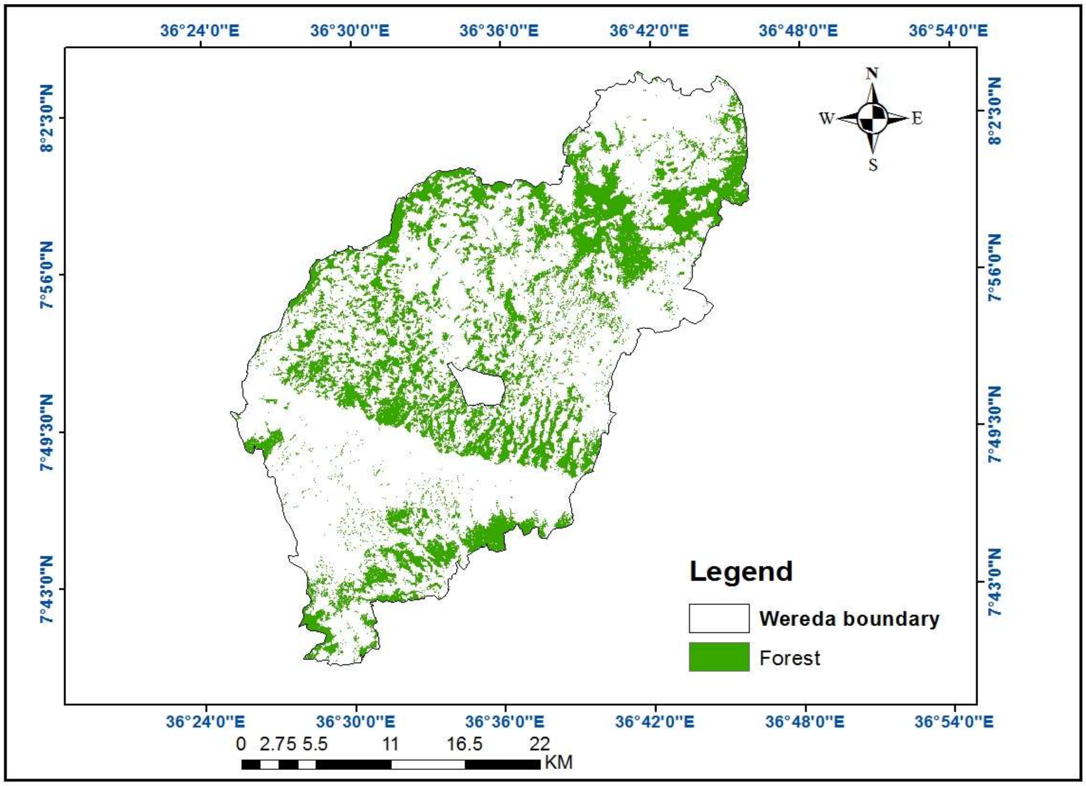

Figure **7**forest cover map of 2001

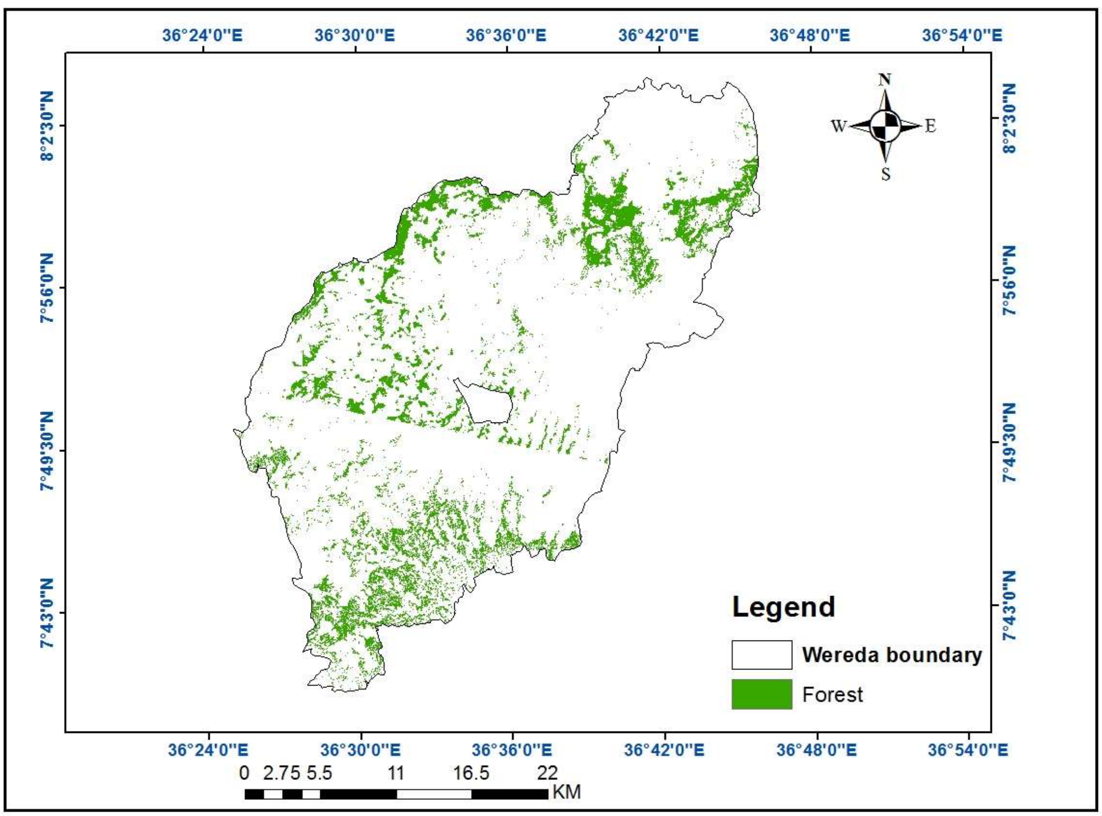

Figure **8**Forest cover map of 201

4.6.2 Rate of forest cover change of study area

Table 8summary on rate of forest cover change

Cover class	Year			Rate of change		
	1985	2001	2017	2001-1985	2017-2001	2017-1985
Forest loss(ha)	26649.99	26062.56	11569.05	-36.7	-905.8	-471.27

Source: computed from table 10

According to Workaferahu (2015) stated between 1973 to 2015 there high rate of deforestation in his case study of Masha wereda, sheka Zone, SNNPRS, Ethiopia. In this study the computed result (table 11) indicates that the average rate of forest cover change from year 2001 to 1985 is -36.7ha per year (26062.56ha-26649.99 ha / 16 years) and from year 2001to 2017, it was reduced by -905.8ha annually (.11569.05ha - 26062.56ha/ 16 years). Besides, considering the annual rate of forest cover change between1985 and 2017, that indicated in the computed result is forest resource was reduced by the 471.27 ha per year (11569.05ha-26649.99ha/32 years).Accordingly, the result which stated above the forest resources of the area was decreased throughout the study period decreased with increasing rate, the same finding of Meseret(2009) in Adaba-Dodola forest priority area, between 1986-2000,2000-2005 and 1986-2005 forest declined by the rate of 0.70,0.38 and 0.57 % per year respectively.

4.7 Normalized Difference vegetation index comparison method

In order to obtain the general over view of forest ecosystem change, NDVI analysis method was employed based on land sat image of 1985, 2001 and 2017 classification statistics. Based on these land sat imageries, computed NDVI values for each individual years to understand forest ecosystem of the study area between these years and compare the NDVI values that possible to determine the forest cover change of Goma woreda.

