JIMMA UNIVERSITY
SCHOOL OF SOCIAL SCIENCES AND HUMANITIES
DEPARTEMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

GIS & RS BASED ANALYSIS OF LAND USE/COVER DYNAMICS

IN GILGEL GIBE_1 DAM SUB- CATCHIMENT, JIMMA ZONE,

SOUTHWEST ETHIOPIA

BY

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OCTOBER, 2018

JIMMA, ETHIOPIA

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IN GILGEL GIBE_1 DAM SUB- CATCHIMENT, JIMMA ZONE,

SOUTHWEST ETHIOPIA.

A Thesis submitted to the school of Graduate studies, Jimma University in partial fulfilment of the requirement for the Degree of master of science (MSc) in GIS & RS.

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DECLARATION

I hereby declare that the thesis entitled "GIS & RS based analysis of land use/cover dynamics: A case study of Gilgel gibe -1 sub-catchment, Jimma Zone, southwest Ethiopia" has been carried out by me under the supervision of Dr. Kenate Worku Department of Geography and environmental studies, Jimma University, as part of master program. I further declare that this thesis is my original work and has not been submitted to any other university or institution for the award of any degree or diploma and that all sources of materials used for the thesis have been dually acknowledged.

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ABBREVIATIONS

^0C	Degree Centigrade
CSA	Central Statists Authority
DA	Development Agent
ERDAS	Earth Resources Data Analysis System
ETM^+	Enhanced Thematic Mapper-plus
FAO	Food and Agricultural Organization
FGD	Focus Group Discussion
GIS	Geographic Information System
KII	Key Informant Interview
LC	Land Cover
LU	Land Use
OLI	Operational Land Image
USGS	United State Geological Survey

Abstract

This study was intended to investigate the trend of land use /land cover dynamics in Gilgel Gibe-1 sub-catchment for the last 29years (1986-2015.) For the selected study years 1986, 2000 and 2015 three-time series satellite images TM, ETM+ and OLI were used respectively. Additionally, socio-economic assessment was conducted by using KII and FGD to investigate the driving forces of land use land cover change. The study covers a total area of 168,857.91 ha. Five land use/ land cover classes namely; farmland, forest, grassland, water body and built-up were clearly identified for the study. The result reported that in the first period, 1986-2000 forest and grassland showed decreasing trend by 37.44% and 1.95%, respectively. But farmland and water body showed increment at the same time by 42.35% and 7.65% respectively. In the second study period farmland, waterbody, built-up and grassland were decreased by 14.83% ,13.07%,15.84% and 6.48% respectively. Forestland showed increment by 49.78%, In the entire period of the study forest, built-up and grass land were decreased by 14.07%, 28.08 and 8.02%, respectively. The extent of deforestation was very high during the second study period. In 1986, the largest area was covered by forest land and small area by water body, which constituted 41.7% (70,345.08ha) and 3.4% (5791.27ha), respectively. The farmland, built-up and grassland covered 14.7 %(24529.68ha), 29.3%(49796.64ha) and 10.9%(18390ha respectively. The land use/ land cover classification for the year 2000, as a year of 1986, the largest area was covered by farm land and small area by waterbody which accounts for 44.8 %(75,648.34 ha) and 8.9 %(15,028ha), respectively. Built-up, forest and grassland were accounted 21.9 %(36,979.88ha), 14.9%(25059 ha), and 9.5 %(16,041.50ha), respectively. In the final classification year (2015) land use land cover classification analysis of the study showed that farmland 38.9%(65685.72ha), water body 3.7% (6247.74ha), forest 34.7% (58593.69ha), grassland 9.5% (16041.50ha) and built-up 15.6%(26341ha) respectively. It was different from the first and second classification years, the farmland was 38.9 %(65,685ha) and dominant classes of the area. Therefore, to solve the forest cover shrink; effective and strong natural vegetation management and utilization policy have to be implemented by districts forest office and the regional government to insure the sustainability of natural resources by protecting natural forest with the participation of local community.

Key Words: Land use Land cover dynamics, GIS, Remote sensing, Landsat image

CHAPTER ONE

1. INTRODUCTION

1.1. Background of the Study

Land cover change is identified as one of the major drivers of changes in ecosystem. The change caused by different factors such as rapid population growth and rural to urban migration that leading to unplanned urban sprawl. Land cover change can be cause for environmental degradation and loss of biodiversity. Moreover, deforestation is the most significant land cover changes mainly caused by urbanization, transformation of agricultural lands and other infrastructures construction like road, industries etc. (FAO, 2006). Land cover dynamics are the most common problem and aggravated by human activities. These modifications affect existences of human beings and different biophysical resources. As a result, land cover changes lead to destruction of the available various resources that serve for human beings like domestic animals, agricultural land and environmental degradation (Agarwal *et al.*, 2002).

LC change affects water, soil and biodiversity. The change in ecosystem function in turn leads to long term decline in human wellbeing (Parksam, 2010). Land cover change is related with farming animal husbandry, charcoal production and firewood. That accelerated land degradation and soil erosion. The extent and the rate at which human being interacts with the environment has been increasing, land resources used for multipurpose at different time and space, human environment interactions facilitate for rapid land cover dynamics and these land cover dynamics continued with an alarming rate from time to time which tied with global environmental problems (Mugagga, 2011).

The term land cover originally referred to the kind and state to vegetation such as forest or grass land cover but it has broadened in subsequent usage to include other things such as human structure, soil type, biodiversity, surface and ground water (Meyer, 1995). Land cover dynamics are caused by both natural and socioeconomic factors (Campbell *et al*., 2005). Socioeconomic factors of land cover dynamics mainly include population pressure and agricultural land expansion (Amare, 2013).

Land cover dynamics is different at different time and space all over the world due to different economic activities. Land cover change has been occurring all over the world, but it is more serious in developing country like Ethiopia. Because in developing countries there are large number of human population that depend more on primary economic activities like agriculture, mining, forestry, fuel wood and charcoal production for home consumptions as well as selling near towns for their livelihoods that directly affect natural resources (Fazad ,2013). Deforestation is a clearly observable major cause of land cover dynamics and critical issue in tropical countries, where 2% or about 13million hectare of natural forest is lost annually, mainly due to the expansion of agricultural lands, extraction of fuel woods, construction materials and overgrazing (Lepers, 2003).

Ethiopia is one of the tropical and developing countries having large number of human population and around 83% of the population lives in rural area depending on agricultural economic activities. However, similar to some tropical countries of the world, rapid population growth, agricultural land expansion, and fuel wood and forest encroachment was a major driving force for land cover dynamics in Ethiopia (Kebrom, 2000). In this regard LC is highly changed especially in the developing countries which have agriculture based economy and rapidly increasing population. Most studies in Ethiopia indicate that population growth and agricultural land expansion are the major drivers of land cover change (Hurni, 1993).

Demands for land are increasing as population increases because of the need of extra land for their farming and housing activities that affect the natural resource coverage of the earth. To plan the proper natural resource policies, first it needs to identify the causes and driving forces of land cover change. What type of land cover change occurred in the past and what type of land cover highly transformed now was analyzed? Therefore, this study was conducted in *Gilgel gibe-1 sub-catchment* to identify changes, trends and ways to conserve these natural resources in *Gilgel gibe-1 sub-catchment* and drivers of land cover dynamics and its impacts and to recommend in the light of the findings.

1.2. Statement of the Problem

Globally, land use/ land cover change was one of the most important causes of global change and affects many parts of global environmental system. In addition, it has problem on biodiversity, land degradation and climatic change. For instance, the number of species and forest coverage declined from time to time (Zubair, 2006). Demographic change stimulates structural dynamics through different effect of converting forest into other forms of land cover. These types of conversions are caused by rapid population growth. Due to human activities the extent of land cover changed from dense forest to sparse or totally changed to bare land and decline in productive agricultural lands (Sharma, 2004).

Land use/ land cover changes in the condition and composition have impact on climate, biodiversity and people. The physical, social and economic situations in Ethiopia have contributed to the degradation of these resources. Both natural and human factors have their own contribution to land cover dynamics. However, human activities have been a main factor for land cover dynamics. The study area is one of the places where vast agricultural activities practiced and settled by agrarian populations. As a result, land covers, especially forest covers and shrub land covers were highly vulnerable from time to time due to increasing of population number that primarily cause for the expansion of agricultural lands, fuel wood extraction, and charcoal production and to obtain construction materials.

Therefore, the extents and the rates of land cover dynamics in the study area were observed and its consequences on environmental, livelihoods of the area and to recommend local administrative and decision makers to improve the existing situation in natural resources and managed properly by identifying its causes based on geographic information system and remote sensing data especially satellite image of the study area.

1.3. Objectives of the study

1.3.1. General Objective

The general objective of this study is to examine the spatiotemporal land cover dynamics taking place over the last 29years (1986-2015) and the main driving factors in *Gilgel gibe-1 sub-catchment Jimma zone,* Oromia Region.

1.3.2. Specific objectives

Based on the general objective, this study intends to achieve the following specific objectives.

1. To examine the trend of land cover change from 1986-2016 in the study area.
2. To examine the major causes of land cover change in *Gilgel gibe-1 sub-catchment*.
3. To investigate the major socio economic impacts of land cover change in *Gilgel gibe-1 sub-catchment.*

1.4. Research Questions

Based on the above objectives, the following research questions were formulated to guide the study.

1. What is the trend of land cover changes from1986-2016 in the study area?
2. What are the major causes of land cover changes in *Gilgel gibe-1 sub-catchment?*
3. What are the major socio economic impacts of land cover change in *Gilgel gibe-1 sub-catchment?*

1.5. Significance of the Study

This research is significant to obtaining adequate information on causes of land cover dynamics of the study area. The study identifies the information gap on spatiotemporal land cover dynamics of the study area by integrating GIS and remote sensing data to know what the land cover was looks like in the past and what it looks like now, what were the forces behind the changes and its implications on ecosystem of the area. Then to fill this gap digital change detection employed and further socioeconomic factors was investigated to identify the causes of changes and consequences of the change on the livelihood condition. The output of this research is essential for governmental and non-governmental organizations that carry out policy planners, environmental researchers, natural resource managers, agricultural office and environmentalists in order to have appropriate environmental protection and development, local community to minimize the problem of environmental degradation.

1.6. Scope of the Study

The spatial scope of this study was focused on land cover dynamics in *Gilgel gibe-1 sub-catchment*. Whereas the temporal scope is limited to land cover dynamics of the past three decades (1986-2015). It is limited both in space and time to investigate total land cover conversion between the past 29 years. In this limited both area and time, the study identify total land conversion and modification between different cover classes.

1.7. Organization of the thesis

This thesis has been organized in to five chapters. The first chapter presents the introduction part which introduces the background of land use land cover dynamics at worldwide, national level and in particular the study area, statement of problem, research objectives, research questions, the scope and limitation of the study. Chapter two focuses on review of literature. Chapter three deals with the general description of the study area and research methods used to data acquisition and the procedures employed in both quantitative and qualitative data analyses. Chapter four states overall interpretations of analyzed results and discussions that mainly focus on the change detection. Chapter five is deals with the overall conclusion and recommendation of the study.

CHAPTER TWO

2. REVIEW OF RELATED LITERATURES

2.1. Theoretical Framework

Different theories and models can be used to understand the process of forest and other natural resource degradation and management approaches and livelihood strategies of the communities. For this study, however, the theory of common pool resources, tragedy of the commons, the livelihood theories and the concepts of population-development nexus environment were reviewed in detailed to get the insights of forest degradation and its impacts on rural livelihood and food security frameworks.

Communal natural resources like forest resources, water resources (streams and rivers, wetlands, traditional irrigation schemes etc.), wildlife, grazing lands (pasture lands) could be considered using the common pool resources and common property management approaches and theoretical lenses (Ostrom, 1990). The theory of "Tragedy of the Commons", proposed by Hardin (1969), deals with the common property use and unsustainable utilization of such resources by the community i.e., common pool resources owned neither by the governments nor privately by the local people. After his thought of over exploitation of such common resources by some people, the" beneficiary groups", at the expense of other community members, Hardin recommended such solutions as state control and individual ownership and governance of the common property resources as the best management measure.

But, this assumption was ignored until the mid-1980s when common resource property regime rather replaced by the state controls and individual ownership in many countries of the world (Halake, 2010). On the other hand, many scholars like Dietz et al. (2003) come up with different ideas against the tragedy of the commons in support of the strength and management potentials of the communities i.e., indigenous management and self-governing institutions and their contribution to the welfare of the communities by solving the problem of common resource uses.

Thus, the community governance and participatory natural resource management seem the sound approach and useful recommendation to overcome forest degradation and promote sustainable natural resource management and forest based livelihoods of the communities at large.

2.2. Concept of Land Cover Dynamics

Land cover is the observed bio-physical covers of the earth's surface. It includes vegetation, grass land, asphalt, water and rocks. Land use refers to the intended use of the land cover type by human beings such as agriculture, forestry and grazing land (FAO, 2000). There are two major categories of land dynamics constitutes that both cover conversion and modification. In land cover conversion, the pre-existing land cover type is completely changed and replaced by another cover type like the change of forest land to cultivated or settlement land and agricultural land to urban land; while land cover modification is small change of land cover which affects the nature of former land cover category like dense forest to open forest, open forest to wood land, wood land to grass land (Lepers *et al*., 2003).

Land use and land cover changes are the main causes of environmental dynamics such as loss of biodiversity, soil degradation and climate change. Land covers dynamics caused by increasing and decreasing numbers of population. In developing countries like Ethiopia population growth has been a main cause of land use and land cover changes as compared to other factors (Sherbin in, 2002). The sustainable resource use refers to the use of natural resources to produce goods and services for a long period of time without destruction of resources that can be met present and future human needs (Lambin, 2005). In this century one of the most significant global challenges relates to proper management of the land cover occurring through transformation of the earth's surface (Mustard *et al.*, 2004).

