

ADDIS ABABA UNIVERSITY



**College of Social Sciences
Department of Geography and Environmental Studies
Land Resource Management Stream**

***Detecting Land use/Land cover Change using Remote Sensing
& GIS Techniques and Analysis of its Causes ,Consequences
and trends in Ofla wereda, Tigray Region, Ethiopia***

**By
ABIY WOGDERES ZINNA**

A Thesis Submitted to the School of Graduate Studies of Addis Ababa
University, College of Social Science, Department of Geography
and Environmental Studies in Partial
Fulfillment of the Requirement for the Degree of Master of Art in
Land Resource Management

June, 2014

ADDIS ABABA UNIVERSITY



**College of Social Sciences
Department of Geography and Environmental Studies
Land Resource Management Stream**

***Detecting Land use/Land cover Change using Remote Sensing & GIS
Techniques and Analysis of its Causes ,Consequences and trends in
Ofla wereda, Tigray Region, Ethiopia***

**By
ABIY WOGDERES ZINNA**

A Thesis Submitted to the School of Graduate Studies of Addis Ababa
University, College of Social Science, Department of Geography
and Environmental Studies in Partial
Fulfillment of the Requirement for the Degree of Master of Art in
Land Resource Management

**Advisor
Dr. Muluneh W/Tsadik**

June, 2014

ADDIS ABABA UNIVERSITY



**College of Social Sciences
Department of Geography and Environmental Studies
Land Resource Management Stream**

***Detecting Land use/Land cover Change using Remote Sensing & GIS
Techniques and Analysis of its Causes ,Consequences and trends in
Ofla wereda,Tigray Region,Ethiopia***

**By
ABIY WOGDERES ZINNA**

A Thesis Submitted to the School of Graduate Studies of Addis Ababa
University, College of Social Science, Department of Geography and
Environmental Studies for Partial
Fulfillment of the Requirement for the Degree of Master of Art in
Land Resource Management

Signed by the Examining Committee:

Examiner Dr. Ephrem G/Mariam Signature _____ Date _____

Examiner Dr. Desalegne Wana Signature _____ Date _____

Advisor Dr. Muluneh W/Tsadik Signature _____ Date _____

Chairman, Department

Dr. Tebarek Leqa Signature _____ Date _____

ACKNOWLEDGEMENT

First and foremost, I would like to thank, the Almighty God. who made it possible to begin and finish this study successfully.

I would like to extend my deepest gratitude and appreciation to my supervisor, Dr. Mulneh Woldetsadik for his expert guidance and concerned supervision throughout all steps of the research. His critical comments has contributed immensely to the completion of the thesis. I am so grateful for that provided sharp eyed comments and critical assistance.

My warm and special thanks goes to Atiresheawal Girma(Atir), for the data entry and her unreserved and tireless support. I am also indebted to Ato Sisay Guta, for arranging my field work in line with CSA field to use vehicles and get assistance from the Mekelle branch office.

I am grateful to all my family members (Atse, Abe, Kure, mestu and Yemane). Adi, Endale and Sele your encouragement is unforgettable. Mekdi has helped me in writing and giving comments on the document and deserves many thanks.

Had it not been just for a matter of space, I would have been happy to mention the names of all those, who, in one way or another, have contributed to the accomplishment of this work, my deepest gratitude goes for all of them.

Table of Contents

CHAPTER ONE	1
1 INTRODUCTION	1
1.1 Background	1
1.2 Statement of the problem	3
1.3 Objective	5
1.4 Significance of the study	5
1.5 Limitation of the study	5
1.5 Organization of the Study	5
CHAPTER TWO	6
2 LITERATURE REVIEW	7
2.1 Theoretical framework	7
2.1.1. Definition and rationale of Land use/Land cover change study	7
2.1.2. Application of Remote sensing and GIS for Land use/Land cover analysis	8
2.2 Land use/Land cover change in Ethiopia	10
2.3 Causes, Rate and Trend of land use/land cover Change	12
CHAPTER THREE	18
3 MATERIALS AND METHODS	18
3.1 Description of the study area	18
3.1.1 Location and relief	18
3.1.2 Population	19
3.1.3 Climate	19
3.1.4 Soil	20
3.1.5 Crop Condition	21
3.2 Data Acquisition	22
3.2.1 Satellite Imagery	22
3.2.2 Household Questionnaire and Focus Group Discussion	23
3.2.3 Software Packages and Dataset	23
3.2.4 Projection of the data	24
3.3 Methodology	26
3.3.1 Image processing	26
3.3.2 Development of classification scheme	26
3.3.3 Image Segmentation	27
3.3.4 Object based Classification	28
3.3.5 Accuracy Assessment	28
3.3.6 Land use/land cover change analysis	29
3.3.7 Establishing the main drivers of Land use/Land cover Change	30
3.3.8 Sampling Design for Household Surveys	30
3.3.9 Sample Size Determination	30
3.3.10 Method of socio economic data analysis	31
CHAPTER FOUR	32
4 DATA ANALYSIS	32
4.1 Landsat Multi spectral scanner (MSS) data	32
4.2 Landsat Thematic Mapper (TM) data	34

4.3 Landsat 8 data	36
4.4 Accuracy Assessment	38
4.5 Change Detection Analysis.....	39
4.6 LULC Change Map.....	40
4.7 Analysis of Socio-Economic Survey	44
4.7.1 Age - Sex Composition.....	44
4.7.2 Marital Status.....	44
4.7.3 Literacy Status of Respondents.....	45
4.7.4 Off - Farm Income	45
4.7.5 Land Size	45
4.7.6 Land condition	46
4.7.7 Land Productivity.....	46
4.7.8 Land use land cover change.....	47
4.7.9 Causes of Land use land cover change	47
4.7.10 Effect of Land use land cover change.....	48
4.7.11 Land improvement measure.....	49
CHAPTER FIVE	51
5 RESULTS AND DISSCUSSION.....	51
5.1 Rate of change of land use/ land cover change (1972 - 2013).....	51
5.2 Analyzing LULC changes in relation to different factors (1972-2013)	52
5.2.1. Analyzing LULC changes in relation to Slope	52
5.2.2 Analyzing LULC changes in relation to agro ecology	54
5.3 Result of Socio-Economic Survey	54
CHAPTER SIX.....	57
6 SUMMARY, CONCLUSION AND RECOMMENDATIONS.....	57
6.1 Summary	57
6.2 Conclusion	59
6.3 Recommendations.....	61
Reference	62

List of Tables

Table 3. 1summary Of Equipment And Materials Used For Data Collection And Analysis.	23
Table 3. 2land Use/Land Cover Classes With Description.....	27
Table 4. 1interpretation Result Of 1972.....	33
Table 4. 2 Interpretation Result Of 1986.	35
Table 4. 3interpretation Result Of 2013.....	37
Table 4. 4 Accuracy Assessment Result.	38
Table 4. 5 Change Of Classes In Three Time Periods.	39
Table 4. 6 Land Use/Land Cover Conversion Matrix(1972-1986).....	41
Table 4. 7 Land Use/Land Cover Conversion Matrix (1986-2013).....	41
Table 4. 8 Land Use/Land Cover Conversion Matrix(1972-2013).....	41
Table 4. 9 Percentage Of Change By Kebele.....	42
Table 4. 10 Household Size Of Selected Kebeles.....	43
Table 4. 11 Sample Size Of Selected Kebeles.....	43
Table 4. 12 Age - Sex Composition Of The Study Population.....	44
Table 4. 13 Percentage Distribution Of Respondents By Marital Status.	45
Table 4. 14 Percentage Distribution Of Respondents By Their Monthly Off Farm Income.	45
Table 4. 15 Percentage Distribution Of Respondents By Land Holding Size.	45
Table 4. 16 Percentage Distribution Of Respondents Reason For Land Scarcity.....	46
Table 4. 17 Percentage Distribution Of Respondents Reason For Land Productivity.	46
Table 4. 18 Percentage Distribution Of Respondents On Justification For Land Use/Land Covers Change.....	47
Table 4. 19 Percentage Distribution Of Respondents On Causes Of Land Use/Land Cover Change.....	48
Table 4. 20 Percentage Distribution Of Respondents On The Effect Of Land Use/Land Cover Change.....	48
Table 4. 21 Percentage Distribution Of Respondents On The Cause Of Soil Erosion.	49
Table 4. 22 Percentage Distribution Of Respondents On Land Improvement Measure.....	49
Table 4. 23 Percentage Distribution Of Respondents Reason On The Failure To Invest On Land.	49
Table 4. 24 Distribution Of Respondents Who Participated In Conservation Activities.....	50
Table 5. 1 Rate Of Change In Land Use/ Land Cover Class.	51