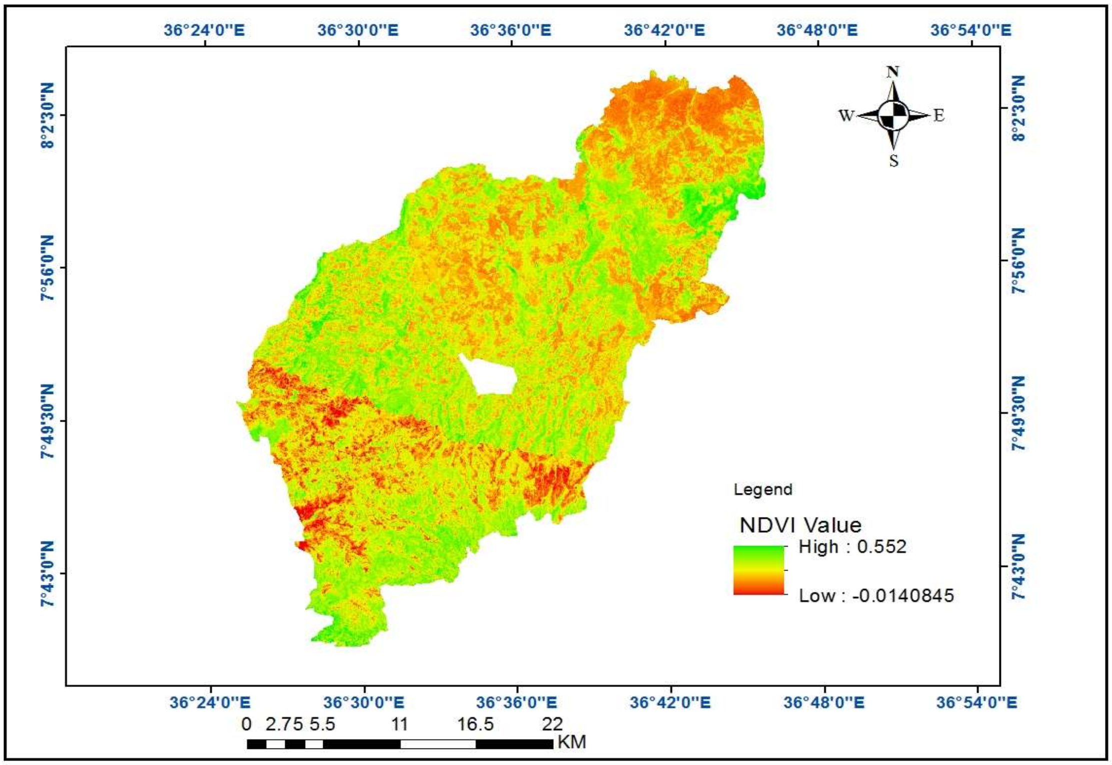

Figure 9NDVI map of 1985

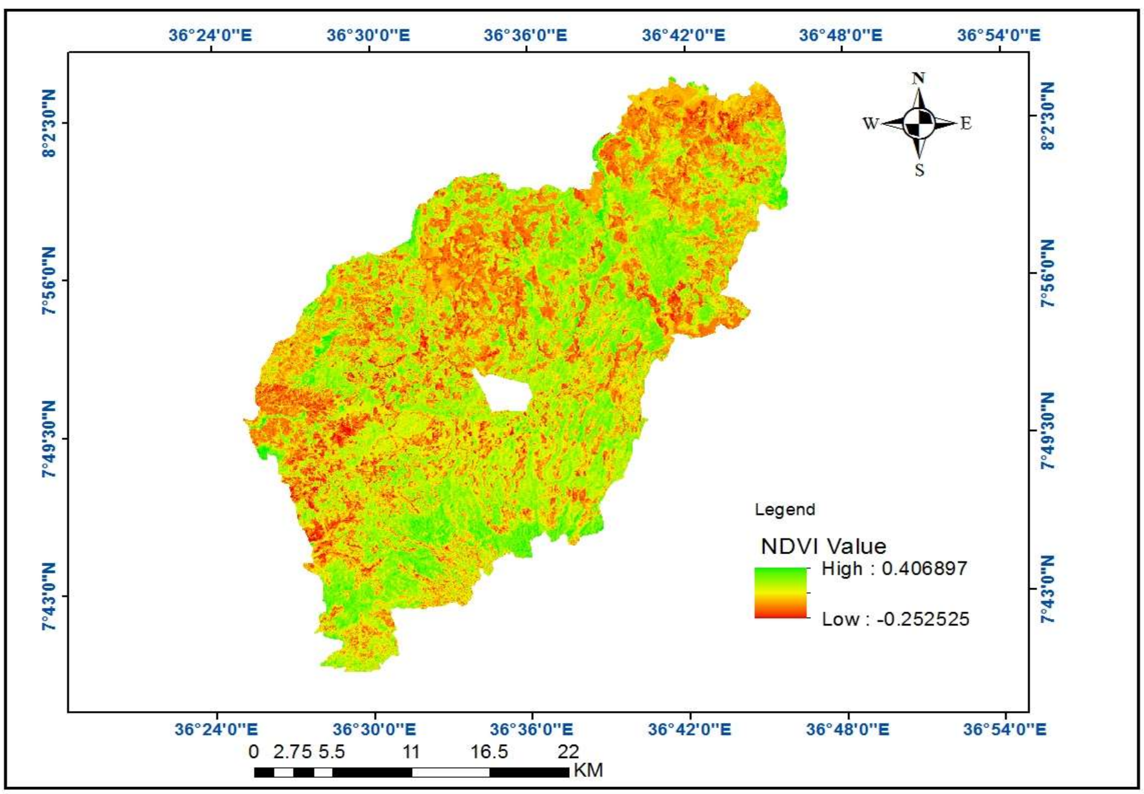

Figure 10NDVI Map of 2001

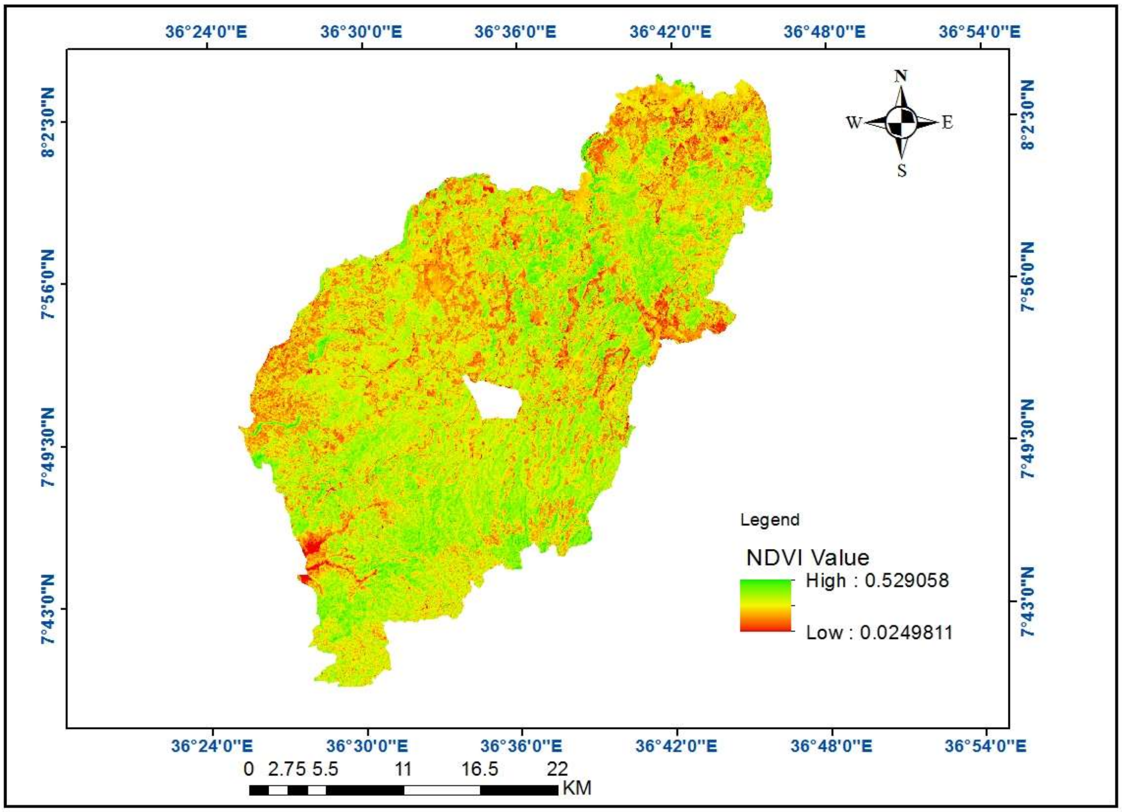

Figure 11 NDVI Map of 2017

Table 9summary statistics NDVI analysis

Years	NDVI value			
	Max	Min	Mean	Standard deviation
1985	0.55	-0.014	0.27	0.76
2001	0.53	-0.25	0.28	0.65
2017	0.407	-0.25	0.38	0.11

Source: computed from arc GIS soft ware

The result that in table 11 above shows the NDVI values of each year's indicated the decreasing trends of NDV value 0.55 to 0.53 and 0.407 for 1985, 2001 and 2017 respectively. This statistical value indicated the decreasing of the amount of green vegetation.

4.8 Major causes of deforestation

Forests are free and useful natural resources of the earth surface and the major victim over exploitation for survival and Scio economic developmental activities of human being .The forest cover change is the results of different factors that deteriorates the potential of forest coverage of an area, which leading to reduction of its Productivity to support the habitat of the earth's surfaces.

There were various human made underlying factors responsible for the causes of the conversion of forest cover of an area in to other land use/land cover purposes in Goma wereda. Generally, in this study the factors were grouped in to population growth, expansion of agricultural land, fire wood and charcoal production, cutting of tree for constructional material, expansion of settlement area. Similarly, in terms of driving forces on the process which responsible for the reduction of forest ecosystem was aggravated due to highest population growth and its resultant like expansion of farmland, fire wood consumption and demand for constructional materials and expansion of residential area. Also another studies which conduct their findings apart from change detection and they identify anthropogenic forces were the major factors for forest declined (Berhan, 2007, Meseret, 2009).

4.8.1 Population growth

According to Frimpong (2011) the declined of forest cover was caused by over consumption by higher rate of population growth, indicated in his case study of Owabi catchment in Kumasi, Gahana, from 1984 to 2002 and 2002 to 2007 forest decreased by annual rate of 24.7% and 24.2% respectively. Goma woreda is located in the area of favorable climatic condition with fertile soil of south west of Ethiopia. As central statistical agency senesces report indicated the population of the woreda was increased from 213023 in 1994 to 343376 in 2007.In the study area higher population growth is the main underlying factors for forest cover change. In the key informants data indicate that population growth is leading to increase in the demands in forest products such as fuel wood for energy consumption, materials for house building and furniture work. The finding of Reusing (2000) stated in Ethiopia forest degradation is directly related with the ongoing population growth which leads to an increasing of demand on land for living and crop cultivation, especially the situation more severe resulted large number of people move in south west of the country due to organized resettlement programs. Consequently the pressure on the forest resource due to increased higher demand of fuel wood and timber production.