2.3 Causes of Land Cover Dynamics

There are two main causes for land cover dynamics all over the world. These are natural causes and anthropogenic causes. Natural causes include atmospheric change, glaciations, tsunamis and fires. On the other hand, an anthropogenic cause which is the main driver of land cover change includes population growth, infrastructure development, deforestation, urban sprawl, and expansion of agriculture land. Hence, human beings are the major contributors to land cover changes and more rapidly affecting the livelihoods of societies. In Ethiopia, inappropriate agricultural practices, deforestation and overgrazing are affecting the rural poor population. This alteration of ecosystem is due to changes in LC and negatively affects the ability of the biological systems to support the human need (McClelland, 1998).

2.3.1. Expansion of Agricultural Land

Human environment interaction is continual at different spatial and temporal scale due to different social and bio-physical changes occurring across a sequence of time. This is due to human's extraction of goods to satisfy their needs which cannot be fulfilled without the conversion of land covers. Now days, the impact of human activities on land has grown enormously because of population increase, technological development, economic factors and cultural factors altering entire landscapes, and ultimately impacting the biodiversity, soil and climate, especially in the developing world. Thus, simple land cover modification grown into overall complicated land cover conversion that cause a significant impact on land capacity at local and global level to support the whole ecosystem. Human beings have increased agricultural production mainly by expansion of farm lands. Consequently, agricultural lands have expanded into forests, woodland, shrub land and grass land in all parts of the world to meet the demand for their basic need of household (Sherbinin, 2002).

According to FAO (2010) estimation, Ethiopia lost 13 million hectares of forest per year during the 1990s and 1.4 million hectares lost per year between 1990 and 1997. The annual rate of net cover change in tropical forest was 0.43 % during that period. Similarly, FAO (2012) has indicated a net decrease in global forest area of 1.7% between 1990 and 2005 at an annual rate of change 0.11%. This shows an annual shift from forest land cover to other land cover of 3 million hectares per year 1990 to 2000 and of 6 million hectares per year between 2000 and 2005. In contrast, the area of agricultural land has increased globally from an estimated 300-400 million hectare in 1700 to 1500-1800 million hectare in 1990, 4.5 -5.0 increase in the Centuries and a 50% net increase just in the 20th Century (Lepers *et al*., 2003). The increase in agricultural land led to the clearing of forest and transformation of wood land, shrub land and grass land to agricultural land. Several researches in Ethiopian highland showed that agricultural and settlement land have increased rapidly at the expense of forest land, wood land and grass lands. The fact that human beings are the major contributors to land cover change and are the ones experiencing the consequences of these changes. Land cover dynamics has gone under continuous change for a long period of time because of humans' production demands (Sherbinin, 2002).

2.3.2. Deforestation

Deforestation is the destruction of forests caused by local residents. The rural poor living around forests strongly depend on natural resources to satisfy their basic needs and social services. The main reasons of deforestation is dependency of the poor rural people on the forest resources as source energy (firewood and charcoal production) and source of income by selling charcoal, fire wood, and timber to the town.

Moreover, the human population increased, the demand for arable land was inevitable and, gradually, the increasing demand for cultivated lands, grazing land, house construction, charcoal production and fuel wood including are the main reason for the forest cover declining in Ethiopia. In addition, forests are deforested to obtain constructional materials, to afford source of energy, to accesses of land for building, grazing and farming (Mesfin, 1991).

2.4. The Impacts of Land Cover Dynamics

2.4.1. The Impacts of Land Cover Dynamics on Biodiversity

Biodiversity plays an important role in the way ecosystems function and in the services they provide. Moreover, these valuable resources, biodiversity is declining rapidly due to land cover dynamics all over the world. Ethiopia is characterized by abundant biodiversity, but shrinking diversity in biological resources: forest, wood, grass lands, shrubs, and varied wildlife (Messay, 2011). In Ethiopia land cover change has significantly affected plant biodiversity (Nyssen *et al.,* 2004). The loss of plant biodiversity due to the human interference in forest areas is common. The problem is occurring particularly in developing countries because vegetation and soils of these areas have been affected strongly (Lambin and Giest, 2003).

2.4.2. The Impacts of Land Cover Dynamics on Climate Change

Land cover dynamics have also different impacts on local and regional climate of the world (Solomon, 2005). As Turner *et al.,* (1995) stated, the release of carbon dioxide (Co2) and carbon monoxide (Co) to the atmosphere from the global terrestrial biosphere has become a serious problem threatening the health of the environment. The primary causes of human induced components of climatic change are the increased amount of greenhouse gasses (GHGs). They are released by the burning of fossil fuels, vast land deforestation for expansion of agriculture and industries which leads to and increased in the green house effects.

2.4.3. The Impacts of Land Cover Dynamics on Environmental Degradation

Land use/land cover change is the most common problem on environment degradation. Human activities like deforestation, urban development, agriculture, and others are significantly changed the earth's landscape. The disturbance of the land affects seriously ecosystem processes. For instance, Conversions of forest land to crop production and irrigation water alterations have brought many wildlife species to the verge of extinction (Marland *et al.* 2003). Moreover, forests provide many ecosystem amenities. They support biodiversity, providing critical habitat for wildlife, remove carbon dioxide from the atmosphere, intercept precipitation, slow down surface runoff, and reduce soil erosion and flooding. These important ecosystem services will be reduced or destroyed when forests are converted to agriculture or urban development. For example, deforestation, along with urban sprawl, agriculture, and other human activities, has substantially altered and fragmented the Earth's vegetative cover. Such disturbance can change the global atmospheric concentration of carbon dioxide, the principal heat trapping gas, as well as affect local, regional, and global climate by changing the energy balance on Earth's surface (Marland et *al.* 2003).

Land degradation is one of environmental degradation and broadly defined as any form of deterioration of the natural resources of land that affect ecosystem integrity either in terms of reducing or shrinking. Land degradation is declination of the resources in quantities and qualities and major global issue now days because of its adverse impact on the agricultural productivity, which resulted shortage of food and the lack of income to satisfy basic needs. Due to land degradation, most developing countries, specially, agrarian communities the agricultural yield reduction was remarkable and reached the level of beyond the subsistence requirement of a household's. As a result, land degradation destroyed soil composition and leads to loss of soil fertilities through the process of soil erosion by water and wind. The main causes of land degradation are unsustainable agricultural practices, over grazing, deforestation and unsecure land tenure (Mesfin, *et al.,* 2016).

The consequence of this land degradation includes inadequate land production, declined in the quality and quantity of water supply, famine, political instability, soil erosion and climate change (Solomon, 2005). Decreased productivity on farm lands due to land degradation can force farmers to clear additional areas of natural habitats to increase production which again contribute for land degradation due to change in biodiversity (Mesfin, *et al.*,2016).

2.4.4. The Impacts of Land Cover Dynamics on Socio economic Development

Land is one of the major factors of production in classical economics and vital input for housing and food production (Lubowski *et al*., 2006). Thus, land use is the backbone of agricultural economies and it provides substantial economic and social benefits. Land use change is necessary and essential for economic development. Moreover, Land use provides many economic and social benefits, but often comes at a substantial cost to the environment. The Conversion of farmland and forests to urban development reduces the amount of lands available for food and timber production. However, the Soil erosion, salinization, desertification, and other soil degradations associated with intensive agriculture and deforestation reduce the quality of land resources and future agricultural productivity (Lubowski *et al*., 2006).

Land conservation is a critical element in achieving long term economic growth and sustainable development. Land use policy must balance between private property rights and the public interests. The sub Saharan Africa countries, the most extensive rangeland and grazing land are also threatened with degradation of land. Ethiopia is one of the sub Saharan African countries where deforestation, cutting trees, degradation of the land and reduction of crop production that hinders socio economic development. Therefore, the country is definitely existing with the difficulty of producing surplus food for its rapidly growing population without natural resource dependency. To insure a sustain natural resources with a population number has been a major challenge for the country (Melaku, 2000).

2.5. Application of Remote Sensing and GIS and analysis of Land Cover Dynamics

Remote sensing is a science and art of obtaining information about an object or phenomenon without any physical contact with the object and thus in contrast to site observation. It is defined as the use of electromagnetic radiation sensor to record images of the environment which can be interpreted to yield useful information while GIS is a computer based system which used to capture, manage, analysis and interpret data in land cover dynamics study (Samuel *et al.,* 2009). Relating the quantitative remote sensing data with social science analysis and socializing the pixels is the main challenge in land use land cover change studies. But GIS enable us to understand the determinants of land use land cover change and to understand the cause-effect relationship between the change and the driving forces of the change (Mugagga, 2011).

GIS data bases are used to improve the extraction of relevant information from remote sensing imagery, where as remote sensing data provide periodic pictures of geometric and thematic characteristics of terrain objects, improving our ability to detect changes and update GIS data bases (Janssen, 1993 Satellite imagery provides a good source of data for performing structural studies of land space. Simple measurements of pattern such as the number, size and shape of patches can indicate more about the functionality of land cover type than the total area of cover alone (Janssen,1993).

2.6. Characteristics of Satellite Images

There are four main characteristics of satellite images which determine the quality of remote sensing data obtained by different sensors. These are spectral resolution, spatial resolution, radiometric resolution and temporal resolution.

Spectral resolution: Spectral resolution refers to the number of spectral bands and the width of each spectral band to which the remote sensing system is sensitive to distinguish different feature classes in a multispectral image based on their responses over a particular wavelength ranges. Accordingly, a narrow band width and large number of bands in each band provide higher spectral resolution and allow us to discriminate different features easily than small number of bands and wide band width (Yeung, 2002). While we compare the spectral resolution of colored film with a black and white film, black and white film records the whole wavelength ranges, of visible portion of electromagnetic spectrum (0.4μm-0.7μm) evenly. But colored film is sensitive to each particular energy reflected at blue (0.4 μm -0.5 μm), green (0.5 μm -0.6 μm) and red (0.6 μm - 0.7 μm) wavelengths spectrum (Reusing, 2000). Therefore, colored film has high spectral resolution and with this higher spectral resolution it can discriminate different feature with different color based on their reflectance at each wavelength range. So this research intended to use the colored film due to the above reasons.

Spatial resolution: refers to the size of pixels that is recorded in an image. Spatial resolution refers to the size of the smallest object that can be distinguished by a given sensor which is determined by the distance between the object or phenomenon and the sensor that discriminate the object (Reusing, 2000). When the distance of the sensor from the target is increased, it covers large area but it cannot provide greater detail, i.e. if volume of data is large, its resolution is low. When the distance between the sensor and an image is large, the sensor covers large area with low resolution/detail. On the other hand, when the distance between the sensor and an image is small, the sensor covers small area with high resolution. Satellite images possess small matrix of pixels which are the smallest possible units of the image. These pixels are normally square in shape and each represents a certain area of land on the ground.

Radiometric resolution: The number of different intensities of radiation sensor is able to distinguish. It is the ability to discriminate the spectral reflectance between different features which depends on the number quantization levels within the spectral band (Reddy, 2008). It is expressed as the number of binary digits from zero to selected power of 2 that needed to store the highest level value and define the tangible facts contained in the image. A sensor that used 8 bits to record an image has higher radiometric resolution than that used 4 bits. Because in the first sensor there are 28= 256digital values ranging from 0 -255 which represents the maximum number of brightness level, but in the second sensor only a maximum 24= 16 brightness levels are available ranging from 0-15.

Temporal resolution: temporal resolution is referring to the visit frequency at which satellites complete one full orbit cycle and obtain image of the same area at different period of time to provide multi-temporal imagery that used to monitor the biophysical changes occurring on the surface of the earth (Yeung ,2002).

2.7. Image Classification Process

Digital image classification is a process by which all pixels in an image are automatically classified in to different land cover classes based on the spectral pattern present within the data for each individual pixel. There are three methods of digital image classification namely: Unsupervised classification, supervised classification and hybrid classification (Yeung, 2002). In unsupervised classification method, the computer classifies the image in to natural clusters of similar brightness value without training area selection in which pixels of the clusters can be related to the actual land cover classes after ground verification.

In case of supervised classification approach, training area are selected to specify the spectral signatures that will represent each desired categories of land covers in each bands of digital image to the computer algorithm (Behailu,2006). This image classification method need prior knowledge of the user to specify appropriate spectral signature of the desired class to the computer algorithm. According to hybrid image classification, both supervised and unsupervised image classification methods are combined together to classify the images. In hybrid image classification methods: first, unsupervised classification is carried out to classify the image in natural clusters and based on these natural clusters, training area are selected for supervised classification in which maximum likelihood decision rule is applied to classify the entire image (Reusing,2000).

2.7.1. Image Enhancement

Image enhancement is the process of making an image more interpretable for a particular application. Image Enhancement is necessary for raw remotely sensed data; it makes more interpretable to the human eye. Enhancement techniques are often used instead of classification techniques for feature extraction studying areas and objects on the ground and deriving useful information from images. The techniques to be used in image enhancement depend upon type of data, objective of the study, expectations and background of the analyst (Erdas, 1999).

2.8. Integration of Remote Sensing and GIS in Digital Change Detection

Integration of GIS and remote sensing technologies can be used to develop decision support systems for planners and decision makers. Remote sensing is a raster based data collection and analysis system; while GIS is vector data based system even though raster based GIS data also exist. The different sectors such as urban planning, natural resource management, forestry, agriculture sector and environmental management needs spatial data tools to work efficiently and effectively (Reddy, 2008).

These days' great improvements have been made in the integration of remote sensing and GIS. Advanced computer hardware & software have permitted the expansion of current GIS and remote sensing capabilities in dealing with data structure conversion. The main important area of GIS integration with remote sensing lies in combining vector information in image classification for the selection of training areas. The integrated system is able to perform a raster-vector intersection query (Yeung, 2003). This is used to find which pixel fall within which polygon, given an image polygon file, without the need of data format conversion. To be valued in GIS environment, remote sensing data need to be digital in format (Reddy, 2008). Remote sensing images and information extracted from these image together with GPS data are the main data source of modern GIS. The combination of these fields will continue to transform the quantification and monitoring of land cover changes. From remote sensing data there are two methods of data extractions for GIS input. These are computer processing of remotely sensed digital images and visual interpretation of satellite imageries in pictorial format (Reddy, 2008). The output of both analysis methods provide data input for GIS that used to any applications. A fully integrated system requires two way flows of data between vector data sets and raster images. Image statistics within a polygon are generated and then returned directly to the GIS data base as attribute of the polygon.