List of Figures

Figure 3. 1 Location Map Of The Study Area.	18
Figure 3. 3 Mean Monthly Rainfalls For The Year 1983-2010.....	19
Figure 3. 4 Maximum Temperature Of The Study Area (1981-2010).....	20
Figure 3. 5 Minimum Temperature Of The Study Area (1981-2010).....	20
Figure 3. 6 Soil Map Of The Study Area (Source: Fao Soil Map).	21
Figure 3. 7 Methodological Flow Chart.....	25
Figure 4. 1 Landsat Mss Band 4, 2, 1 Combination.	32
Figure 4. 2 Interpreted Results Of Landsat Mss, 1972.	33
Figure 4. 3 Landsat Tm Bands 4, 3, 2 Combinations.	34
Figure 4. 4 Interpreted Result Of Landsat Tm, 1986.....	35
Figure 4. 5 Landsat 8 Bands 5, 4, 3 Combinations.	36
Figure 4. 6 Interpreted Result Of Landsat 8, 2013.	37
Figure 4. 7 Land Use/Land Cover Change Map(1972-2013).....	42
Figure 5. 1 Slope Of The Lulc Change Area In Degrees.....	53

List of Appendix

Appendix 1 Questionnaire	68
Appendix 2 Sample pictures from field	74
Appendix 3 Classification accuracy assessment report	75

Abbreviation

AEZ - Agro Ecological Zone

CSA- Central Statistical Agency

DN - Digital Number

EMA - Ethiopia Mapping Agency

GCPs - Ground Control Points

GIS - Geographic Information System

LUCC – Land use/Land cover Change

LULC - Land use/Land cover Change

MOA - Ministry of Agriculture

MSS – Multi Spectral scanner

NMA – National Meteorological Agency

TM – Thematic Mapper

UNFAO – United Nation Food and Agriculture Organization

USGS – United States Geological Survey

ABSTRACT

Land use/land cover (LULC) change is one of the challenges which strongly influence the process of agricultural development. The study intended to carry out land use /land cover changes, trends and their magnitude over the last 40 years using remote sensing and GIS and establish the main drivers of land use /land cover change in Ofla wereda of Tigray region.

For the identification of land use/ land cover change landsat imagery of 1972, 1986 and 2013 were used to determine the change in land use/land cover using object based classification. In establishing the main drivers of land use/land cover change, the study utilized household questionnaire and a focus group discussion. A total of 362 respondents were randomly selected from the kebele's where the land use/land cover change for the last 40 years is more than 60%, accordingly Sasela, Zata and Guara Kebeles were selected which satisfies the criteria. The object based classification result revealed that in 1972 MSS Landsat imagery, crop land (35.8%), grass land (19%), Forest land (43.7%) and water body (1.5%) were identified with their respective percentage. The change result showed a rapid reduction in forest cover of -49.2% and +18% increase occurred between the first (1972-1986) and second (1986-2013) study periods, respectively. Similarly water body decreased by -11.1% during the first and increased by +9.3% during the second period. On the contrary, crop land increased in the two periods by 31.7 % and 13.8% respectively.

The analysis of the last 40 years in the study area revealed that about 48% of the landscape showed changes in LULC. Changes were also analyzed in relation to slope and agro ecological zone and it showed that in 1972, more than 69.2 % of the crop areas fall below 20° slope but in 2013 the percentage declined to 54.5% for the same slope indicating agriculture is expanding to the steep slopes and regarding agro ecological zone woina dega is more prone to change in the study area. From the analysis of the socio economic situation of households to identify the underlying causes of the change in land use/land cover, population growth and land tenure insecurity were identified as the major underlying causes. This study generally has shown that the recent advancement in spatial technology can provide a sound mechanism to quantify change at any scale.

Keywords: GIS, LULC, MSS, Remote Sensing

CHAPTER ONE

1 INTRODUCTION

1.1 Background

Land use/land cover (LULC) changes play a major role in the study of global change. Land use/land cover and human/natural modifications have largely resulted in deforestation, biodiversity loss, global warming and increase of natural disaster-flooding. These environmental problems are often related to LULC changes. Giri et al. (2003, as cited in Katana et al., 2013) stated that time series analysis of land cover changes and the identification of the driving forces responsible for these changes are needed for sustainable management of natural resources and also for projecting future land cover.

Therefore, available data on LULC changes can provide critical input to decision-making of environmental management and planning the future. Determining the effects of land use and land cover change on the earth system depends on an understanding of past land use practices, current land use and land cover patterns and projection of future land use and land cover, as affected by human distribution, economic development, technology and other factors (Thadiparthi and Mekonnen Aregai, 2011).

Land use/ land cover change has become a central component in current strategies for managing natural resources. The advancement in the concept of vegetation mapping has greatly increased research on land use/ land cover change (Zubair, 2006). It is also important to notice that LULC change is one of the challenges which strongly influence the process of Agricultural development and the food security situation in Ethiopia (Daniel Ayalew, 2008).

Being a land of great geographic diversity, Ethiopia is characterized by sharp and repeated environmental contrasts. There are areas where population pressure, in conjunction with a growing rural populations and rising subsistence demand have contributed to the deterioration and depletion of natural resource base. In the highlands of Ethiopia, the impact of human activity on the environment is so striking owing to intensive cultivation; land fragmentation, economic and political forces that relate to

peasant agriculture. More than ever, the need for rational planning of land use/cover development and optimal use of the land resources is evident. That is why precise and credible data on land use /cover change and their trends are necessary for understanding local environmental problems (Milanova and Telnova, 2007).

Two ways of capturing LULC dynamics are available. These are conventional ground based and remote sensing based approaches. The ground method is labor intensive, time consuming and difficult for capturing data from inaccessible areas with rugged topographies like the case of most Ethiopian landscape. On the contrary, remote sensing is considered the most efficient technology to handle these problems since it can explicitly reveal spatial patterns of land cover change over a large geographic area in a regular and consistent way and readily available in digital format. These advantages have attracted great interest in the scientific community (Mengistie et al., 2013).

In this regard, remote sensing data have been one of the most important data sources for studies of land cover spatial and temporal changes. Multi temporal remote sensing data sets allow to map and identify landscape changes, giving an effective effort to sustainable landscape planning and management. By means of integration of remote sensing and GIS techniques, it is possible to analyses and to classify the changing pattern of land cover during a long time period and as a result to understand the changes within the area of interest (Fichera et al., 2012).

Various techniques are available to extract meaningful information of LULC from remotely captured datasets. Recently, object-based image analysis has been applied more frequently for remote sensing image classification than pixel-based analysis. Pixel-based methods classify individual pixels mainly using spectral patterns. The use of spatial or contextual information from neighborhood pixels remains a critical drawback to pixel-based image processing. On the other hand, object-based methods allow integration of different object features, such as spectral values, shape, and texture. One of its strength is the ability to combine spectral information and spatial information for extracting target objects (Mengistie et al., 2013).

The causes for the change in land use/land cover can be divided into two categories: proximate(direct or local) and underlying (indirect or root). The underlying causes of land use/land cover change explain how and why local land cover and ecosystem

processes are modified directly by humans, while underlying causes explain the broader context and fundamental forces underpinning these local actions

(<http://www.eoearth.org/view/article/150964/>).