4.8.2 Expansion of agricultural land

As Abyot *et al* (2014) stated that based on image classification and respondent the forest area declining was resulted due to conversion of forest area in to agricultural land. In addition to this Badege (2001) also states that Deforestation was occurred due to expansion of small level agriculture through removal of natural forest land. In previous discussion in chapter three the study area has favorable agro ecological condition agricultural activities due to well distribution rain fall and fertile soils. In addition to this, about 94% of the population was rural dwellers as well as agriculture is the major economic activities of population of the study area. Crop production is the main production system that supports livelihoods of Goma woreda.

According to the result that indicated in table (4, and 4.1) there is increasing of farm lands between 1985 and 2017 which increased from 8224.68 ha to 26700.78ha respectively. Therefore, the increased trend of farm land indicated that there is the conversion of other land use land cover units in to farm lands. Besides to this, as the response of key informants the uncontrolled expansion of farm land was the leading causes of forest cover change in the Goma woreda.

4.8.3 Fire wood

According to Warner A. Kruz in (2010) stated that included in literature part in Ethiopia the major sources of household energy supply is comes from fuel wood that covered 90% of it for house hold cooking purpose that derived from biomass fuel and 78% of it comes from fire wood. In the previous section that discussed the majority of population are rural dwellers, according to respondents view the energy sources of the population of the study area was highly depended on fire wood for cocking purpose. In addition the argue fire wood consumption was the causes of forest cover change of the study area.

4.8.4 Cutting trees for constructional materials and timber production

According to key informant and field observation data indicated that forest biomass are the main sources of houses and fence construction and production of goods. This demand of forest biomass for construction is increased the deterioration of forest resources. The view of respondents that cutting of trees for construction purpose is responsible for the forest cover change of the study area. Currently, the national and regional government in creation of youth job opportunity campaign program of in the surrounding and small towns of the study area, which increased the demands for timber raw material as well as increase the cost of timber the accelerate the removal of trees without any replacement.

Photograph, from field survey

4.8.5 Expansion of residential area

Expansion of settlement area was the result of population growth and it is the major factor for the forest cover change of the study area. As the statistical data depicted in table (1, 3) above and as well as key informants and field observation data indicated settlement area has increased from 897.8 ha to 13644.54ha between 1985 and 2017 respectively.

4.9 Impacts of deforestation

Throughout human history peoples are highly depend on forest resources for socio economic and environmental services. Forests area provides different products and services such as raw material for housing, source of fuel wood and soil conservation services. However, beyond their importance people negatively threaten as result of higher population growth leading to higher demand of forest product for fuel wood, constructional material, and timber production farm land. There are different environmental problems in Goma wereda which consequences of forest cover change such as land degradation, soil erosion and loss of biodiversity.

4.9.1 Land Degradation

.According to Angelsen, A and Kaimowitz, D (1999) stated the decline of forest of an area resulted for the environmental degradation and loss of biodiversity. Land degradation is the declining of biological productivity of land due to unwise and over exploitation of land use such as cultivation, deforestation, and overgrazing, as well as poor land management. As the explanation of agricultural officers argue that the removal of vegetation cover major causes for land degradation which resulted due to loss of minerals and decline of organic matter of the area. Land degradation accelerates soil erosion, Goma wereda receives high amount of year round rain fall which the mountainous part of the area affect by soil erosion.

4.9.2 Loss of biodiversity

Biodiversity is a contraction of "biological diversity" and refers to the number, variety and variability of living organisms. The study area has suitable agro ecological condition and high amount of year round rain fall which make the owner of different tree species include *Albizia lebbeck, Milita ferruginea*, *Juniperus procera (*remenants*) Cordia africana, Croton macrostachys, Acacia* spp*.,Podocarpus gracilior*, Tikur enchet, Bosoka (Geteme/a). However, the highest population pressure, natural resources (vegetation, wildlife and soils) are depleting mainly due to expansion of cropland (Oromia, 2003). Due to cutting of tree highly affect the bio diversity of the area. According to the response key informant of the area, the higher population growth that increases the demand of construction materials, fuel wood that resulted for over exploitation of forest leading to loss of biodiversity.

CHAPTER FIVE

5. CONCLUSION AND RECOMMEDATION

5.1 Conclusion

Analyze the forest cover deals with the assessment of the rate of spatial and temporal forest cover change of a particular area under investigation. Therefore in this study, depending on these concepts tries to analyze areal extent, temporal variation and the rate of forest cover change of Goma woreda between the years of 1985 and 2017.Goma woreda is composed of six land use land cover types, forest, shrub land, farmland, settlement, grazing land and fallow land.