2.9. Methods of Digital Change Detection

Change detection is the process of investigating and identifying differences in state of phenomenon by observing and analyzing it at different times (Yeung, 2002). Change detection process in remote sensing can be facilitated and performed by using GIS. There are two broad methods of Change detection: Map-to-map comparison approach and image-to image comparison.

I. Image to image comparison approach

Image to image comparison approach is a change detection approach which involves the analysis of spectral characteristics of two or more images to identify the actual spectral differences caused by the desired variables. Like in map-to-map comparison approach, the two images are geometrically rectified and accurately registered to match exactly. After one of the image classification systems is employed, the two images are compared by means of image differencing. Then when raster GIS overlay is performed, in case of image subtraction the results can be negative or positive. The constant value is used to convert the negative value to positive value. Thus, in the resulting image, value greater than the constant value indicate increased reflectance, value less than the constant value indicate decreased reflectance, and the constant value indicate no change (Yeung,2002).

ii. Map to map comparison approach

Map to map comparison approach is also called post classification comparison change detection approach. In this method satellite images of two or more different dates are used. First the two images are pre-processed such as geo-rectification and registration to match exactly. Using one of the image classification systems, each image is classified in to different land cover classes and two independent land cover maps are generated to visualize the classes. After that the overlay function of GIS is used to compare the two maps pixel by pixel or polygon by polygon (Fazad, 2013). Then, between the two maps cross-tabulation of change detection matrix is generated.

When the two maps overlay and subtracted pixel by pixel the resulting map may show negative, zero and positive for cover loss, no change and regeneration respectively (Yeung, 2002). In using polygon by polygon comparison the raster image need to be converted in to vector format and land cover change information is extracted with appropriate GIS functions.

CHAPTER THREE

3. DESCRIPTION OF STUDY AREA AND RESEARCH METHODOLOGY

3.1. Description of Study Area

3.1.1. Location

The Gilgel Gibe-I Dam is a rock-filled embankment dam on the omo river in Ethiopia, it is located about around 260km far from the capital Addis Abeba and 57km north east of Jimma in Oromia regional state, the primary purpose of the dam is generation of Hydroelectric power production and it diverts water through a 9.2km tunnel to underground power station to Gilgel Gibe-II downstream of Gilgel Gibe-I. The Gilgel Gibe –I sub-catchment is geographically located at Latitude 7.8314 N and Longitudes 37.3216 E.

Gilgel Gibe River is one of the major tributaries of Great Gibe River, which originates in mountainous area south – west of Jimma and flows towards the north until it joins Great Gibe River. The river regulated by the upstream dam (which is currently in operation) here after called Gilgel Gibe-I could be utilized further downstream without constructing substantial structure. This site has a total catchments area of about 3,602km^{2}.

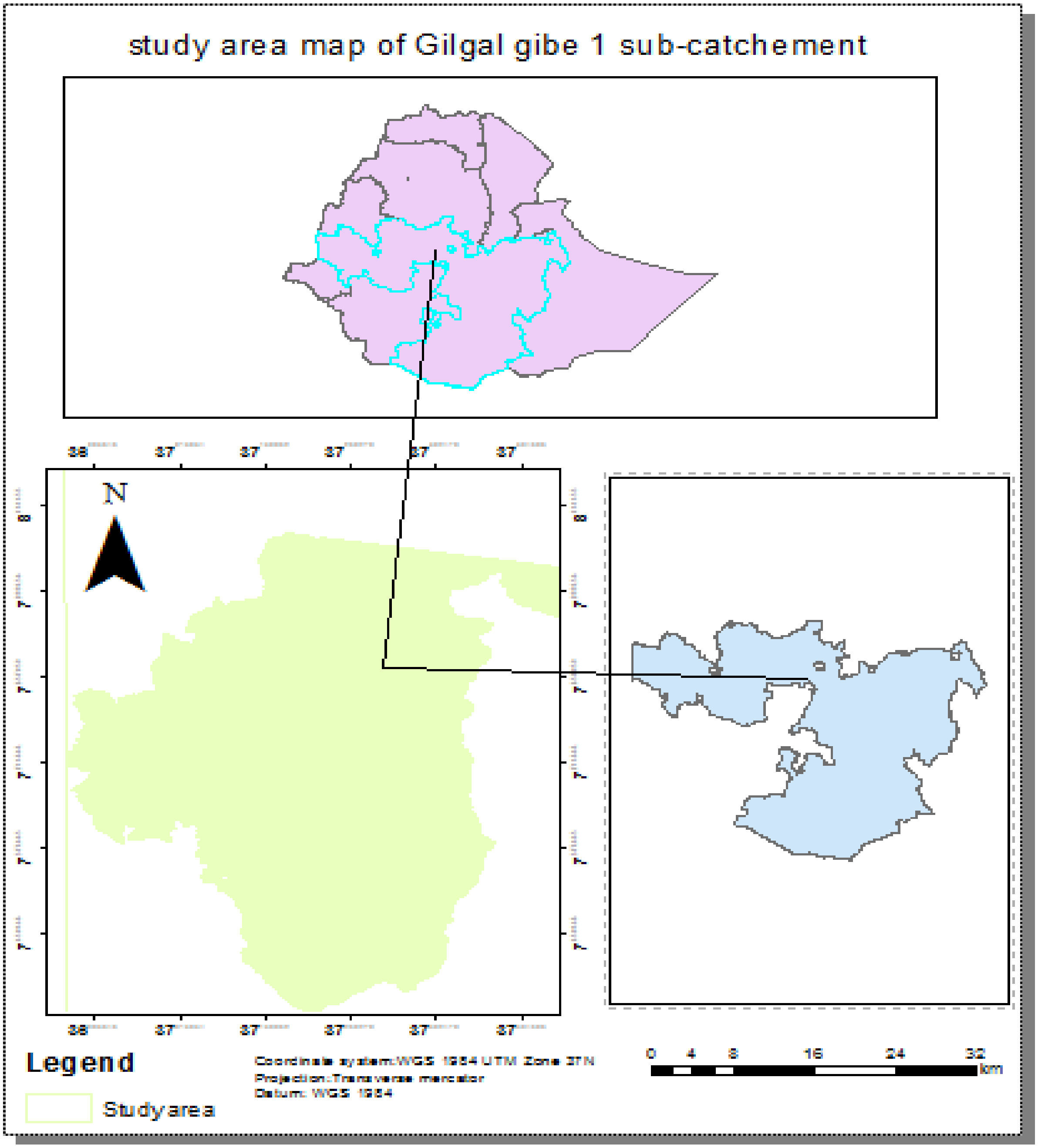


Figure: 3. 1 Map of study area

3.1.2. Demographic and socio-economic characteristic of the study area

According to CSA (2016) the total population of *Gilgel gibe-1 sub-catchment* was116, 822, of whom 60,257 were men and 56,565 were women; 22,539 of its population were urban dwellers. The majority of the inhabitants were Muslims, with 80.74% of the population observed this belief, while 19.26% of the population practiced Ethiopian Orthodox Christianity and 1.37% of the population were protestant (CSA,2016). Afan Oromo is spoken as a first language by 85%, and 14.50% spoke Amharic; the remaining 0.50% spoke all other languages. Industry in the *district* includes quarrying and pottery making, 61 small scale industries that employ 178 people, as well as 727 registered traders 17.6% of whom were wholesalers, 42.4% retailers and 40% service providers. There were 25 Farmers Associations with 14,179 members and 4 Farmers Service Cooperatives with 6958 members. *Gilgel gibe-1 sub-catchment* has 148 kilometers of dry-weather and 105 of all-weather road, for an average road density of 197 kilometers per 1000 square kilometers. About 22.7% of the total population has access to drinking water (*Socio-economic profile of Jimma Zone, 2006).*

3.1.3 Agriculture and Livestock

The major means of livelihood of the study area are crop production and animal rearing. In addition to this, charcoal and fire wood extraction also alternative incomes for the local community. Rain fed crop production is a dominant agricultural activity because most of the people of the study area engaged in agricultural activities. Major food crops grown in the area includes teff, wheat, sorghum and maize. The smallest parts of the area have irrigation farms to produce fruits and vegetables for market. In addition to this there are irrigation farms that are owned by government, individual farmers and investors according to the information from Agriculture Office of the *districts*.

3.2. Methods and Materials

3.2.1. Research design

This study was undertaken using both quantative and qualitative research methods or on partially mixed sequential dominant status-quantitative or technical research design. The quantative method was the first emphasizing on acquisition, processing and analysis of Landsat images followed by collection of primary qualitative data for the analysis of socio-economic and physical data**.** The main reason of qualitative research method used for this study was that, qualitative method enables the researcher to gain adequate understanding of the problem, to clarify the result to extend the width and range of inquiry by incorporating the findings of the at the final result interpretation stage.

3.2. 2. Data Types and Sources

In order to achieve the stated objective of the study, two types of data were used. These were Primary data and secondary data. Primary data includes, socio economic data collected from selected household heads through key informant interviews and focus group discussions. These data were mainly concerned with the socioeconomic issues and livelihood conditions that typically include historical spatiotemporal land cover changes. Focus group discussions also summarized the opinions and understanding of the local communities of the study area. Participants in both key informant interviews and focus group discussions were selected purposively from the population of the study area. Secondary data used for this study included: official reports, local and national CSA data of the study area. Land sat images were considered as the main data source of the study and aims to create the overall image of spatiotemporal land cover dynamics of the study area. Land sat images on sunny day which acquired for the three Observation years were downloaded from USGS website.

3.2.3. Method of Data Acquisition

The analyses of spatial and temporal land use /and land cover changes, satellite image maps were produced. The satellite imagery provides excellent sources of data for performing well organized studies of a land use/ land cover (Sachs *et al*., 1998). Present and past information on land cover and land use changes for the study area was generated from remotely sensed data. The main purpose of studies was quantifying the land use /land cover change of the study area and evaluating the dynamics between the different LULC classes. To quantify the extent and rate of the changes as well as the dynamics of major land use/land cover types in the study area three Land sat imageries of 1986(TM), 2000(ETM+ and 2015(OIL) that acquired during sunny day that means between January and March Land sat image of 30m x 30m spatial resolution were downloaded from USGS website and used.

Table:3. 1 Land sat images used in the study

Sensor	Spatial resolutions(m)	Date of acquisition	Path and row
TM	30m×30m	1986/01/21	169/55
ETM+	30m×30m	2000/02/05	169/55
OLI	30m×30m	2015/01/05	169/55

3.3. Tools of Data Collection

Tools of primary data collection used for this study are focus group discussion and key informant interview questions.

A. Key Informant Interview (KII)

This was undertaken by the researcher just with well-experienced and informed individuals to get information in depth on the socio-economic and physical data which the investigator wants to go through. Therefore, Key informant interviews were conducted with experts in Agricultural Office, Developmental Agent Workers, and Chair persons of *Kebeles* and Districts Forest Office of the study area about spatiotemporal land cover dynamics taking place over the past 29 years. Thus, key informant interview was conducted to get first-hand information of socio economic, biophysical (based on their perception of change) and policy related to land use land cover information of the study area to strength the findings of satellite images. Key informant interview totally included 8 persons and 2persons for each sectors. They were selected purposively based on the following criteria by the help of chair persons of *Keble's:* they lived in the study area for long periods of time and they have enough information about the study area.

B. Focus Group Discussion (FGD)

The four FGD discussions have been conducted. Each group consisted of five persons. FGD were consisted elderly men, elderly women, poor farmers and rich farmers of the study area. Poor farmers and rich farmers were identified based on the data obtained from agricultural office of the *districts*. To extract valuable information, discussion points were translated into Afan Oromo language. The information extracted from this group discussion points were summarized at the end of the discussion to strength the findings of quantitative satellite image data and history of land cover experiences of the study area. Pseudonym (false) names were assigned for KII in the analysis part of the study area to keep their confidence.

3.4. Methods of Data Analysis

3.4.1. Analysis of Land Cover Dynamics

The extent of land covers dynamics was analyzed in the study area in the years 1986, 2000 and 2015 using land sat image of these years. Before using these data, each image was preprocessed. The term preprocessing comprises a number of image processing activities carried out to improve the quality of the image and information that were extracted from the image. These include layer stacking, radiometric correction, topographic correction and image enhancement. First, the separate single band images were stacked in to a single output multi-band image file. Subsequently, image enhancement was done to minimize error in the detector and to maximize the brightness value of the data. This function used histogram equalization applying linear contrast stretch to redistribute pixels of the same number of values within a range. Band combination and false color combination were also used to improve identification of the class. In unsupervised classification method, the computer classifies the image in to natural clusters of similar brightness value without training area selection in which pixels of the clusters was related to the actual land cover classes after ground verification. Moreover, supervised classification was used to cluster pixels in data set into classes corresponding to user defined training classes. This classification method requires selecting training areas for use as the basis for classification. It requires a prior knowledge of the area in order to provide the computer with training classes. In this method, the user defined the original pixels that contain similar spectral classes representing certain land cover class. The Supervised Maximum Likelihood classifier algorism classification system was used, since it is the most common method in remote sensing image data analysis (Richards, 1995). In addition to after supervised classification, post classification and accuracy assessment were taken place.

3.4.2. Accuracy Assessment

In order to produce land cover maps from remote sensing always contain some errors due to several factors which ranges from classification technique to method of satellite data capture. To wisely use of the land cover maps which were derived from remote sensing the errors should be quantitatively explained in terms of classification accuracy. Whether the output meets expected accuracy or not is usually determined by the users depending on the type of application the map product used. The accuracy essentially measured how many ground truth pixels were classified correctly. Accuracy levels that acceptable for certain task may be unacceptable for others. The common means of expressing classification accuracy the preparation of classification error matrixes. An error matrix (confusion matrix) is a square array of numbers organized in rows and columns which express the number of sample units assigned to a particular category relative to the actual category as indicated by reference data (Congalton *etal*., 1999).