Conceptual approaches for analyzing land use/land cover change and identification of driving forces such as political ecology and landscape ecology have emphasized the need to examine the interaction between biophysical and societal processes over time, not only at the local scale but also in ways that elucidate the interaction between local patterns of land use/land cover and the national context (Campbell et al., 2003).

There are many factors identified as underlying causes in different areas by different researchers since it is highly correlated to local environment and social condition. In middle high land Tigray indicated that there was a common agreement between the interviewed households that increasing population was one of the major causes of land cover change in the study area (Thadiparthi and Mekonnen Aregai, 2011) and many more results mention this factor as the major cause for the change in land use land cover.

Therefore, attempt will be made in this study to map out the status of land use land cover of Ofla wereda, Tigray region between 1972 and 2013 with a view to detect the land consumption rate and the changes that has taken place using remote sensing and GIS and establish the main drivers of land use/land cover change through household questionnaire and a focus group discussion.

1.2 Statement of the problem

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

Change in LULC can also affect biodiversity, contribute to forest fragmentation, lead to soil erosion, alter ecosystem services, and increase natural disasters such as flooding. This calls for global attention for continuous monitoring of the changes and prediction (Mengistie et al., 2013).

Lambin et al. (2003) noted that land cover change information is needed regarding what changes occur, where and when they occur, the rate and the social and physical forces that drive those changes.

As in the case in many developing countries, most of the population of Ethiopia lives in rural areas and depends directly on land for its livelihood. This rural population is currently growing rapidly and consequently inducing many effects on resource base brought about by the decrease in the area under natural vegetation and its conversion into other types of land use/land cover (Woldeamlak and Sterk, 2005).

Studies were conducted to estimate and monitor LULC change in different parts of the Ethiopian highlands. These reports have shown heterogeneity in direction, pattern, type, and/or magnitude of LULC change in the country (Mengistie et al., 2013).

Hence, Land resource and environmental decision makers require quantitative information on the spatial distribution of land use types and their conditions as well as temporal changes. Undoubtedly Remote Sensing and GIS technology has enabled ecologists and natural resource managers to acquire timely data and observed periodical change (Mengistie et al., 2013).

This study therefore analyzed land use/land cover change in Ofla wereda, Tigray region using remote sensing and GIS in addition the underlying causes were also identified using household questionnaire. Regarding similar works on land use/land cover in the study area (Ofla wereda), there is no work as such but there is one research done by Dagnaw Belay (2007) on assessment of causes and extent of land degradation around Ashenge Lake by considering the catchment of the lake using conventional approach. While this research used remote sensing approach.

This research problem has also been identified by the researcher practical concern on the area to provide information on the change of LULC and causes and consequences of the changes.

1.3 Objective

General objective of the research is to assess land use/ land cover change over a period of 40 year (1972-2013) using remotely sensed images and GIS and identify causes and consequences of the changes.

Specific objectives are:-

- To identify and map the extent of LULC change over a period of 4 decades.
- To determine the nature, rate and location of land use /land cover change.
- To investigate the underlying causes of LULC changes and its consequences.

1.4 Significance of the study

The research output will be used to support decision making at the wereda level for sustainable land use/land cover management hence data on land use change are of great importance to planners in monitoring land use/land cover change. Such data are of value to resource managers that plan and assess land use/land cover patterns by giving tangible information about the land use/land cover changes in the wereda in the last 40 years and enable to foresee the future of that wereda if things will not be changed.

1.5 Limitation of the study

To identify causes and consequences of the LULC changes in the study area, only kebeles with more than 60% change were considered for the socio economic survey due to financial and time constraint to cover the whole wereda.

1.5 Organization of the Study

Including this introductory chapter, the study is organized into five chapters. Each chapter has its own heading and sub headings. Chapter one gives back ground information about the study. Chapter two introduces the study in the context of existing literature on land use and land cover change and its drivers and impact. It also includes a review of studies done in the areas along with their important findings. Chapter three describes the study area, sources and methods in collection of primary and secondary data and methodologies to follow to meet the objectives of the study. Chapter four presents

analysis of all available data and chapter five presents and discusses the major findings of the study. Finally Chapter six presents conclusion and recommendation of the study in which the whole process is concluded and recommendations are forwarded.

CHAPTER TWO

2 LITERATURE REVIEW

2.1 Theoretical framework

2.1.1. Definition and rationale of Land use/Land cover change study

Many books use land use and land cover concepts interchangeably, although they are different. Land cover refers to the physical characteristics of the earth's surface, captured in the distribution of vegetation, water, desert, ice and other physical features of the land, including those created solely by human activities such as settlement (Billah and Anisur, 2004). And the same authors define land use as the intended employment and management of strategy placed on land cover type by human agents or land managers.

According to UNFAO, Land use is “the total of all arrangements, activities and inputs that people undertake in a certain land cover type”. In contrast, Land cover “is the observed physical and biological cover of the earth's land as vegetation, rocks, water body or man-made features” (UNFAO, 2000). However, Land use is obviously determined by environmental factors such as soil characteristics, climate, topography, vegetation and water body etc. but also reflect the land's importance as fundamental factor of production.

Land use change is defined to be any physical, biological or chemical change attributable to management, which may include conversion of grazing to cropping, change in fertilizer use, drainage improvements, installation and use of irrigation, plantations, building farm dams, pollution and land degradation, vegetation removal, changed fire regime, spread of weeds and exotic species, and conversion to non-agricultural uses (Quentin et al., 2006).

Land cover data documents how much of a region is covered by forests, wetlands, impervious surfaces, cropland, and other land and water types. Water types include wetlands or open water. Land use shows how people use the landscape, whether for development, conservation, or mixed uses. But here there are classes like crop land which is both land use and land cover at the same time, therefore land use /land cover is the most preferable term to use (MaD CAT manual, 2011).

Liang et al. (2002, as cited in Hussein Ali, 2009) stated that land use/land cover classification has recently been a hot research topic for a variety of applications. A great deal of research has been conducted throughout the world in an attempt to understand major shifts in land use and land cover and to relate them to changing environmental conditions.

Hence Land use /land cover pattern of a region is an outcome of natural and socio economic factors and their utilization by man in time and space. Land use/land cover change has become central component in current strategies for managing natural resources. The advancement in the concept of vegetation mapping has greatly increased research on land use /land cover change (Zubair, 2006).

Therefore, Land use/land cover change (LUCC) research needs to deal with the identification, qualitative description and parameterization of factors which drive changes in land use/ land cover, as well as the integration of their consequences and feedbacks. However, one of the major challenges in LUCC analysis is to link behavior of people to biophysical information in the appropriate spatial and temporal scales. But, it is argued that land use and land cover change trends can be easily assessed and linked to population data, if the unit of analysis is the national, regional, district or municipal level (Codjoe, 2007).

In order to use land optimally, it is not only necessary to have the information on existing land use land cover but also the capability to monitor the dynamics of land use/land cover resulting out of both changing demands of increasing population and forces of nature acting to shape the landscape (Zubair, 2006).

2.1.2. Application of Remote sensing and GIS for Land use/Land cover analysis

Remote Sensing is defined as the science of acquiring information about an object through the analysis of data obtained by a device that is not in contact with the object. The instruments used for measuring electromagnetic radiation are called sensors. These sensors record the reflected radiation from the surface of the earth and will be used for many analyses; one of these is land use land cover change analysis (Lelesand and Kiefer, 1994).

Remote sensing data have been one of the most important data sources for studies of land cover spatial and temporal changes. In fact, multi temporal remote sensing datasets, opportunely processed and elaborated, allow to map and identify landscape changes, giving an effective effort to sustainable landscape planning and management (Dewan and Yamaguchi, 2009).