The analysis and the result part indicate there is a variation of areal extent of the land use and land cover types from the years of 1985 to 2017.particularly, farm land and settlement are increasing from time to time. Now days the forest coverage Goma woreda was decreased due to expansion of farm land and settlement because of higher population pressure. According to statistical evidence the indicated in the result part, in 1985 the total area of forest was covered 30.7% of total land area of the study area. Besides to this, in 2001 total forest land was decreased in to 30% and the large portion of forest cover change was observed in the years between 2001 and 2017 from 30% reduced to 13.3 % respectively. In addition to this, field observation and key informant respondent data indicated that forest was the main victim of human activities due to population pressure and its resultant such as expansion of farm land and residential area, demand of constructional materials, fire wood and timber production. There are different environmental problems in the study area which consequences of forest cover change such as land degradation, soil erosion and loss of biodiversity.

5.2 Recommendation

The application of GIS and remote sensing technologies in the field of forest resource which create better performance in the management and monitoring of deforestation and forest degradation. As indicated in the result section of the study, the forest resource of the study area was reduced during the study period. Therefore, in order to reduced the rate of deforestation and further disturbance and to provide ideas that used as input on the sustainable use of resources and for remedial actions the researcher forwarded some suggestions for National, regional and local government bodies and community.

As discussed previously agricultural land expansion was the major factors for the forest cover change of the study area. Therefore, the implementation of different technological inputs are required in the agricultural sector such as improved and selected crop verities, modern and traditional fertilizer which increased the crop production in small plot of land instead of the expansion of agricultural land.

The energy consumption of the rural population of the study area was highly dependent on the fire wood comes from forest biomass that speed up the huge clearance of forest ecosystem of the study area. Because of this, in order to save these forest resources must be adapted alternative energy sources such as energy save cooking stoves.

In the study area population growth is major sources of forest degradation. In order to protect the forest in particular as well as natural resources as general from the impact of population pressure national and regional government as well as nongovernmental organization play their role on the implementation of family planning awareness.

In the process of forest protection campaign awareness creation was necessary for the local people that live surrounding of forest resource on the wisely using of forest as well as natural resource in general and on the impact of deforestation.

Give continues training for the local population on the alternative environmental friendly agricultural production system such honey product

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Appendix I

Image interpretation and classification ground control points

No	x	y	Land use/land cover class
1	245917	889300	Farm land
2	246377	889309	Farm land
3	246489	889397	Farm land
4	246800	889681	Farm land
5	246875	889757	Farm land
6	246892	889852	Farm land
7	246657	889991	Farm land
8	246596	889986	Farm land
9	246493	890041	Farm land
10	246023	888142	Farm land
11	246158	887969	Farm land
12	244578	891083	Farm land
13	244811	891046	Farm land
14	244939	890722	Farm land
15	247547	890073	Settlement
16	244739	891008	Settlement
17	244768	890885	Settlement
18	244665	890812	Settlement
19	249367	888880	Settlement
20	249136	888744	Settlement
21	244675	884504	Settlement
22	245447	882057	Settlement
23	245335	882005	Settlement
24	245302	881878	Settlement
25	241919	873551	Settlement
26	246107	889639	settlement
27	246146	887160	Settlement

28	245559	887835	Forest
29	245415	888716	Forest
30	245154	887922	Forest
31	245559	892593	Forest
32	247101	892360	Forest
33	246909	892130	Forest
34	245780	892429	Forest
35	246792	892221	Forest
36	24700	892168	Forest
37	247253	891935	Forest
38	247564	892004	Forest
39	247466	891942	Forest
40	247427	891854	Forest
41	247465	891774	Forest
42	246866	892005	Forest
43	246635	892000	Forest
44	246583	892221	Forest
45	246247	892454	Grazing land
46	245971	889990	Grazing land
47	246194	890623	Grazing land
48	246479	890904	Grazing land
49	2466828	891154	Grazing land
50	2471970	891323	Grazing land
51	246164	891647	Grazing land
52	246126	891126	Grazing land
53	246151	889553	Grazing land
54	246387	889790	Grazing land
55	246152	889122	Grazing land
56	246136	886707	Grazing land
57	245475	889920	Grazing land

58	245387	889920	Grazing land
59	245325	890659	Fallow land
60	246874	889920	Fallow land
61	246707	890139	Fallow land
62	246877	890033	Fallow land
63	247102	889311	Fallow land
64	247914	890033	Fallow land
65	245935	890878	Fallow land
66	245935	890885	Fallow land
67	245935	889705	Fallow land
68	245935	884737	Fallow land
69	245935	884643	Fallow land
70	245935	884388	Fallow land
71	245935	884703	Fallow land
72	245935	883572	Fallow land
73	245935	883668	Fallow land
74	244639	891233	Shrub land
75	244578	891083	Shrub land
76	244811	891046	Shrub land
77	244939	890722	Shrub land
78	245325	890659	Shrub land
79	246874	889920	Shrub land
70	246707	889920	Shrub land
81	246877	889920	Shrub land
82	247102	889920	Shrub land
83	247914	889920	Shrub land
84	245935	889920	Shrub land
85	245995	889920	Shrub land

Appendix II

Key informant Interview questions on the investigation of the trends and causes of forest cover change in Goma Woreda.