Error of omission is the percentage of pixels that should have been put into a given class but were not. Error of commission indicates pixels that were placed in a given class when they actually belong to another. These values are based on a sample of error checking pixels of known land cover that are compared to classifications on the map. Errors of commission and omission can also be expressed in terms of user's accuracy and producer's accuracy. User's accuracy represents the probability that a given pixel appears on the ground as it is classed, while producer's accuracy represents the percentage of a given class that is correctly identified on the map and overall accuracy is calculated by summing the number of pixels classified correctly and dividing by the total number of pixels. One of the problems with the confusion matrix and the kappa coefficient is that it does not provide a spatial distribution of the errors (Foody, 2002).

The accuracy is essentially a measure of how many ground truth pixels were classified correctly. The kappa coefficient is a measure of the agreement between classification and reference data with the agreement due to chance removed. The kappa coefficient is greater than 0.80 represented strong agreement between the classification and reference data; between 0.40 and 0.80 represented moderate agreement; and less than 0.40 represented poor agreements. The Kappa coefficient lies typically on a scale between 0 and 1 and usually multiplied by 100 to give a percentage measure of classification accuracy. This implies that the Kappa value of 0.80 represents a probable80% better accuracy than if the classification resulted from a random assignment (Anderson, 1971).

Knapp and Mueller (2010), validity is the usefulness of research instruments in addressing research objectives and research questions. Therefore, as a principle, in order to assure the validity of the research, the researcher was tried to review quite adequate conceptual and empirical literatures related to the problem under investigation. Generally, to ensure the validity and reliability of this study, ground reference data assumed correct was collected from topographic map for the initial Land sat image, Google earth map for the second and Google Earth Image for the third Land sat images. The ground reference data from sample points was compared with the corresponding class on the pixels' groups/polygon. Then, the final evaluation result was presented in the form of error or correct.

3.4.3. Socioeconomic Data Analysis

In this investigation, the major concern of integrating socioeconomic data with quantitative remote sensing data to obtain supplementary information from the local community that explained the results of the study in depth. Therefore, socioeconomic data collected from KII and FGD were interpreted to identify the understandings and perceptions of local community on the interaction of socioeconomic activity and biophysical attributes of the study area on spatiotemporal land cover dynamics. The data analysis has taken the form of paraphrasing and quoting the words of key informant interviews and focus group discussions.

3.4.4. Land cover and land use classes and its definitions

Land use and land cover in study area, forest land, water land, crop land, bare land and Settlement were identified and the description of each land use and land cover type is given based on FAO (1997) in below Table 3.2

Table:3. 2 Description of Land use and land cover classes found in the study area

Land use/cover categories	**Land use/cover description**
Crop land	Areas of land that is ploughed and/or prepared for raising crops.
Settlement	Small rural communities and other built up area
Forest land	Tree canopy cover >70%.Amulti-strata community, with interlocking canopies, composed of canopy, sub canopy, shrub and herb layers
Grass land	All areas of grassland with less than 10 % tree and/or shrub canopy Cover and greater than 0.1% total vegetation cover. Dominated by grass-like, non-woody, rooted herbaceous plants
Water body	Rivers, streams & including artificial lake

Source: FAO (1997)

Work flow chart

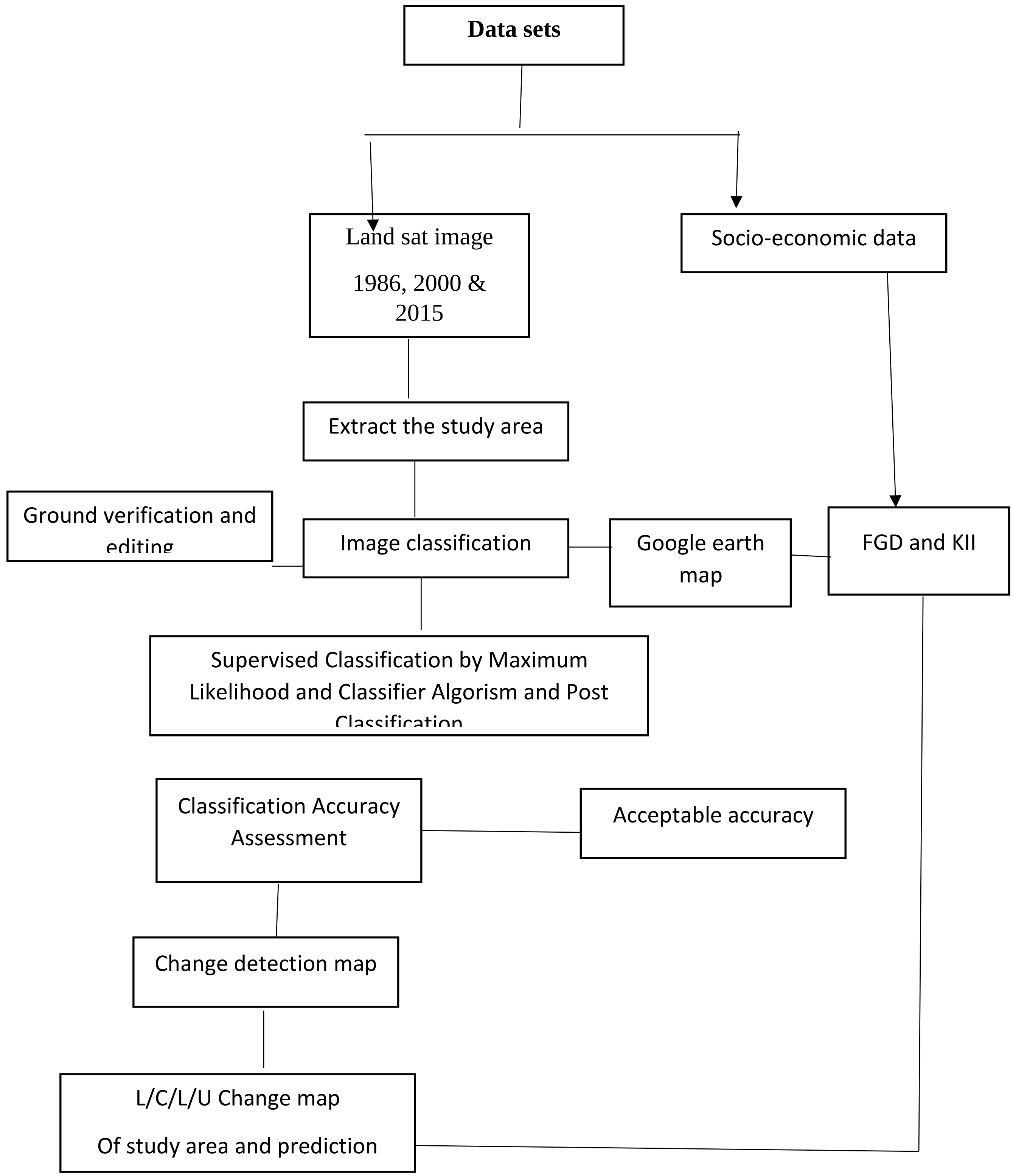


Figure: 3. 2 Flows of the study (developed by researcher)

CHAPTER FOUR

4. RESULTS AND DISCUSSIONS

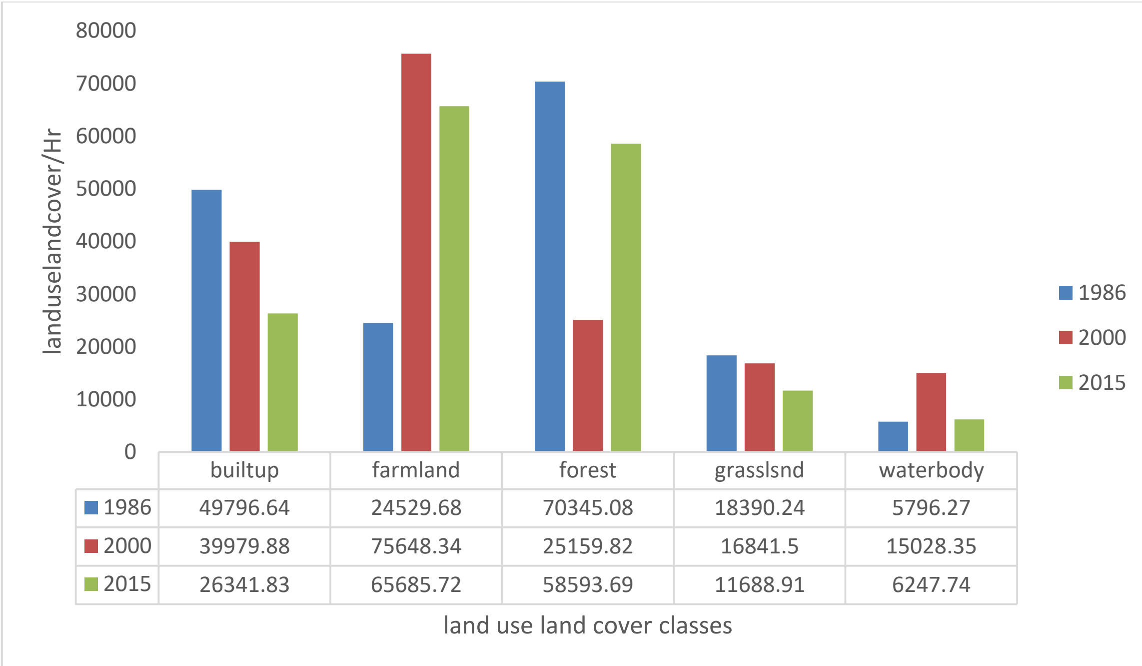
4.1. Results

For the study area five land use land cover classes were identified. These were cropland, settlement, forest, water bodies and grass land. The land use land cover classification result for the study year 1986, 2000 and 2015 indicated in (Table 4.1). In 1986, the largest area was covered by forest and small area by water body, which constitutes 70345.08ha (41.7%)and5796.27ha (3.4%), respectively. The farmland, built up and grassland were covered24529.08ha (14.7%),49796ha (29.3%)&18390.24ha (10.9%)respectively. The land use land cover classification for the year 2000, as a year of 1986, the largest area was covered by farmland and small area by water body which accounts75648.34ha (44.8%)&15028.35ha (8.9%), respectively. Built up, forest and grassland were accounted 36979.88ha (21%),25159.82ha (14.9%)&16041.50ha (9.5%) respectively. In final year (2015) land use land cover classification analysis shows that the same classes and area with the first and second observation year, but covering different quantity of area: farmland 65685.72ha (38.9%), water body6247ha (3.7%), forest58593.69ha (34.7%), grassland11688.91ha (7.1%) and built up 26341ha (15.6%). It was different from the first and second classification years, the farmland was 65685ha (38.9%)dominant classes of the area.

Table 4 1: Land use land covers changes (1986, 2000&2015)

Land use land cover change class	Area in hectare and percentage during the three seasons						Percentage rate of change per annum		
	1986 Hectares	%	2000 Hectares	%	2015 Hectares	%	1986-2000	2000-2015	1986-2015
Built up	49796.64	29.3	36979.88	21.9	26341.83	15.6	-12816	-10638	-23454
farm land	24529.68	14.7	75648.34	44.8	65685.72	38.9	51118	-9962	41156
forest	70345.08	41.7	25159.82	14.9	58593.69	34.7	- 45185	33433	-11751
grass land	18390.24	10.9	16041.50	9.5	11688.91	7.1	-2348	-4352	-6701
water	5796.27	3.4	15028.35	8.9	6247.74	3.7	9232	-8780	-451
total area	168857.91 ha	100	168857.91ha	100	168857.91ha	100			

Source: computed from Land sat images of 1986, 2000 and 2015.



	builtup	farmland	forest	grasslsnd	waterbody
1986	49796.64	24529.68	70345.08	18390.24	5796.27
2000	39979.88	75648.34	25159.82	16841.5	15028.35
2015	26341.83	65685.72	58593.69	11688.91	6247.74

Figure 4. 1: Land use land cover change1986-2015

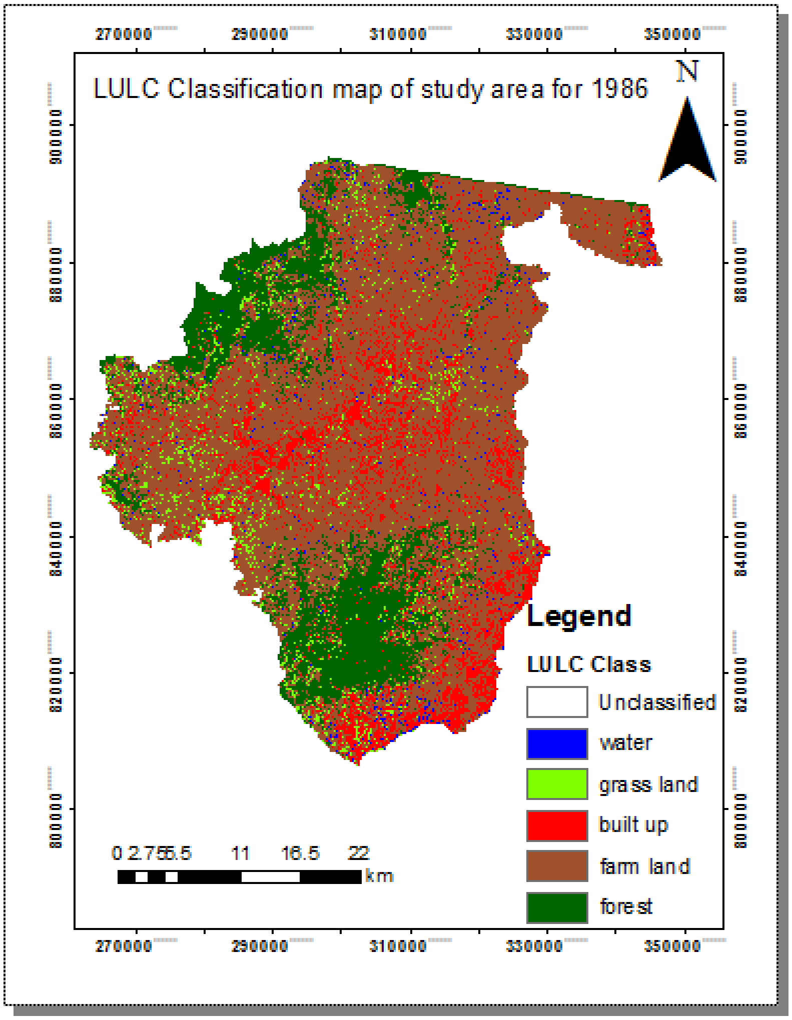


Figure 4. 2 LU/LC classification map of study area for 1986.