The most useful characteristic of Remote Sensing in land use and land cover change detection is the multi spectral and temporal resolution of the data. That is, images are obtained in different portions of the electromagnetic spectrum and the same area is imaged with a specified periodic time interval. The advantage of using remote sensing in land use/land cover is that information from the same area could be easily obtained at different times, and this is important in change detection applications. Furthermore, remote sensing can provide the required data in short time with a reasonable accuracy (Billah and Anisur, 2004) and has an important contribution to make in documenting the actual change in land use/land cover on regional and global scales from the mid-1970s (Ashenafi Burqa, 2008).

Analysis mechanisms of land use pattern changes play an important role not only forecasting changes but also formulating local development strategies. At present, remote Sensing in combination with GIS have given rise to the advent of more precise and geographically referenced data on land use/ land cover, which in turn have created opportunities for improved assessments and analysis issues related with the land use/land cover dynamics (Ashenafi Burqa, 2008).

Campbell (1987, as cited in Ephrem Haile, 2008) stated that Satellite imagery has been well utilized in the natural science communities for measuring qualitative and quantitative terrestrial land cover changes. Qualitative changes in landscapes occur either as natural phenomena (lightning strikes, storms, pests) or can be human induced (selective logging, agroforestry). Quantitative land cover change is the wholesale categorical transformation of the land, and although it can occur as a natural phenomenon as caused by fires and storms, large scale replacement of one land cover type by another is usually induced by human activity (forest clearing, agricultural expansion, urban growth). Both qualitative and quantitative changes in land cover have been successfully

monitored with remote sensing, with research dominated by efforts at monitoring change in vegetation and forest canopies.

Research on various land cover change detection methods using remote sensing has indicated that no uniform combination of data types and methods can be applied with equal success across different ecosystems. Despite this, the two general approaches to change detection using remote sensing are comparative analysis of independently produced classifications, and simultaneous analysis of multi temporal data. Comparative analysis of independently produced images is the most prominent approach employed because it is straight forward and allows compensation for variation in many conditions while the simultaneous analysis techniques which include image differencing, rationing, principal component analysis (PCA), and change vector analysis are based on the image raster value (Hussein Ali, 2009).

Following image classification as part of the change detection process, accuracy needs to be assessed to evaluate the degree of acceptability of the classification process. A standard accuracy assessment procedure for baseline land cover products involves the use of the error matrix and the standard procedure for one-point-in-time land cover products can be extremely difficult to apply to multi-temporal change analysis products (U.S EPA, 1999).

The methods are well established for small areas and single time periods. However, the assessment of accuracies for past time periods, and change databases can become problematic as it will be difficult to acquire an adequate database of historical reference materials. Accordingly, accuracy assessments are usually limited to the very recent image that serves as a reference using ground control points (GCPs) collected as part of the data required for the change analysis (Hussein Ali, 2009).

2.2 Land use/Land cover change in Ethiopia

In Ethiopia, the availability of natural resources as well as their dynamics and management vary considerably from area to area. For instance, different parts of the Ethiopian highlands receive between 600 and 2700mm of rainfall annually. Besides high rainfall variability and water shortage is prevalent in the highlands (Hussien Ali, 2009).

Land use/land cover (LULC) change is one of the challenges which strongly influence the process of Agricultural development and the food security situation in Ethiopia. With an area of 1,130,000 km² and as one of the most populous countries in Africa, Ethiopia is experiencing huge land use/land cover dynamics from natural vegetation to farming practices and human settlement. This problem is more severe in the highlands which account nearly 44% of the country's landmass and which has been cultivated for millennia (Mengistie et al., 2013).

Research conducted in Ethiopia has shown that there were considerable LULC changes in the country during the second half of the 20th century. Most of these studies indicated that deforestation and encroachment of cultivation into marginal areas were the major causes of land degradation, particularly in the highland part of the country (Daniel Mengistu, 2008).

Studies have been conducted to estimate and monitor land use/land cover change in different parts of Ethiopian highlands. According to Mengistie et al (2013), these reports shown heterogeneity in direction and/or magnitude of land use/land cover changes in the country. For instance, according to their review, Zeleke and Hurni reported a sharp decrease of forest cover in their respective study area in Ethiopia while Woldeamlak and Sterk (2005) found the opposite i.e an increasing trend by 19 % from 1957-1982 and 27% from 1982 -1998. Even the magnitude of the change with the same direction varies considerably like zeleke indicates increase of cultivated land by 38% in 38 years (1957-1995) on the other hand Tegene reported an increase in crop lands only by 5.5% in 43 years (1957-2000).

Mengistie et al. (2003) have examined LULC change using object-based classification of multi- temporal remotely sensed data (Landsat and RapidEye) from four reference years followed by post classification comparisons using recent advancements of remote sensing and GIS technologies. This approach in object-based methods increased the classification accuracy. This is new for the case of Ethiopian landscapes having diverse features and ragged topographies. The approach has the potential to be extended across other parts of the country for improved classification results. According to Mengistie et al. (2013) findings, there are few studies which are undertaken in an integrated analysis

which means analyzing the changes in relation to other geographic aspects on LULC change in the Ethiopian high lands.

2.3 Causes, Rate and Trend of land use/land cover Change

Understanding the mechanisms leading to land use/land cover changes in the past is crucial to understand the current changes and predict future ones. Therefore land use and land cover change research needs to deal with the identification, qualitative description and parameterization of factors which drive changes in land use/land cover as well as the integration of their consequences and feed backs (Hussein Ali, 2009).

The causes of landuse/landcover change can be divided into two categories: underlying (direct, or local) and underlying (indirect or root). The underlying causes of land use/land cover change explain how and why local landcover and ecosystem processes are modified directly by humans, while underlying causes explain the broader context and fundamental forces underpinning these local actions. In general, underlying causes operate at the local level (individual farms, households, or communities) and underlying causes originate from regional (districts, provinces, or country) or even global levels, though complex interplays between these levels of organization are common. As a result, underlying causes also tend to be complex, formed by interactions of social, political, economic, demographic, technological, cultural, and biophysical variables. Some local-scale factors are endogenous to decision makers and are therefore under local control. However, underlying causes are usually exogenous (originate externally) to the local communities managing land and are thus uncontrollable by these communities. In general, underlying causes tend to operate more diffusely (i.e., from a distance), often by altering one or more underlying causes (<http://www.eoearth.org/view/article/150964/>).

According to the above article, major causes of land use/land cover change are natural variability, economic and technological factors, demographic factors, institutional factors, cultural factors and globalization. Natural variability, natural environmental changes interact with the human decision making processes that cause land use/land cover change while Economic and technological factors influence land use decision making by altering prices , taxes etc on land use inputs and products. The unequal distribution of wealth between households, countries and regions determines who is able to develop, use and

profit from new technologies that increase profits from land management such as adoption of mechanized large scale farming.

Demographic factors, in most cases a measurable cause of land use/land cover change, both increase and decrease in local population have large impacts on land use/land cover. Demographic factors include not only shifts in fertility and mortality but also changes in the house hold structure and dynamics including labor availability, migration, urbanization etc. making migration the most important factor which cause rapid land use/land cover change.

Institutional factors are also cause of land use/land cover changes which are influenced directly by political, legal, economic and traditional institutions and by their interactions with the individual decision making in line with cultural factors which are the motivations, collective memories, personnel histories, attitudes, values, beliefs and individual perception of land managers.

Globalization processes as one cause can amplify or attenuate existing driving forces for land use/land cover change by removing regional barriers to change , weakening national connections and increasing the interdependency among people and between nations (<http://www.eoearth.org/view/article/150964/>).

According to Lambin et al. (2003) land-use change is driven by a combination of the following fundamental high level causes. These are:

1. Resource scarcity leading to an increase in the pressure of production on resources,
2. Changing opportunities created by markets,
3. Outside policy intervention,
4. Loss of adaptive capacity and increased vulnerability, and
5. Changes in social organization, in resource access, and in attitudes.