1. What are the major uses of forests for the local people?

2. How do you understand the pressure of population growth on forest resources of the area?

4. How do you do compares the forest when compared to the conditions before 1985?

   A. Declined (thinned)

   B. Increased

   C. No change

5.Do you think there is land use change in the area today?

6. Do you think there is deforestation in the area currently?

7. If the answer for question number '5' is yes, what were/ are the major causes of deforestation?

A. Cultivated land expansion _________ B. Cutting trees for fire wood _____

C. For charcoal production____________ D. for additional grazing lands ___

E. Cutting of trees for house and fens construction------ f. Wild fire ______

G. Cutting trees for timber production.___

8. What is the major source of energy in the area?

1. Forest trees
2. Crop residue
3. Cow Dung
4. Charcoal
5. Kerosene

9. What are the main economic activities in the Goma woreda?

General Interview questions for the Goma wereda administration on the background information of the study area and the condition of forest resource of Goma Woreda.

Information for identification:

Name of office...

Informant position..

Date..

1. How many people live in this area?

a) Male**…….**.

b) Female**….**

2. What is the population growth the area in different period?

3. What do the majority of people in the region/district do for a living?

4. What are the main economic activities in the goma woreda?

5. How much conserved forest has in the goma woreda?

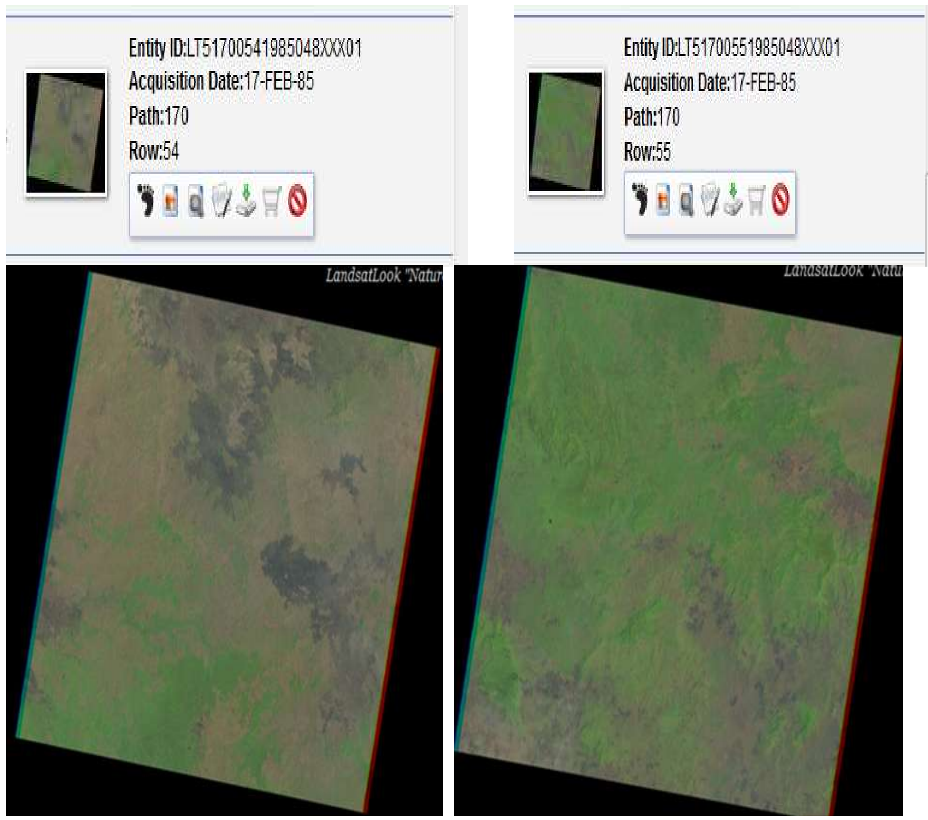
6. If the answer is yes for question 8 , what are the types of the forest?