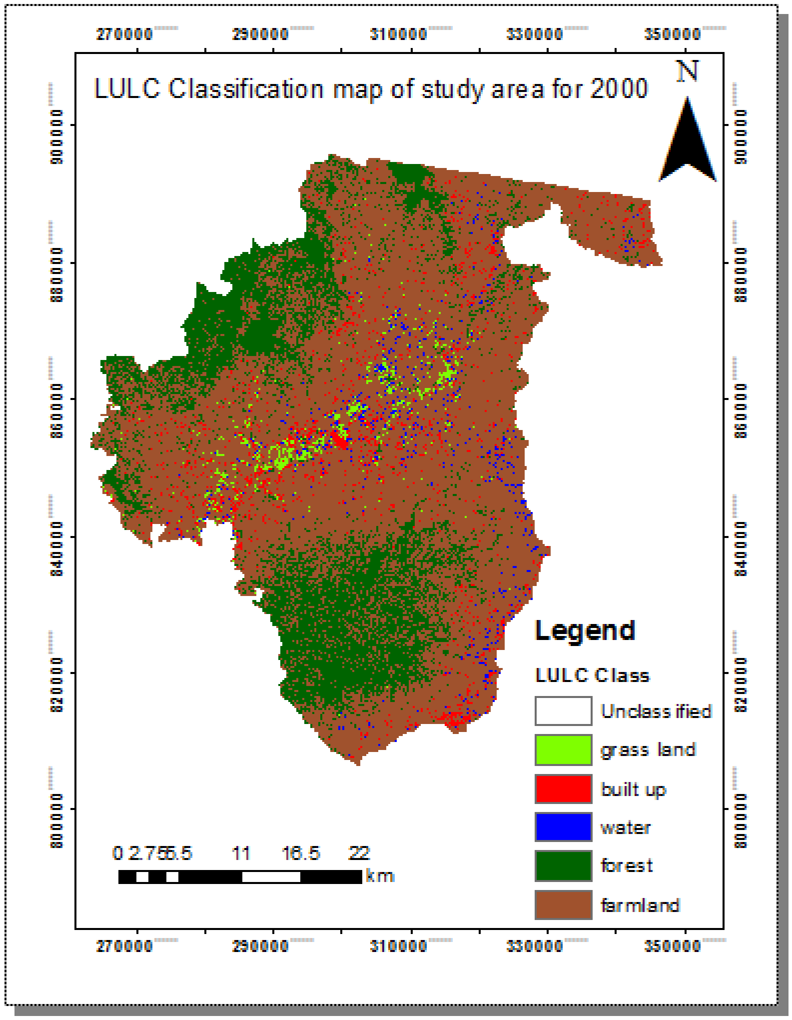


Figure 4. 3 LU/LC classification map of study area for 2000

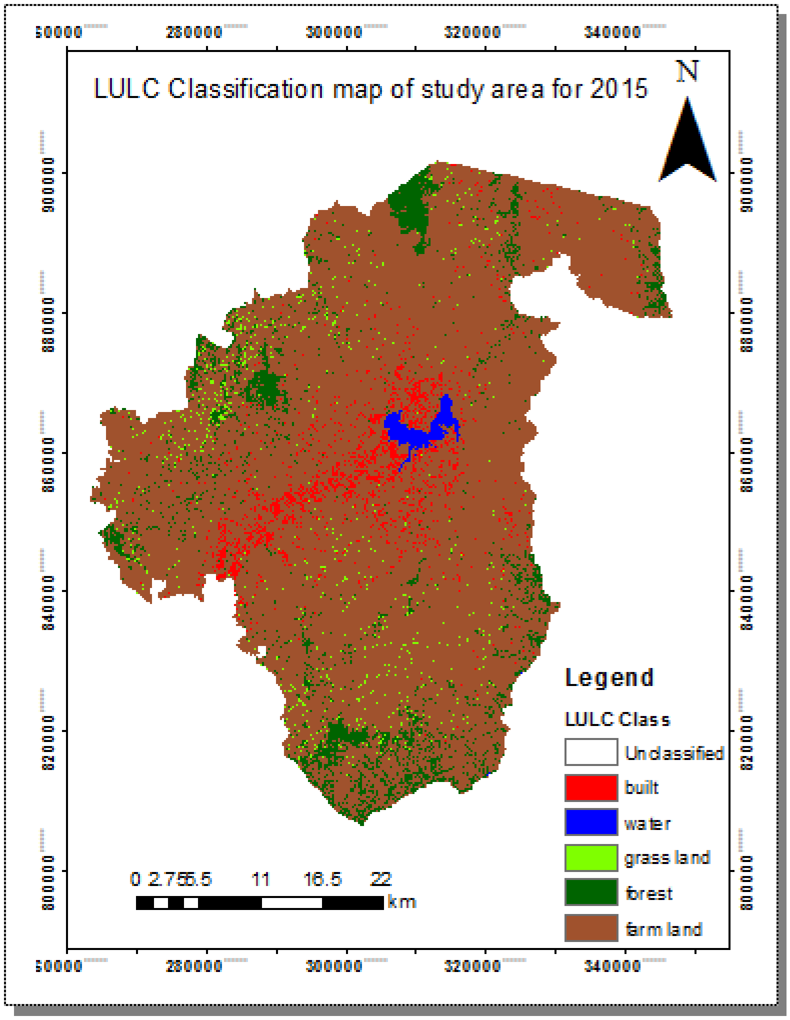
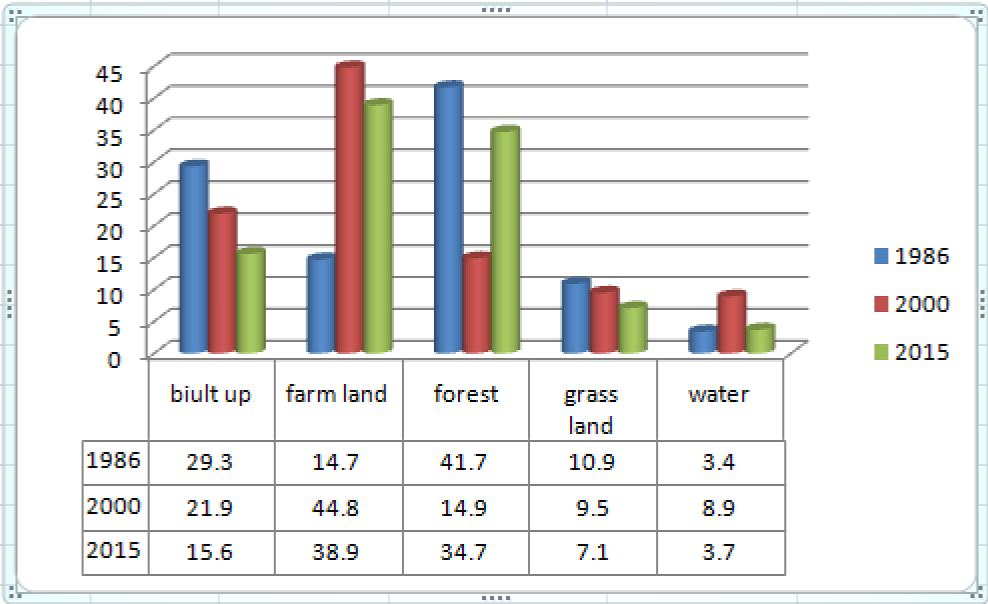


Figure 4. 4 LU/LC classification map of study area for 2015.



	biult up	farm land	forest	grass land	water
1986	29.3	14.7	41.7	10.9	3.4
2000	21.9	44.8	14.9	9.5	8.9
2015	15.6	38.9	34.7	7.1	3.7

Figure 4. 5 Temporal distribution of land cover area in percent from 1986-2015.

4.2. Classification Accuracy Assessment

Accuracy assessment for the land use land cover classification has been conducted and the 1986, 2000 and 2015 classification retained 92.8%, 92.5% and 94.55% respectively indicated in (Table4.2). In land use land cover classification, accuracy assessment and kappa statistics values are important to quantify the accuracy of the classification. The Kappa coefficient lies typically on a scale between 0 and 1 and usually multiplied by 100 to give a percentage measure of classification accuracy. This implies that the Kappa value of 0.80 represents a probable 80% better accuracy (Anderson, 1971). As a result, the overall accuracy and kappa values for the study year are acceptable.

The result showed the kappa values were 0.9277 for 1986, 0.9548 for 2000 and 0.9455 for 2015 classification and User accuracy of the study period were 92.77%, 95.50.38% and 94.55% for 1986, 2000 and 2015 respectively with corresponding to 0.88, 0.873 and 0.89 kappa statistics shown in (Table4.2). Almost all of the values in area were an indicative of a perfect agreement.

Table 4 2 Accuracy assessment and Kappa statistics for land use land cover classification 1986, 2000 and 2015

Year	LULC Class	Producer accuracy (%)	User accuracy (%)	Overall accuracy (%)	kappa statistics
	Built up	77.7 97.1	70		
	farmland	87.5	95.71		
	Forest	62.5	87.5	92.8	0.88
1986	Grassland		71.4		
	Water body	80.76	87.5		
	Built up	88.8	80		
	farmland	98.6	95.95		
2000	Forest	80	80	95.50	0.873
	Grassland	75	85		
	Water body	77.78	100		
	Built up	100	80		
	farmland	100	96.1		
2015	Forest	100	80	94.55	0.89
	Grassland	75	100		
	Water body	66.67	100		

Source: Analysis based on data obtained from Land sat images of 1986, 2000 and2015.

Moreover, user's accuracy and producers' accuracy also determined for all the three classified images. Users' accuracy measure the percentage of pixels or points mapped as a given class is indeed belongs to that class on the ground and producers' accuracy measure the percentage to which the ground reference data itself was correctly classified. Image 1986 was classified at maximum and minimum producers' accuracy 97.1 %(farmland) and 62.5 %(grassland) and Users' accuracy at maximum 95.1 %(farmland) and minimum70 %(built up) respectively. Image 2000 was classified at maximum and minimum producers' accuracy 98.6 %(farmland) and 75 %(grass land) and Users' accuracy at maximum100 %(water body) and minimum 80 %(built up) was classified. Similarly, for image 2015 all land use land cover classes were classified. Land use land cover class that classified producers' accuracy was 100 % (built up, forest and farmland) and grassland and water body 75%and 66.67% respectively. Users' accuracy of grassland and water body was 100%, built up and forest was 80% and farmland was 96.1%.

4.3. Land Cover Change Detection: Extent and Change

4.3.1. LU/LC Change Detection for 1986 to 2000

In the case of the year 2000, the area covered by built up decreased by 12,816.66 ha from 1986 which was 49,796.64ha. The forest cover decreased in 2000 by 45,185.26 ha from 1986, 70,345.08ha. In other words, from the analysis, it was found that, the forest cover declined from 41.7% in 1986 to14.9% in 2000 but in 2015increased to34.7% from 2000 which was 14.9%(Table4.1). In the study area, forest coverage showed a decrease between 1986 and 2000 in the area and the push factors were expansion of land for agriculture and construction of artificial dam lake. The study conducted by Gete and Hans, H. (2001), stated the quest for agricultural land is the one that made the deterioration of forest cover significant. Kebrom and Lars, H. (2000), also discussed the effects of cultivation land increase on the dramatic decrease of forest cover. The total cleared forest area between 1986 and 2000 was 45,185.26.6ha. Therefore, major deforestation took place in study area between 1986 and 2000 that decreased by 45,185.26 ha and the need for agriculture land was increased tremendously and cleared the forest. Land use land cover change with regard to forest cover, in 14 years from 1986 to 2000 the cover declined from 70,345 ha to 25,159.82ha in 2000.