Some of the fundamental causes leading to land use/land cover change are mostly endogenous, such as resource scarcity, increased vulnerability and changes in social organization, even though they may be influenced by exogenous factors as well. The other high-level causes, such as changing market opportunities and policy intervention, are mostly exogenous, even though the response of land managers to these external forces is strongly mediated by local factors (Lambin et al., 2003).

Analyses of the causes of land use/land cover change have moved from simplistic single cause explanations to an understanding that integrates multiple causes and their complex interactions. A few general pathways leading to land-use change have been identified from a wealth of local case studies. This inductive process of generalization paves the way for the development of more realistic models of land use change.

Nevertheless, different perspectives of understanding still tend to follow different lines of explanation of the causes of land use/land cover change because each focuses on specific organizational levels and temporal scales of the human environment systems.

Improved understanding of the complex dynamic processes underlying land use/land cover change will allow more reliable projections and more realistic scenarios of future changes. Crucial to projections understands factors that control positive and negative feedback in land use/land cover change. Positive feedback loops amplify change and lead, in some cases, to a rapid degradation of ecosystems and the impoverishment of the societies using these ecosystems. By contrast, institutional and technological innovations may lead to negative feedback loops that decrease the rate of change or even reverse land use/land cover change trends. The relative strength of amplifying and attenuating feedback can be influenced by policies that control switches between land use/land cover change regimes dominated by positive or negative feedback. The analysis of interaction, coherence, or conflict between social and biophysical responses to changes in both ecosystem services and earth system processes caused by land changes is still a largely research area (Lambin et al., 2003).

According to Bernard et al. (2009) findings have revealed that household size, weak land use laws, type of crops grown, extension agents' visits, and customary land tenure are vital drivers of land use/land cover change. On the contrary, increasing livestock activities and education levels turned out to be non-important drivers of land use/cover change in Kirima sub-county. These findings reveal that the drivers of land use/cover change are location specific. As cited in Floriane & Amezaga (2008) highlighted that local and historical factors specific to geographic areas and individual communities, combine to drive land use/cover change. As cited in Frammer-Browers et al., (2006) there are two categories of land use/cover change drivers; mega drivers which we have control of and environmental factors which we hardly have any control over. All the identified

drivers in this study therefore, fall in the latter category of the mega drivers (Bernard et al., 2009).

Results have further reinforced the notion that population is a key driver of land use/cover change over time. The fact that the higher the household size the more likely a household was to drive change falls into the land use/cover change. This argument is reinforced by the assertion made by Ramankutty et al. (2002 as cited in Bernard et al. 2009) that the driving force for most land use change is population growth. Indeed the population and household size of the study has been growing overtime. Equally social ties of extended families in the area have kept the household sizes larger and this has a bearing on land use patterns especially cultivation of gardens so as to meet the household food requirements (Bernard et al., 2009).

According to Campbell et al., (2003) work on root causes of land use change in the Loitokitok Area, Kenya mentioned that the principal land cover resulting from land use change are related to expansion of the area under cultivation. As an indication the period of most rapid expansion of both irrigated and rainfed cultivation was between 1973 and 1984. The general pattern of Agricultural expansion of these years matches with the distribution of rainfall. Therefore considerable opportunities for cultivation and by mid 1980s, almost all area between the Tanzania border and the semi-arid plains has been cleared and planted. This study has illustrated that the process of land use change is the outcome of complex interaction between biophysical and societal processes. Further it has shown that the nature of the driving forces and thus their interaction has altered over time in response to events such as droughts and to trends such as migration, population growth and climatic pattern. Generally, the study has shown the importance of a methodological pluralism that integrates analysis of remotely sensed data with analysis of multiple sources of social data.

As indicated in Codjoe (2007) the major challenge in LULC change analysis is to link behavior of people to biophysical information in the appropriate spatial and temporal scales. But it has argued that LULC change trends can be easily assessed and linked to population data. Land use/land cover change studies have been designed to improve understanding of the human and biophysical forces that shape land use/ land cover change (Hussien Ali, 2009).

According to Hussein Ali (2009), remote sensing results showed that the area of cultivated land in Kuhar Michael and Lenche Dima of Blue Nile and Awash basins of Ethiopia has undergone a change, but with differing magnitude and rates. In Kuhar Michael, an expansion was found during the first two periods with annual rates of 1.7% and 0.6% , while a decline was revealed during the third period at annual rate of -1% . Despite the periodic variations in change of cultivated land, the overall rate of change during the whole period of analysis (1972-2005) is found to be 0.8% per annum, which resulted in a net increase. However, in Lenche Dima, cultivated land showed a declining trend both at household and landscape level during most analysis periods largely due to land degradation. Expansion of cultivated land was encountered only during the first period (1972-1986) with annual rate of 0.6%. During the second and third periods, a decline was found at annual rate of -0.3 to -2.4%, making the overall rate of decline - 0.2% per annum.

Another research done by Ephrem Haile (2008) concludes that based on the analysis of the input data of land use and land cover, in general about six land use land cover classes were identified for each year. These include natural forest, shrub land, wood land, grass land, agriculture & settlement, bare land and plantations. Land cover post classification change analysis for the sub periods (1973- 1986, and 1986-2000) revealed that dynamism for all land cover classes. Taking the 1973-1986 agriculture & settlement, grass land and shrub lands increased by the expense of natural forest, wood land, and bare land. Whereas for 1986-2000 sub periods the results revealed that the extent of agricultural & settlement, and plantations has increased at the expense of mainly grass land, natural forest, wood land, bare land and shrub lands.

In Ethiopia, the ratio of people per hectare of land under cultivation as of 1998 was about 0.14 hectare. This means a family with seven members has only a hectare of land (Sisay Worku, 1998). Hence, pressures on land at household level have been increasing as long as the population growth is there. According to another scholar, per capita arable land declined from 0.5 ha per/head in 1965 to slightly less than 0.3 ha in 1990 (Gedion Asfaw, 2003). Studies have shown that households with smallholdings are more likely to apply conservation measures than households with large holdings. On the other hand, it is argued that pressure on land leads to reduction of fallow periods. In extreme case,

shortage of arable land may force households to advance into marginal land (Bahru Shikur, 1993).

Another study carried out in middle high land Tigray indicated that there was a common agreement between the interviewed households that increasing population was one of the major causes of land cover change in the study area (Thadiparthi and Mekonnen Aregai, 2011).

CHAPTER THREE

3 MATERIALS AND METHODS

3.1 Description of the study area

3.1.1 Location and relief

The study was conducted in Ofla wereda, south Tigray zone, Tigray Region of Ethiopia. Geographically it is situated between 12°22'3"N to 12°42'30" N and 39 °10'32"E to 39°34'40"E covering a total area of about 1086 km² (figure 1).The altitude of the study area ranges from 1587 to 3682 m above sea level and covers slope range from flat (0°) to very steep (71°).