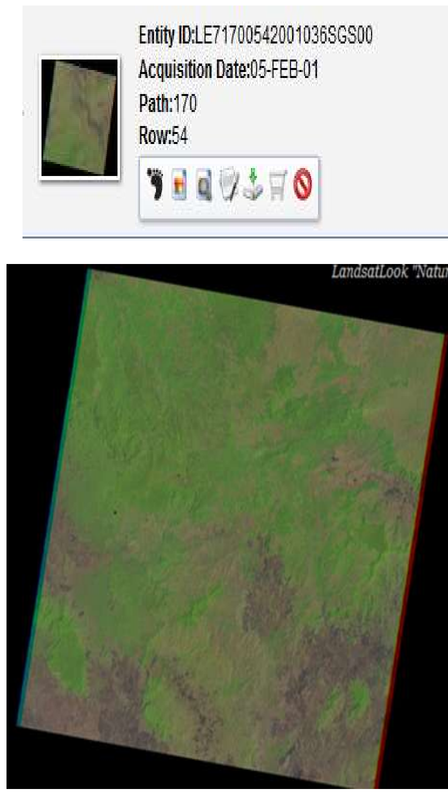
a) Natural**…………………**

b) Man made**………………**

Appendix III

Raw Landsat image of TM1985 and ETM+2001 and 2017

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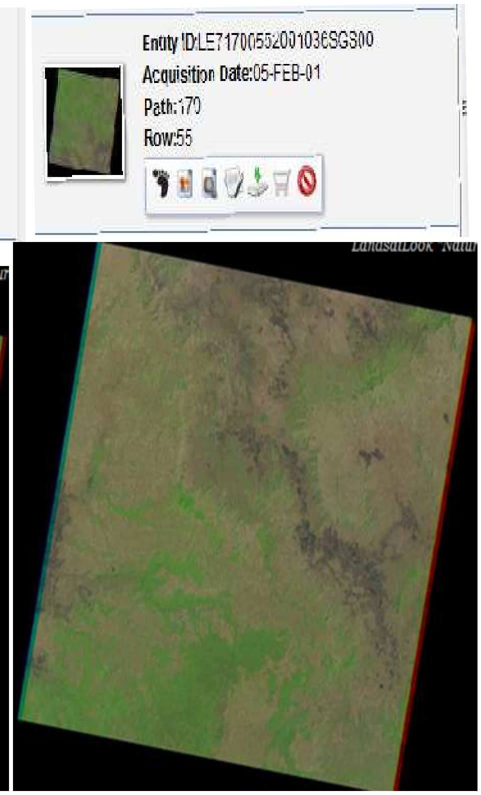
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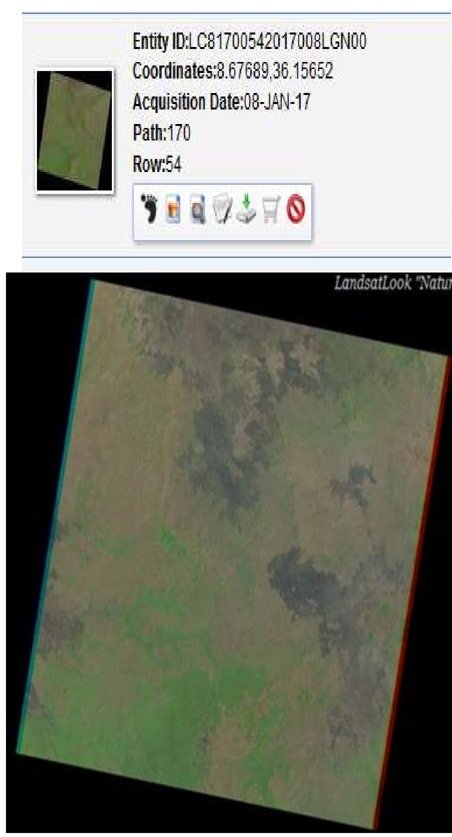
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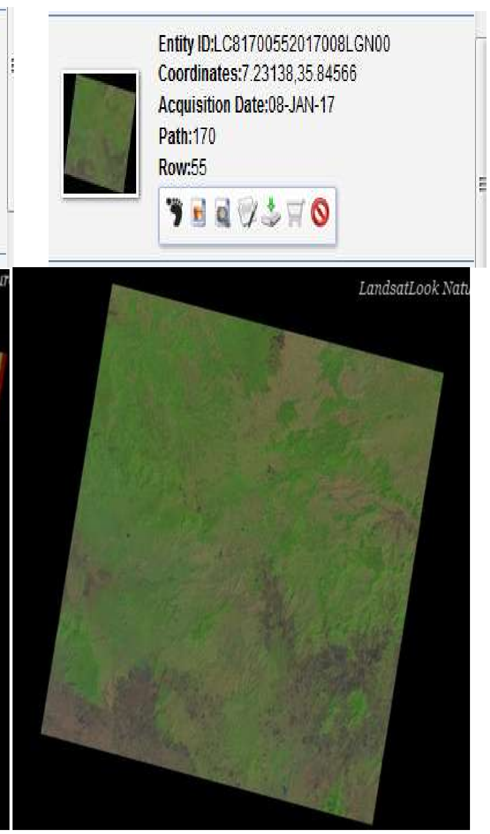
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