Table 4 3 Land use land covers change for 1986- 2000

Land use/ land cover change class	Study years				change	
	1986 Hectares	%	2000 Hectares	%	1986-2000 hectares	%
built up	49796.64	29.3	36979.88	21.9	-12816	-10.61
farm land	24529.68	14.7	75648.34	44.8	51118	+42.35
forest	70345.08	41.7	25159.82	14.9	- 45185	-37.44
grass land	18390.24	10.9	16041.50	9.5	-2348	-1.95
water	5796.27	3.4	15028.35	8.9	9232	+7.65
total area	168857.91 ha	100	168857.91 ha	100		

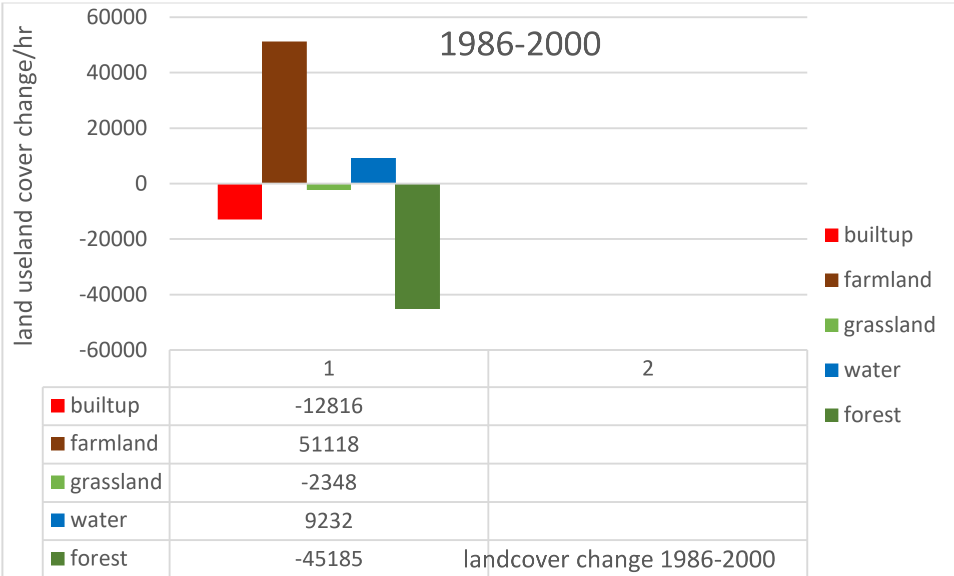


Figure 4. 6 : Land cover change from 1986-2000

4.3.2. LU/LC Change Detection for 2000 to 2015

From 2000 to 2015 the forest coverage increased by 33,433.87 ha and reached 58593.69ha in 2015. In this study, the expansion of agricultural land 75,648.34 ha in 2000 to 65,6885.72 ha in 2015 and built up decreased from 36,979.88 ha in 2000 to 26,341.83 ha in 2015. The group discussion and interview result also indicated, the forest cover was decreased from year to year due to timber production, fence, house construction wood, charcoal production, fuel wood and expansion of Agricultural land.[1]Gessesse and Johan, K. (2007), in their study found that, the forest cover mainly lost by expansion of agricultural land. The respondents also emphasized on the increase of expansion of agricultural land and settlement was affected the forest cover. The farmland area was decreased in 2015 by 9,962.62 ha from the second study year indicated (Table 4.4). With regard to built-up, in 2000 and 2015 constitutes 21.9% and 15.6%, respectively. Built-up coverage in 2000 was 36979.88 ha decreased to 26341.83ha in 2015 the built-up was decreased by 10,638.5ha.

Table 4 4 Land use land cover change for 2000-2015

Land use /land cover change class	Study years				change	
	2000 Hectares	%	2015 Hectares	%	2000-2015	%
built up	36979.88	21.9	26341.83	15.6	-10638	-15.84
farm land	75648.34	44.8	65685.72	38.9	-9962	-14.83
forest	25159.82	14.9	58593.69	34.7	33433	49.78
grass land	16041.50	9.5	11688.91	7.1	-4352	-6.48
water	15028.35	8.9	6247.74	3.7	-8780	-13.07
total area	168857.91 ha	100	168857.91 ha	100		

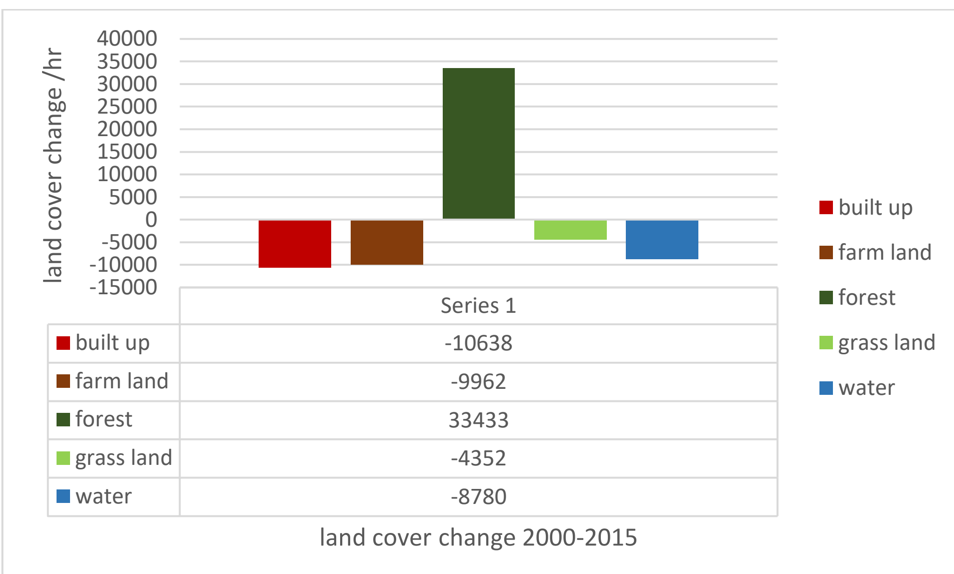


Figure 4. 7 : Land cover change between 2000and 2015.

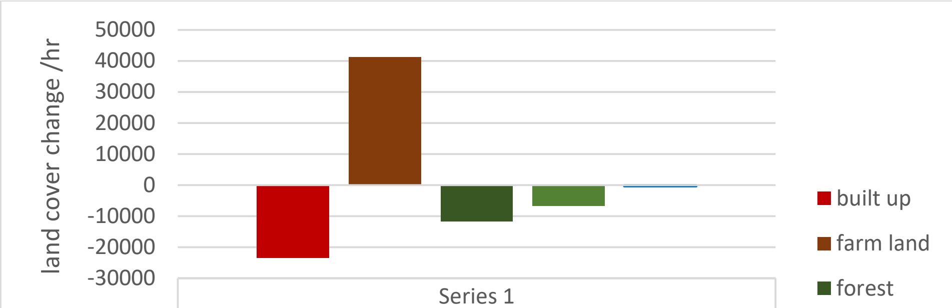
4.3.3 LU/LC Change Detection for 1986 to 2015

From initial to final year, built-up was decreased by 23,454.81ha. The settlement category result showed there was a change in coverage or settlement expanding from 1986 to 2015. Statistically, the area used for settlement in 1986 was 49,796.64 ha and this was decreased by 23,454.81ha and cover 26,341.83ha in 2015. During this time land use also showed the change that existed in the study area. In the case of farmland, the northern part of the study area was dominated by extensive farming system and the change was not significant, but in the south western and southern part clearly indicates an expansion of farmland area was increased by 41,156ha from reference year in 2015.

The water body coverage in1986 and 2015 was 5796.27 ha and 6247.74ha respectively. Between these years, water body was increased by 451 ha. The grassland land covers in 1986 and 2015was 18,390.24ha and 11688.91 ha respectively; decreased by 6,701ha. Settlements were decreased from time to time; between 1986 and 2015 settlement was decreased by 23454ha shown (Table 4.5)

Table 4 5 Land use/ land cover change for 1986-2015

Land use land cover change class	Study years				change	
	1986 Hectares	%	2015 Hectares	%	1986-2015	
built up	49796.64	29.3	26341.83	15.6	-23454	-28.08
farm land	24529.68	14.7	65685.72	38.9	41156	49.28
forest	70345.08	41.7	58593.69	34.7	-11751	-14.07
grass land	18390.24	10.9	11688.91	7.1	-6701	-8.02
water	5796.27	3.4	6247.74	3.7	451	0.54
total area	168857.91 ha	100	168857.91 ha	100		

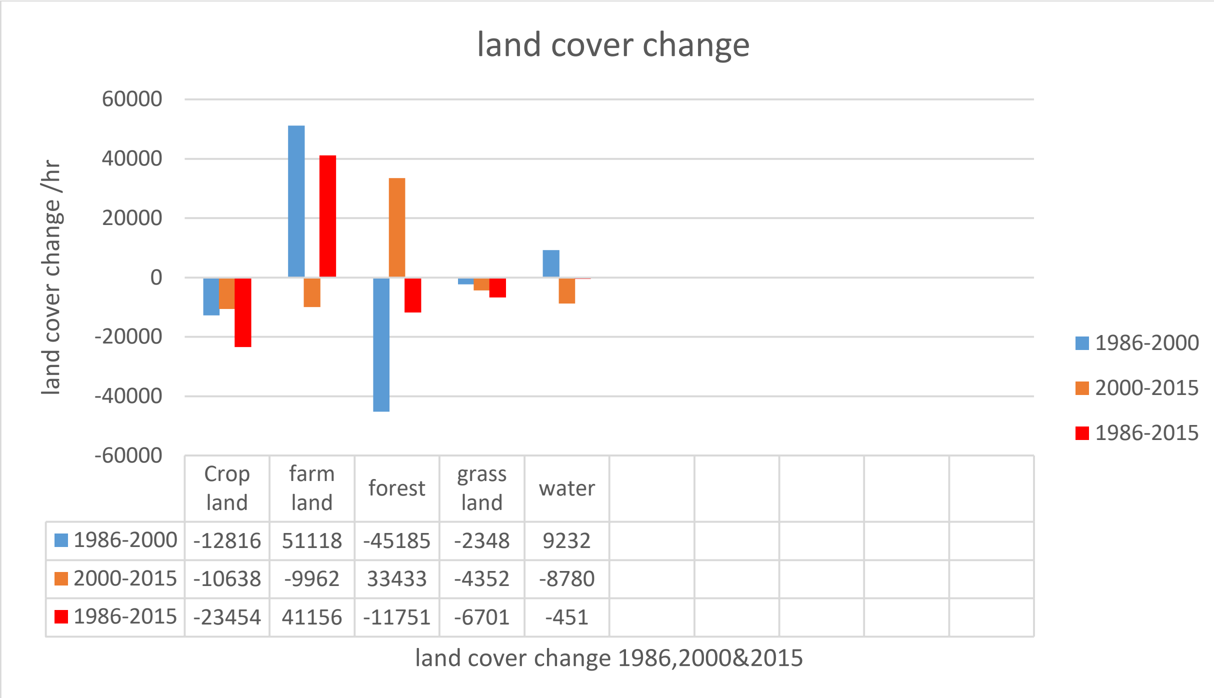


	Series 1
built up	-23454
farm land	41156
forest	-11751
grass land	-6701
water	-451

Figure 4. 8 Land cover land use change of between 1986-2015

The total area covered by forest in 1986 was 70,345.08 ha and after 30 years, in 2015 the forest coverage was decreased by 34.7% it reached58,593.69ha and this indicated the vulnerability and pressure on forest was increased. However, farm land, increased at least 2 times from 1986 total area, 24,529.68ha to 65,685.72 ha in the year 2015. The expansion of farmland and decline of forest coverage was a serious problem.

Generally, land use land cover change result shows changes were clearly identified. The expansion of farmland area and forest coverage was highly changed as compared to the other classes. Extensive hectares of forest land were changed to agricultural land and converted to other classes. Considering the 30 years, the forest area is deteriorating, statistical values also support this decline and about 11751 ha of land covered by forest were cleared for the expansion of agriculture and to some extent for settlement purpose. Clearly shows that land use land covers change from 1986-2015 in (Figure 4.9).



	Crop land	farm land	forest	grass land	water
1986-2000	-12816	51118	-45185	-2348	9232
2000-2015	-10638	-9962	33433	-4352	-8780
1986-2015	-23454	41156	-11751	-6701	-451

Figure 4. 9 Land use land covers changes for 1986, 2000 and 2015

4.3.4 Land use land cover change matrix

Land use land cover matrix was produced by overlaying two land use land cover maps of the same area to show the probability that one particular land use land cover category changed in to other land cover category**.** It is used to predicting the likely possible change between different particular states. In this study, from initial to final year transitional land cover matrixes were produced for each three periods of the studies in which column stands for the initial state of land use/ land cover categories and the row stand for the final state of land use land cover categories. Considering the land use land cover matrix indicated (table 4.4), the forest area about 16.70% in 1986 was changed to other classes in 2015. In the case of farmland category, from the 1986 area covered by farm land, gain 41,156ha which was 49.28% of area from other land use land cover classes and the water body from other classes dominated the increment to crop land category.

Table 4 6 Land use land cover matrix

	To 2015						
	Land use land cover classes	built up	farm land	forest	grass land	water	total class
	built up	31990	17569	9955	1320	3244	26341
	farm land	27197	17568	42356	9799	9436	65685
	forest	5139	23686	62737	12214	1788	58593
	grass land	36710	67704	3828	44138	1973	11688
	water	155	19169	5122	1685	7028	6247
From 1986	total class	4976	24529	7455	18390	5796	168857
	class change	-23454	41156	-11751	-6701	451	

4.4. Discussions

The extent, trend, and the change of each land cover classes in the study area were summarized as follows for the three study periods. In the first study period from 1986-2000, the analysis of both TM and ETM^{+} satellite images showed that the total size of land area covered by forest was 70,345.08 ha and 25159.82 ha respectively. In the second observation year (2000), it decreased in 44,985.26 ha of the study area due to the conversion forest to farmland and artificial dam lake. In the year 2000 -2015 forest increased by 3343ha and between the years 1986-2015 declined by 11,751 ha.

4.5. Analysis of Socioeconomic Data

According to FGD and KII *Gilgel gibe-1 sub catchment* experienced land cover dynamics during the study period. In different extents, forest land and farm land were converted to water body/settlement land. Moreover, the agricultural land expansion in to forest areas, timber, charcoal and fire wood was another major land cover dynamic in the area.[4]

4 All FGD and Informants: Mohammed Abba Gumbul, Amin Abba Fira and Mohammed Kedir

As 58years old DA worker in the study area stated that... "I was born and work here for 32 years within the district in different Kebeles. All most the whole areas in this district were covered by dense forest and grasslands during my childhood. Nowadays the forest coverage declined and totally changed. Not only forest everything is changed. The wild animals have been endangered. The amount of rainfall and temperature are also greatly changed. The livelihood in the area became difficult because there are no alternative sources of income without agriculture and selling forest products for the most people in the study area. Due to low amount of rainfall, crop production is decreasing from year to year and livestock is dying. During past times, farmers produce at least two times in a year (summer and Autumn seasons). Currently, farmers produce once in a year and the production is low when we compare with the past. Moreover, the charcoal, fuel wood extraction and timber harvesting is not easy task now. Before some years ago, they get forest products within short distances travelling. Now they travel long distances up to 3to 4 hours to collect fire wood and others forest products to house consumption as well as for selling."[5]

4.5.1. Major causes of land cover dynamics

Several land use land cover change studies carried out in different parts of Ethiopia showed that land cover change which resulted from land use change was activated by different factors such as immediate and proximate factors which broadly include social, economic, institutional and natural factors that drive land use land cover dynamics at different rates and extents based on different terrestrial and chronological circumstances (Emmanuel and Samuel, 2014). The recent study confirms with these studies and identified different drivers of land use land cover change in the study area for which mainly human being was responsible. These include livelihood situation, expansion of agricultural and settlement land that aggravated by population pressure, charcoal and fuel wood extraction, intensified timber harvesting and construction wood and ineffective forest management system and frequent fire. All these factors have been discussed as follows:

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5 Informants: Mohammed Kedir.