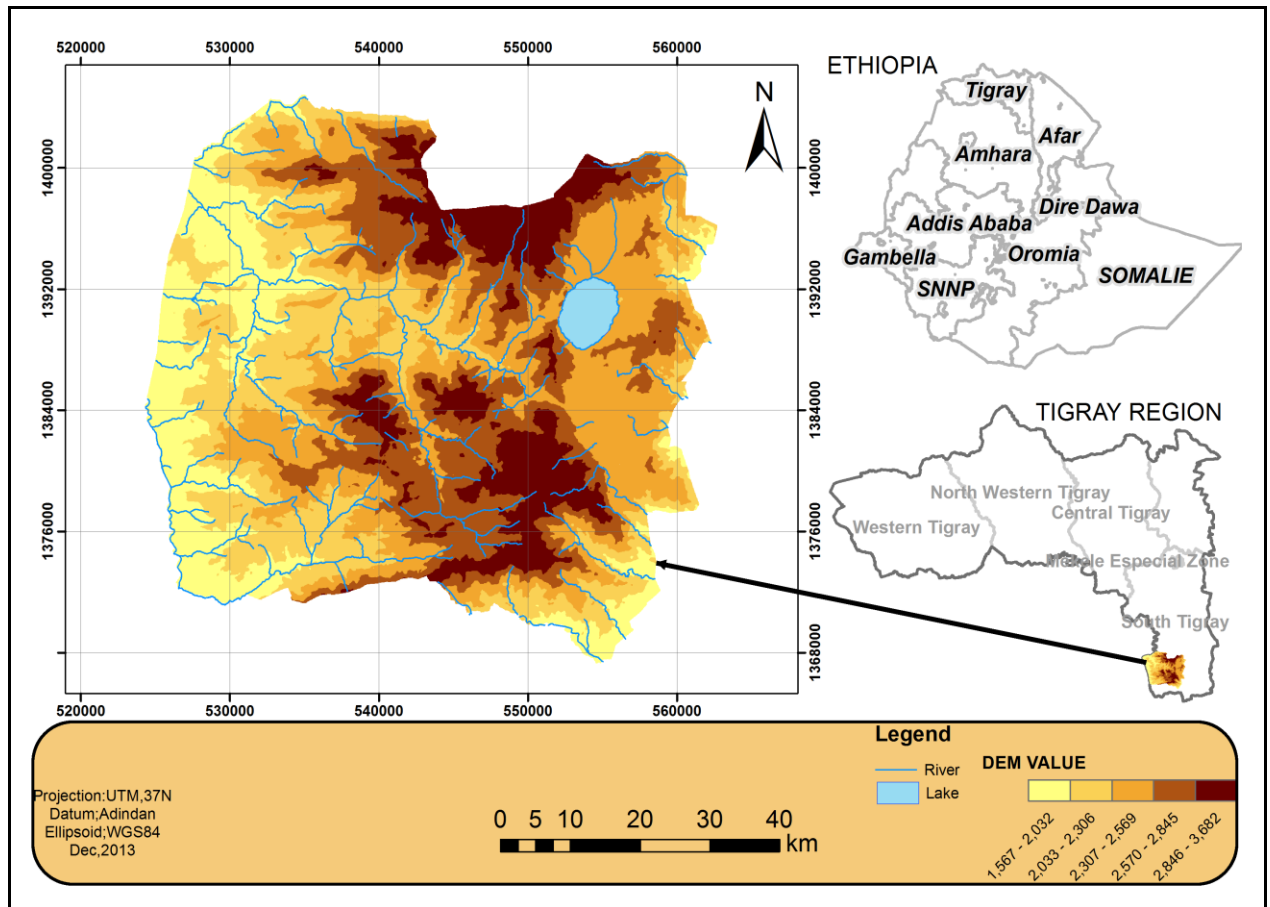


Figure 3. 1 Location map of the study area.

3.1.2 Population

Based on the 2007 Census conducted by the Central Statistical Agency of Ethiopia (CSA), Oflla wereda has a total population of 126,889, of whom 62,278 (49%) were male and 64,611 (51%) female with a density of 116.8 peoples per square kilo meter. But the total population of the wereda in 2012 increased to 144,027 of which 70,689 (49%) were male and 73,338(51%) were female (<http://www.csa.gov.et/index.php/2013-02-20-13-43-35/national-statistics-abstract/141-population>).

3.1.3 Climate

The climatic variables of the study area are highly governed by topography of the area (mainly altitude). Mean annual temperature of the study area ranges from 5°C to 26°C(Fig.3.3 and 3.4). The area is characterized by a bimodal rainfall pattern with a short rainy season “Belg” from March to May and a long rainy season “Kiremt” from June to September with a peak in August. During the long rainy season (Kiremt), mean monthly rainfall ranges from 40–240 mm and between 40-60mm during short rainy season (Belg) as it is clearly indicated in figure 3.2. The rainfall pattern in the area is relatively erratic and unpredictable (Misgina Gebrehiwot, 2012).

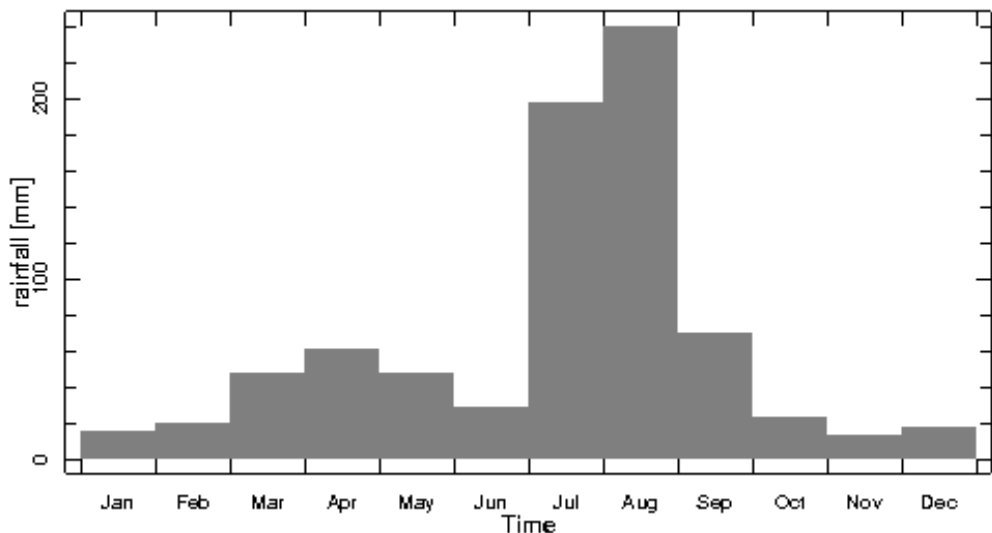


Figure 3. 2 Mean monthly rainfalls for the year 1983-2010.

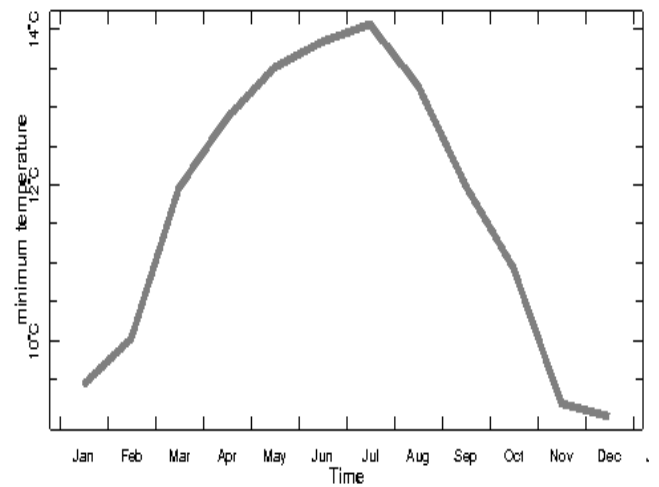
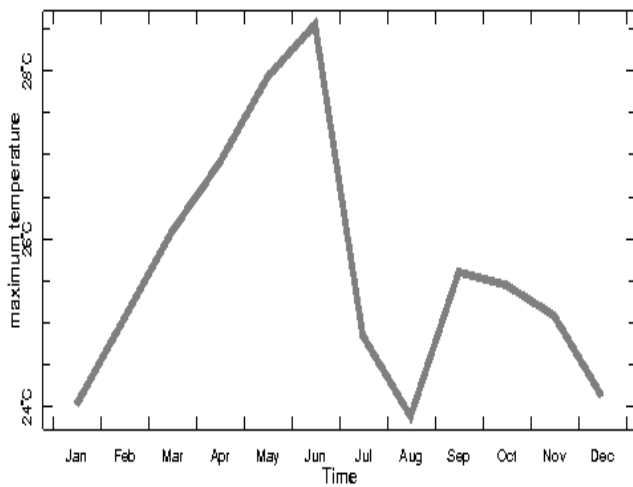


Figure 3. 3 Maximum temperature of the study area (1981-2010). Figure 3. 4 Minimum temperature of the study area (1981-2010).