I. Livelihood situation

As both key informants and focus group discussants, agricultural activity including both crop production and animal rearing was considered as the major economic activity of the study area and it was the major source of income for the local community. Agricultural activity was widely practiced as the main source of income for the people of the study area. However, it couldn't generate enough annual income for most of the people for their family needs. Hence, they participated on other alternative sources of income like timber, fence wood, fire wood extraction and charcoal making to get additional income that helps them to fulfil their family needs by selling it to the nearby town. Therefore, such livelihood situation activity facilitated for decline of forest land.[6]

ii. Expansion of agricultural land and population pressure

The focus group discussants were agreed with this data during their discussion and they explained that population of the study area was increased from year to year by both high natural increase and in-migration to the study area from neighboring *Districts.* Agriculture was main livelihood for the local community on which most of the local community practiced agricultural activity as major income sources for their household needs. Agricultural land was increased from time to time to balance the increasing demand of food with population pressure. Then, as agricultural land increased from year to year and other land cover classes were decreased continuously such as forest land. [7]

Kassay (2004) stated that the expansion of cultivated land from 25 % in 1972 to 56.4 % in 2000 in the central highlands of Ethiopia due to expansion of farm land pressed by high population pressure. Emmanuel and Mulugeta (2014), also suggested that the continuous increment of agricultural land from 19.16 % 1973 to 65.6 % in 2004 in Nada Asendabo watershed, south western Ethiopia instead of forest land, grass land, bush land and riverine forest due to high population pressure and expansion of farm.

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6. FGD: Discussion with elder Women and Informants: Mohammed Kedir.

7. Informants: Tadese Gemeda, Mohamed Kedir and Genet Tolosa

iii. Charcoal and fuel wood extraction

As focus group discussants, the most common traditional energy sources like fire woods, charcoal and crop residuals were identified as the dominant sources of energy for the study area. Fire wood and charcoal was not only sources of energy for local population. It was the sources of income by selling it for the town population.[8] A key informant supported that population growth of the study area pressure the local community to engage in exhaustive charcoal production and fire wood extractions to get income for their basic needs. Specially, economically ineffective households were involved in these activities. Therefore, intensive firewood extraction and frequent charcoal production of the study area have been considered as the main cause for the destruction of forest land of the study area.[9]

As stated in Messay (2011) woodland was tremendously declined in Nonno district, Central Ethiopia due to intensified extraction of fuel wood, construction wood, charcoal making, farm equipment's and cropland expansion. Additionally, Zenebe (2007) showed that devastation of remnant natural forests in Tigray regional state was resulted from the alarming rate of agricultural land expansion, fuel wood collection, timber harvesting forced by increased human pressure.

iv. Intensified timber harvesting and construction wood

A key informants and focus group discussants agreed that timber and construction wood products for domestic use such as house construction, farm tools, simple furniture and fence highly demanded in all parts of rural areas. In addition, the small land holders and landless community in the study area mainly engaged in timber harvesting and fence wood extraction illegally and sell it to the local communities nearby markets at night. In the same way, Zenebe (2007) revealed that destruction of remnant natural forests in Tigray regional state was resulted from the alarming rate of agricultural land expansion, fuel wood collection, timber harvesting forced by increased human pressure which can be considered as causes for change in the forest structure that resulted mostly in transition between forest, shrub land and grassland. Furthermore, the key informants stated that forests close to settlement areas were vulnerable to great extraction of construction woods and timber products and resulted in fast deforestation which is similar to the findings of the studies conducted by Yosef (2014) in Anferara Wadera high forest. _______________

8FGD: Discussion with elder Women. 9Informants: Husen Ali and Tadese Gemeda

v. Ineffective natural resource conservation

According key informant's population pressure and agricultural land expansion considered as main factors that enforced local communities to forest extraction to increase food production for their household needs in study area. This forest and other natural resource destruction were occurred due to ineffective conservation and protection of natural resources of the study area.[10] As FGD discussants expressed.... "The proper natural resource conservation and planning was weak especially in forest resource. Therefore, the conservation method should be applied to recover the forest by creating awareness to the societies, government must be take more responsibility, the salary of guards that protect forest is very small. Due to this, they participated in selling forest products or works with those people engaged in timber production to get additional incomes. In addition to this, the numbers of guards are very small and they have no training regarding forest conservation method. Therefore, increasing the numbers of guards, giving training regarding natural resources conservation and improve their salary is possible solution. The government must revise strategies and policies related to natural resources and additional investigation is needed because during Derg regime there was better forest resources management in the area."[11]

4.6. Impacts of Land Cover Dynamics on the Study Area

4.6.1. Impacts on socio economic development

The forest land cover was entirely deforested and converted to other land cover within the indicated period of time. Selling of fuel wood and other forest products were alternative source of income in study area. Additionally, local communities engaged in collecting medicinal plants and selling it for local dwellers. Gathering and selling medicine plants economically useful plants shows that there has been a tremendous loss in plant biodiversity over the last half century (Nanyunja, 2003).

10 Informants: Mohammed Abba Gumbul, Genet Tolosa, Amin Abba Fira and Mohammed Kedir.

11 FGD: Discussion with Elder Men and Rich Farmers.

Therefore, according to the key informants, due to weak natural resource conservation, the forest trees of the study area were destroyed. As a result, indigenous trees which were planting previously are now in the way to disappear. Today, these indigenous trees are found only in protected areas. The impacts of land use land cover change on the livelihood of communities brought drought most frequently. Before 20 years, they cultivated a crop twice a year. Now days, due to forest resources shrinking, there is the shortage of rainfall that caused shortage of production and lack of income.

12 Informants: Genet Tolosa, Amin Abba Fira and Mohammed Kedir.

Informants stated that…. ‘‘In the past, the soil was very fertile. As a result, farming was very easy and productivity was also very high. During that time, cultivation was on small plot of land and the other part of the land was for livestock grazing. There was no need of fertilizer even we were not using animal manure. Large plot of land was under fallowing so that there was no other conservation measure we put into practice. Currently, we plough large plot of land but every land requires fertilizer to increase the productivity. Now, without fertilizer the land doesn't give yield and production decreases from year to year. As result, we faced shortage of food and unable to cover the expenses like chemical Fertilizers, insecticides and herbicides. Furthermore, we need government supports to improve our livelihoods. Generally, currently, our livelihood faced difficulty both socially and economically.”[13]

4.6.2. Impacts on Extinctions of biodiversity

Rapid land cover dynamics reduced quantity and quality of biodiversity from year to year which highly affect natural ecosystem of the earth's surface. In Ethiopia land cover change has significantly affected plant biodiversity that strongly related with loss of wild animals (Messay, 2011). Wildlife diversity is generally the decline species of wildlife have declined strongly around the park and forest area (Lamprey and Mitchelmore1996). The reasons for losses of biodiversity are the expansion of agriculture to other land cover classes (Dublin, 1995). FGD similarly stated that the decline of forest cover caused a decline in the number of wild animals in study area. For example, animals such as tiger and lion which were commonly found in the study area now disappeared. [14]

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12 Informants: Genet Tolosa, Amin Abba Fira and Mohammed Kedir.

13 Informants: Mohammed Kedir, Genet Tools', Mohammed Abba Gumbul and Amin Abba Fira.
14 FGD: Discussion with all group

4.6.3. Impacts on climatic variability

Land cover dynamics have also different impacts on local and regional climate of the world (Solomon, 2005). Climate change affected water resources and soil formation systems directly and indirectly (Mesfin, *et al*., 2016). Similarly, agricultural officers and forestry experts in study area agreed that the local communities deforested the forest area to obtain different forest products that maintain local climates. The study area exhibited a gradual warming with decreasing rain fall. Furthermore, the climatic changes were unfavorable to agricultural activities. Therefore, recently local communities faced shortage of rain fall as well as unseasonal rainfall. The decline in forest and rainfall resulted in decline in agricultural production and productivity. This forced local communities to live under difficult livelihood situation.[15]

4.6.4. Impacts on Soil Degradation

Soil degradation facilitated by soil erosion and loss of soil fertility by different agents mainly water. It was commonly caused by human activities such as deforestation, agricultural land and burning forest. Due to rapid population growth, Soil degradation in the form of soil erosion is common particularly in the northern and central high lands of Ethiopia (Hurni, 1993).The effect of land degradation includes insufficient crop production, decline in the quality and quantity of water supply, famine, soil erosion and climate change (Solomon, 2005).Likewise, an informant in study area stated that, soil erosion was most common in cultivated land washed out by running water and develops gully erosion that reduced cultivated land. Due to population pressure, land resources were become fragmented and forest coverage declined. Additionally, farmers in study area used chemical fertilizer unknowingly which resulted in soil degradation and environmental pollution. On the other hand, the water bodies such as rivers, streams and ponds were declined and dry out due to deforestation. Now days, it is difficult to search water in most for livestock and home consumption and we travel a long distance to obtain water. This affected our working time and energy.[16]

15 Informants: Tadese Gemeda and Kedir Tufa.

16 Informants: Mohammed Kedir and Hawa Kemal.

4.7. biophysical impacts of artificial dam lake on the study area

Dams represent one of the most significant human interventions in the hydrological cycle. Through provision of water for drinking, irrigation and electricity, they have supported human socio-economic development, but simultaneously they have had a considerable impact on freshwater ecosystems. Where water is over-extracted, its quality degraded or hydrological regimes modified, the natural environment deteriorates, habitats are destroyed and ecological functions, many of which enhance peoples well-being, are lost.

It is estimated that inter-basin transfers and water withdrawals for supply and irrigation have fragmented 60% of the world's rivers (Revenga *et al*. 2000). For most of the world's existing stock of dams, environmental issues played little part in their design and operation. However, in the last two decades, an increase in environmental awareness has led to the recognition that the management of water resources includes a responsibility to protect the users of water, and the natural resources that depend on water, from over-utilization or impacts that cause degradation. As a result, considerable effort has been invested in developing approaches to lessen the most damaging effects of dams. However, experience indicates that the success of these measures is extremely variable and far from assured (Bergkamp *et al*. 2000).

4.7.1. Abiotic impacts of dams

Rivers exist as a continuum of linked surface and groundwater flow paths and are important natural corridors for the flows of energy, matter and species. The spatial and temporal heterogeneity of river systems is responsible for a diverse array of dynamic aquatic habitats and hence biological diversity, all of which are maintained by the constantly changing flow regime. Inundation of floodplains increases organic matter decomposition and nutrient cycling and has led to the evolution of adaptive strategies that are tightly coupled to the flood regime.

Dams constitute obstacles for longitudinal exchanges along fluvial systems and so result in discontinuities in the river continuum (Ward and Stanford 1995). Post impoundment phenomena directly and indirectly influence a myriad of factors that affect natural processes and so, ultimately, alter the ecological structure of ecosystems, sometimes tens or even hundreds of kilometers downstream.

4.7.2. Impacts on flow regime

The most obvious impact of storage reservoirs is the upstream inundation of terrestrial ecosystems and, in the river channel, the conversion of lotic to lentic systems. Dams also alter the downstream flow regime. The effect of a dam and its reservoir on flow regimes depends on both the storage capacity of the reservoir relative to the volume of river flow and the way the dam is operated. The most common attribute of flow regulation is a decrease in the magnitude of flood peaks and an increase in low flows. A consequence of reduced flood peaks is reduction in the frequency and extent of overbank flooding. For example, in the Hadejia-Nguru wetlands in Nigeria, annual flooding of about 3,000 km^2, prior to the building of dams was reduced to less than 1000 km^2 after construction (Hollis *et al*. 1993). In some circumstances, operational procedures can result in rapid flow fluctuations that occur at non-natural rates. Hydroelectric power and irrigation demands are the most usual causes, but short-duration high discharges are also utilized for navigational purposes and for recreation. For many purposes, so called pulse releases are made regularly. For example, daily releases through power turbines often reflect diurnal variation in power demand.

4.7.3 Impacts on thermal regime

Water temperature influences many important ecological processes. Temperature is an important factor affecting growth in freshwater fish, both directly and indirectly, through feeding behavior, food assimilation, and the production of food organisms. Under natural conditions the relatively small volume of water in a river section and turbulent mixing ensure that river water responds rapidly to changes in the prevailing meteorological conditions. In contrast, the relatively large mass of still water in reservoirs allows heat storage and produces a characteristic seasonal pattern of thermal behavior. Depending on geographical location, water retained in deep reservoirs may become stratified. Releases of cold water from the hypolimnion (i.e. the deep cold layer) of a reservoir, is the greatest non-natural consequence of stratification. However, even without thermal stratification, water released from reservoirs is often thermally out of phase with the natural regime of the river.

4.7.4 Impacts on chemistry

Water storage in reservoirs induces physical, chemical and biological changes, all of which affect water chemistry. Consequently, the water discharged often has a very different composition to that of inflowing rivers. Nutrients, particularly phosphorous, are released biologically and leached from flooded vegetation and soil. Oxygen demand and nutrient levels generally decrease as the organic matter decays.

Some reservoirs require many years for the development of stable water-quality regimes. After maturation reservoirs can, like natural lakes, act as nutrient sinks. For example, in comparison to the inflows, mean concentrations of orthophosphate in the outflows from the Callahan Reservoir, Missouri, USA, were reduced by 50% (Schreiber and Rausch 1979). Eutrophication of reservoirs may occur as a consequence of large influxes of organic material and nutrients, often arising as a consequence of anthropogenic activity in the catchment (Chapman 1996). Hence catchment management has a key role to play in sustaining reservoir water quality.

The quality of water released from a reservoir is determined by the elevation of the outflow structure(s). Water released from near the surface is generally well-oxygenated, warm, nutrient-depleted water. In contrast, water released from near the bottom is often cold, oxygen-depleted, nutrient-rich water that may be high in hydrogen sulphide, iron and manganese.

Bacterial decomposition of material in reservoirs can transform inorganic mercury into methylmercury, a toxin of the central nervous system. Bioaccumulation results in levels of methylmercury in the tissues of fish at the top of the food-chain several times higher than in small organisms at the bottom of the food-chain (Bodaly *et al.* 1984). This can have serious implications for people that depend on fish for a large proportion of their diet. For example, mercury levels in hair samples of Cree Indians in the James Bay region of Quebec in Canada, were found to be above the World Health Organizations recommended upper limit (i.e., 6 ppm by weight) as a consequence of eating fish from reservoirs (Dumont 1995).

4.7.5. Impacts on sedimentation

Reservoirs reduce flow velocity and so enhance sedimentation. The rate at which sedimentation occurs within a reservoir depends on the physiographic features and land-use practices of the catchment, as well as the way the dam is operated. Large magnitude and frequent fluctuation in water levels in reservoirs can cause erosion of the shores and add to deposition. It is estimated that between 0.5% and 1% of the storage volume of the world's reservoirs is lost annually due to sediment deposition (Mahmood 1987).

Downstream of a dam, reduction in sediment load in rivers can result in increased erosion of river-banks and beds, loss of floodplains (through erosion and decreased over-bank accretion) and degradation of coastal deltas. Removal of fine material may leave coarser sediments that armour the riverbed, protecting it from further scour. In some circumstances, material entrained from tributaries cannot be moved through the channel system by regulated flows, resulting in aggradation. Reservoir flushing (i.e. the selective release of highly turbid waters) is a technique sometimes used to reduce in-reservoir sedimentation. Consequently, reservoir operations may periodically result in unnaturally high concentrations of sediment in downstream systems.

4.7.6. Impacts on organisms and biodiversity

Dams, through disruption of physiochemical and biological processes, modify the conditions to which ecosystems have adapted. The impacts of dams vary substantially from one geographical location to another and are dependent on the exact design and the way a dam is operated. Every dam has unique characteristics and, consequently, the scale and nature of environmental changes are highly site-specific. However, impacts invariably affect biota and can impact biodiversity.

4.7.7. Impacts on primary production

The introduction of a dam into a river system affects primary production. In freshwater ecosystems, phytoplankton, periphyton and macrophytes form the base of the food web. Upstream of a dam, the slow-moving water of the reservoir is often an ideal habitat for phytoplankton, but, depending on depth, temperature, light penetration and the nature of the substrate, may be less suited for periphyton and rooted macrophytes. Downstream of a dam, primary production is affected by the changes to flow, water chemistry and thermal regimes, as well as current velocities and turbidity. In many temperate climates, increased summer flows, higher water temperatures in winter, reduction of turbidity, decreased scouring of the substrate and reduced effluent dilution often enhance primary production. Modification of primary production may alter the aquatic environment directly. For example, blooms of phytoplankton and floating plants (e.g. water hyacinth) reduce light penetration and deplete oxygen when they decompose, and so have an adverse impact on other species (Joffe and Cooke 1997).

Dams can also affect riverside and floodplain vegetation, the characteristics of which are often controlled by the dynamic interaction of flooding and sedimentation. By changing the magnitude and extent of floodplain inundation and land-water interaction, dams can disrupt plant reproduction and allow the encroachment of upland plants previously prevented by frequent flooding. Studies in Norway have shown that the presence of storage reservoirs permanently reduces the diversity of riparian vegetation (Nilsson *et al.* 1997).

4.7.8. Impacts on fish

Few fish are adapted to both lotic and lentic habitats. Consequently, the transformation of a river to a reservoir often results in the extirpation of resident riverine species. Downstream of dams, marked changes in fish populations occur as a consequence of blockage of migration routes, disconnection of the river and floodplain and changes in flow regime, physiochemical conditions (e.g. temperature, turbidity and dissolved oxygen), primary production and channel morphology. These changes may benefit some species but they generally have an adverse effect on the majority of native species.

The 1996 IUCN Red List of Threatened Animals includes 617 freshwater fishes (i.e. about 6% of the known number of freshwater species). Other researchers have speculated that globally between 20% and 35% of all freshwater fish are threatened (Staissny 1996). Although the loss of species is not solely a consequence of dams, they are one of the principal factors. It is estimated that half the fish stocks endemic to the Pacific coast of the USA have been lost in the past century to a large extent because of dam construction (Chaterjee 1998).

4.7.9. Impacts on birds and mammals

The importance of riparian corridors for birds and terrestrial animals has been demonstrated (e.g. Decamps *et al.* 1987). The creation of reservoirs has both positive and negative effects for aquatic and terrestrial species. The inundation of ecosystems inevitably leads to the loss of habitat and terrestrial wildlife. In tropical areas, flooding forests high in endemic species extirpates many and, in some circumstances, may result in species extinction. In contrast, in arid climates, reservoirs provide a permanent water resource that may benefit many species. In South Africa, the presence of reservoirs has greatly increased the availability of permanent water bodies, and has had a major effect on the distribution and numbers of waterfowl (Cowan and Van Reit 1998).

The most negative downstream consequence of river regulation on mammals and birds is the disruption of the seasonal flood regime along the river (Nilsson and Dynesius 1994). In the long term, reduced flooding can alter vegetation communities that may be important for a wide range of mammal and bird species. In arid regions, riparian vegetation may be the only significant vegetation, and many animals will have adapted behavioral patterns to fit with seasonal flooding. If the flooding regime is altered, changes in vegetation may place at risk the birds and animals that depend on it.

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusions

Gilgel gibe-1 sub catchment is one of the *catchment* in the Oromia Region of Ethiopia. It's a Part of the Jimma Zone. Change detection of land cover dynamics and its trend and extent description of the driving forces of the dynamics are the most important information for environmental resource planning and management. This study focused on quantitative analysis of satellite image integrated with qualitative data to investigate past and present land cover change conducted in *Gilgel gibe-1 sub catchment*. This study provides three land cover maps from quantitative analysis of satellite images that used to detect the dynamics of land cover and its transitional matrix. There are five land cover classes identified during satellite image classification namely: forest land, water body, grass land, farmland and built up. The quantitative analysis of satellite images of the study area showed that the occurrence of significant land cover dynamics in the study area was between 1986 and 2015.

The land use land cover classification result for the reference year 1986, the largest area was covered by forest land and small area by water body, which constitutes 41.7% (70,345.08ha) and 3.4% (5796.27ha) respectively. The farmland, built up and grassland were covered24,529.68ha (14.7%), 49,796ha (29.3%)and18,390.24ha (10.9%) respectively. The land use land cover classification for the year 2000 area was covered by forest land 25,159.82ha (14.9%), farmland 75,648.34ha (44.8%), built-up 36,979.88ha (21.9%), grassland 16041.50ha (9.5%)and water body 15028ha (8.9%) respectively.

In final year (2015) land use land cover classification analysis the study showed that the farmland 65685.72ha (38.9%), forest 58593.69ha (34.7%), built-up 26341.83ha (15.6%), grassland 11688.91ha (7.1%) and 6247.74ha (3.7%)respectively. The change was significant and continuous on forest due to high demand for agricultural land, charcoal making and fire wood. Agricultural increased continuously in the entire study periods to balance the increasing demand of food for the rapidly growing population. In addition to this, the socioeconomic factors like population pressure, agricultural and settlement land expansion, charcoal making, fuel wood extraction, construction materials, timber wood harvesting and ineffective natural resource conservation methods were clearly shown as drivers of land cover dynamics of the study area.

The management of natural resources and particularly freshwater will be a key human endeavor in the 21st century. Given the large number of existing dams and those that may be built in the future, it is clear that humankind must live with the environmental and social consequences for many decades to come. Most dams are built with the best of intentions: to provide water supplies and power at times when water is naturally scarce and to reduce the devastating effects of floods. These are all worthy reasons for river regulation. However, it is now recognized that if development is to be sustainable, the effects of impoundment on ecosystems and other species cannot be neglected. Minimizing the negative environmental effects of dams must become a prime focus of attention by owners, operators, financial institutions and environmental managers.

A prerequisite for sustainable development is that future dam planning, construction and operation must become part of an integrated management effort that gives prominence to environmental protection. All the environmental impacts of a dam should be evaluated within the specific environmental, social and economic context of the catchment in which it is located. This requires inter-disciplinary thinking and basic understanding of the complex interactions between ecological and socio-economic systems. This is particularly true of environmental flow releases, where lack of hydro-ecological understanding remains a key constraint to successful implementation. There is an urgent need for further research to link abiotic processes and the impact of dams on these processes to ecological change and the socio-economic consequences.

5.2. Recommendations

The study showed that different driving factors including livelihood situation of population, expansion of agricultural, settlement land, timber harvesting, fence wood, charcoal making, intensive fuel wood extraction, construction materials, fire and lack of effective management of natural resource were contributed to the transformation in the study area. Therefore, based on the findings of this study to minimize the impacts faced by inappropriate land management strategies, the following points are recommended:

- In order to solve agricultural land shortage problem and destruction of natural forest for expansion of agricultural land should be adopted and alternative economic activities should be encouraged by administrative of the *sub-catchment districts.*
- Encourage local community and indigenous knowledge and planting wood lots to reduce the influence on the natural forest and give more responsibility to community with appropriate management incentives.
- Fuel wood was the dominant energy source for house hold energy consumption and distinguished as one factor that increases deforestation. Therefore, to decrease the devastation of natural vegetation, the administrative of the sub –catchment districts, especially Natural Resource Management Offices should raise awareness of the communities to use alternative energy like biogas.
- Provide a short term Training and technical support exposure to natural resource management experts should be implemented in the area integrating with Zone and Regional responsible bodies.
- The amount of water in the Gilgel gibe-sub catchment especially Gilgel gibe-1hydroelectric power dam lake water decreased time to time, it may collapse the 50 years’ plane of using dam, if all the concerning bodies participate on planting trees i.e. reforestation and afforestation in the sub-catchment.

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APPENDIXES

Appendix I: Interview Guide

Dear respondents

My name is Tilahun Tadese. I am a postgraduate student at Jimma University, Department of Geography and Environmental studies. Now I am writing my thesis on the spatiotemporal land cover dynamics in *Gilgel gibe-1 sub- catchment*, *Jimma* zone, south west Ethiopia. You have been selected purposively from experts in *Gilgel gibe-1 sub- catchment districts* Agricultural office, Developmental Agents, chair persons and forest management office of study area. The responses you give are important and used for the analysis of this research. You not be identified by your name in any case. If you accept to participate in this research you so voluntarily. You are also free to refuse to respond to any questions you do not feel comfortable or to withdraw from the research participation.

Thank you.

Interview Guide 1: To be administered to Chair person, Agricultural office, Forest management office and Developmental Agents of *Gilgel gibe-1 sub catchment districts.*

Part I: - Background of Key informants.

1. Age __________
2. Sex   _________
3. Level of education________________________________
4. Your position in the Office_____________________
5. Year of services in the Office_____________________

Part II. Interviews about land cover dynamics and its impacts.

1. For how many years do have you been hear ?
2. Can you please describe land cover dynamics in the area from1986-2015?
3. What do you think the main causes of land cover change?
4. Which period is remarkable for you in the process of forest cover declining?
5. Which type of land cover classes increases, decrease and unchanged?
6. What are the major socio economic impacts of land cover change in *Gilgel gibe sub-catchment district*?
7. What do you recommend to avert the impacts?

The focus group discussion Guide: to be administered to poor farmers and rich farmers, Elderly Men and Women of the study area.

Part I: - Background of focus group discussants

1. Age __________
2. Sex   _________
3. Level of education________________________________
4. Your major source income _____________________
5. is there additional source of income, please mention____________________?

Part II. Focus group discussants about land cover dynamics and its impacts discussion Points

1. What are the main livelihoods you practiced to sustain your family?
2. How do you see the population number of this area? Increasing or decreasing?
3. What do you think is there significantly changed land cover in *your district?*
4. Which land cover has greatly changed over the last 29 years?
5. Which period is remarkable for you in the process of forest cover declining?
6. What does the trend of natural forest cover look like in this area?
7. What do you suggest the major causes of land cover change?
8. Please can you describe any land cover types that significantly increase, decrease and unchanged?
9. What are the major socio economic impacts of land cover change in your area*?*
10. What do you recommended possible solutions to be taken to reduce the impacts of land cover dynamics of the area?

Appendix II: Profile of key informants.

No	Name	Sex	Age	Religion	Family size	Marital status	Position	Education level
1	Mohammd Kedir	M	58	Islam	4	Married	Development agent worker	Diploma
2	Tadese Gemmeda	M	42	Christin	3	Divorce	Forest management officer	Degree
3	Hawa Kemal	F	39	Islam	4	Married	Expert in agricultural office	Degree
4	Genet Tolosa	F	45	Christin	5	Married	Development agent worker	Diploma
5	Mohammed Abba Gumbul	M	47	Islam	4	Married	Chair person	Grade complete 12
6	Amin Abba Fira	M	50	Islam	6	Married	Chair person	Grade complete 10
7	Kedir Tufa	M	35	Islam	1	Single	Forest management officer	Degree
8	Husen Aman	M	37	Islam	1	Single	Expert in agricultural office	Degree