3.1.4 Soil

The study area is dominantly leptosol type followed by vertisols (Fig.3.4). Leptosols are by far the most extensive group of soils in the world. They are found mainly in mountainous regions and in areas where soil has been eroded to the extent that hard rock comes near to the surface. Other (minor) occurrences are along rivers where gravely deposits have accumulated without substantial admixture of fine earth material. Ofla wereda is dominantly leptosol soil area except around the lake and town where vertisols type of soil exists¹.

Vertisols are clay-rich soils that shrink and swell with changes in moisture content. During dry periods, the soil volume shrinks, and cracks deep wide. The soil volume then expands as it wet up. Such shrink/swell action creates serious engineering problems and generally prevents formation of distinct, well-developed horizons in these soils. They are found around Ashenge lake².

¹ <http://www.isric.org/about-soils/world-soil-distribution/leptosols>

² <http://www.cals.uidaho.edu/soilorders/vertisols.htm>

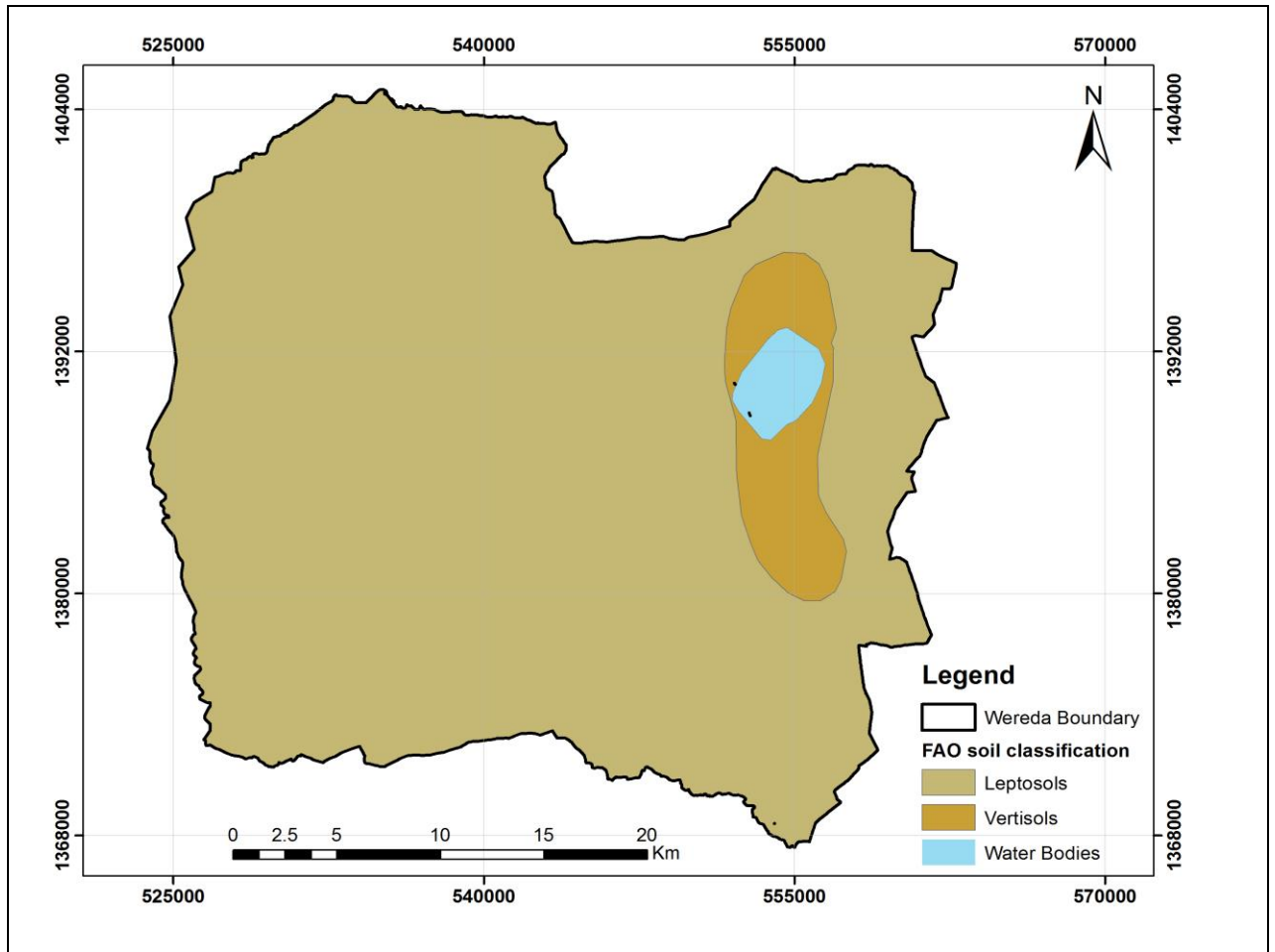


Figure 3. 5 Soil map of the study area (source: FAO soil map).

3.1.5 Crop Condition

The planting or sowing time of different crops varies depending on the onset and continuity of the rainfall. There are two distinctly known and traditionally used cropping seasons. Short cropping season is the one, which starts as soon as the last harvest of the previous crop is over. Successful short rainy season crops are meant to leave the land for the second crop season and hence will be harvested around May, allowing enough time for land preparation and sowing of the long rainy season crops. The second cropping season is the long rainy season as it is practiced in most parts of the country (Dagnev Belay, 2007).

3.2 Data Acquisition

Different kinds of data have been collected to conduct this study. The collected data were from different sources. The data from primary sources include satellite imagery, field data and information from local experts. The secondary data such as topographic map, climate, census and socio economic data were used to carry out this study and were dealt in detail.

3.2.1 Satellite Imagery

Landsat imagery was the main data source for classification and change analysis. The USGS (United States Geological Survey) Earth Explorer website allows to custom tailor your search parameters for Landsat data. After entering the website (you must create a login), you can either search for data by selecting a region on a map, by entering coordinates, or by entering a place name. Additionally, there is an option to choose your data set (e.g. “Landsat 4-5 TM”, “Landsat 7, LANDSAT 8”, “Landsat Orthorectified LANDSAT 8”) and then select parameters such as acceptable cloud-cover percentages and the range of desired acquisition dates.

The USGS also freely offers the Landsat Orthorectified data collection which consists of a global set of high-quality, relatively cloud-free Orthorectified MSS, TM and LANDSAT 8 imagery from Landsats 1-5 and 7. This dataset was selected and generated through NASA’s Commercial Remote Sensing Program, as part of a cooperative effort between NASA and the commercial remote sensing community to provide users with access to quality-screened, high-resolution satellite images with global coverage over the Earth’s land masses (<http://Landsat.gsfc.nasa.gov>).

This Landsat imagery data include Landsat MSS, Landsat Thematic mapper (TM) and LANDSAT 8 scenes of the year 1972, 1986 and 2013 respectively. These data sets acquired from the National Aeronautics and Space Administration (NASA) through their EOS data gateway database (<http://Landsat.gsfc.nasa.gov>).

A 30 m Digital Elevation model (DEM) imagery was also employed in order to study the relationship between LULC types with that of slope and Agro ecological zone of the study area.

No	Equipment	Source	Purpose
2	Topo sheet	1239 A ₃ ,A ₄ ,B ₃ ,C ₁ ,C ₂ ,D ₁	- For checking of Geometric correction
3	GPS (Global Positioning System)		- Positioning and receiving data from satellites
4	Erdas Imagine, ArcMap10, e- Cognition SPSS, MaDCAT3.2, Envi 4.2	GIS software for image processing and analysis.	
5	MS office	For word ,excel processing	

3.2.4 Projection of the data

All data that were utilized during analysis including satellite imagery ,topographic maps , thematic layers like road, towns, kebele, wereda etc. were projected to the universal transverse Mercator (UTM) projection system Zone 37 N and datum of World geodetic system 84 (WGS 84), ensuring consistency between datasets.

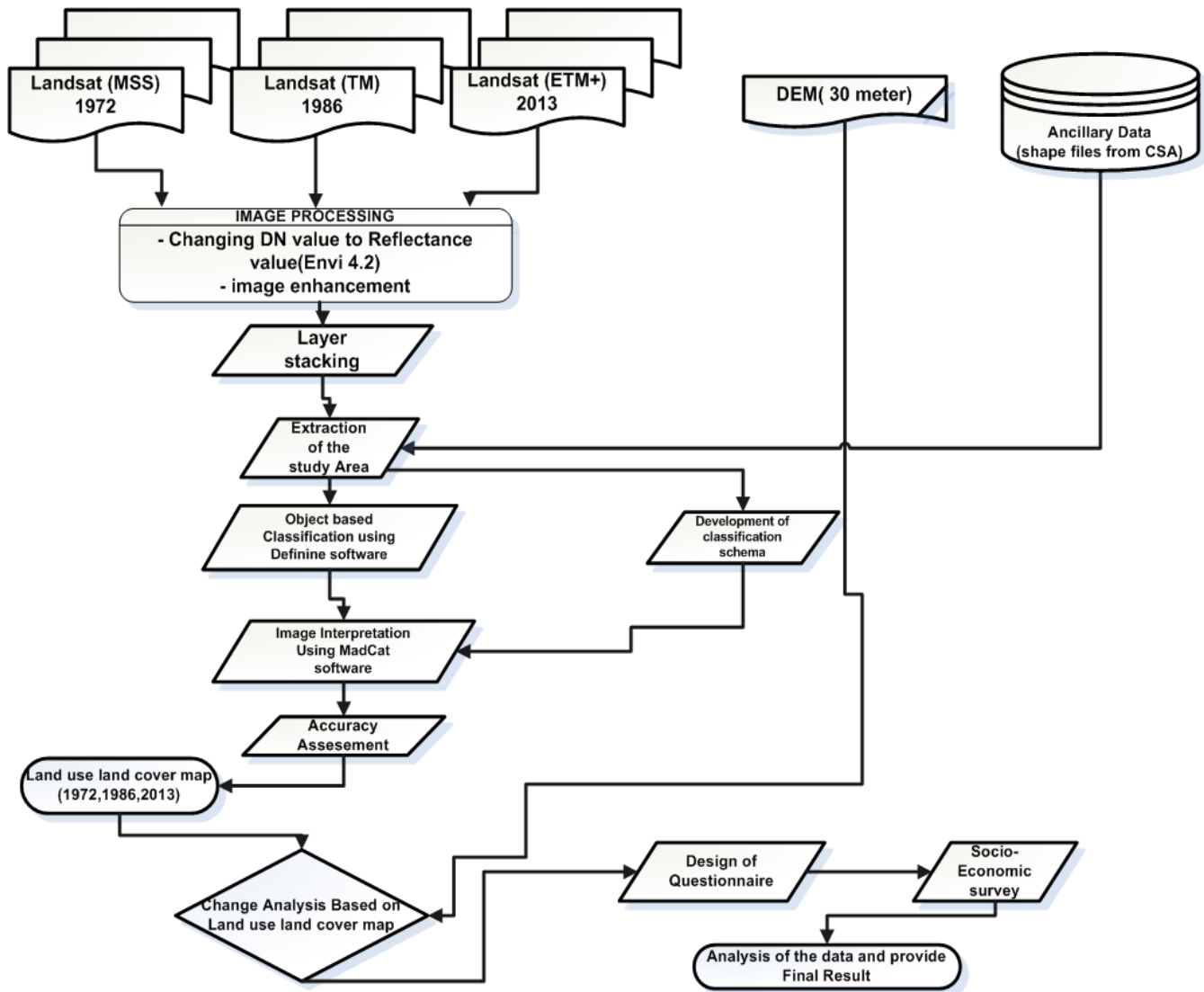


Figure 3. 6 Methodological flow chart.

3.3 Methodology

3.3.1 Image processing

The remotely sensed image data are usually not ready for use directly but need to undergo a series of preprocessing steps. Image processing consists of processes aimed at the geometric and radiometric correction, enhancement or standardization of imagery to correction, enhancement or standardization of imagery to improve our ability to interpret qualitatively and improve our ability to interpret qualitatively and quantitatively image components.

In order to cover the intended period of study, different types of imageries originating from different types of sensors were used. Hence Landsat multi spectral scanner(MSS), Thematic mapper(TM) and Landsat 8 from beginning of 1970s, mid 1980s and 2010s respectively for about 4 decadal time.

Since the United States Geological Survey(USGS) freely offers the Landsat Orthorectified data collection which consists of a global set of high-quality, relatively cloud-free Orthorectified MSS, TM and Landsat 8 imagery therefore there is no need for geometric correction but checking of the position was made using scanned Toposheet of 1:50000.

Since MSS and TM data of Landsat were downloaded with their Digital Number (DN) value, there is a need to change the DN value to reflectance value using ENVI software in one go for each band but Landsat 8 have reflectance value when it was downloaded and there was no need to run for Landsat 8. Besides different image enhancement techniques were carried out in order to have an interpretable image.

The next step was layer stacking of the bands excluding band 6 of TM and LANDSAT 8 imageries. Extracting region of interest was another activity which enables to focus on area of interest making ready for the analysis.

3.3.2 Development of classification scheme

Based on the prior knowledge of the study area, a brief reconnaissance survey was carried out using subseted image (based on the shape of the study area) and with additional information from previous research, a classification scheme was developed for the study area.

Accordingly Four classes were identified namely crop land, grassland, forest, and water body, it was impossible to detect the residential places due to low spatial resolution of MSS image in the region where scattered residential areas are dominant and due to this, the class was removed from the classification (Table 3.2).

Table 3. 2Land use/Land cover classes with description.

Land use / Land cover class	Description
Crop land	Contiguous areas for rainfall and irrigated cultivation, including fallow plots, cultivated land mixed with some bushes, trees and rural homesteads but dominated by farmland.
Grass land	Areas covered with permanent grass for grazing
Forest	Areas covered with tress, bushes, shrub.
Water body	Areas covered with lakes and ponds.

Source: Girmay Kassa., 2003 and Woldeamlak and Sterk., 2005

3.3.3 Image Segmentation

Object based image analysis requires the creation of objects or separated regions in an image. One established way to do so is image segmentation. Depending on its application, different approaches exist for image segmentation ranging from very simple to highly sophisticated algorithm (Mengistie et al., 2013).

The researcher used multi resolution segmentation (MS) which is available in e-cognition developer 8.0 software. The MS algorithm is bottom up region merging technique starting with a single image object of one pixel and repeatedly merges them in several loops in pairs to larger units. It also optimizes the procedure that minimizes the average heterogeneity for a given number of objects and maximizes their homogeneity based on defined parameters. These parameters are scale, shape and compactness and defined through trial and error to successfully segment objects in an image (Mengistie et al., 2013).

3.3.4 Object based Classification

Using identified target LULC classes object based classification was applied to a segmented image in order to assign a class to each of the segments using MaDCAT software. This approach attempts to assign objects that are generated through image segmentation in to a specific class of interest. Here visual interpretation was used to assign the labels of the predefined classes for each of the polygons derived by the segmentation process.

3.3.5 Accuracy Assessment

Lillesand and Kiefer(1994) stated that although a large number of change detection applications have been implemented and different change detection techniques have been tested, conclusion on which method is best suitable for a specific study area remains unanswered. Which method is selected depends on an analyst's knowledge of the change detection methods and the skill in handling remote sensing data, the image data used, and characteristics of the study area. Because of the difficulty in identifying a suitable method, in practice different change detection techniques are often tested and compared to provide a best result based on the accuracy assessment matrix. Therefore accuracy assessment matrix was employed to evaluate the accuracy of the classification since classification is not complete until its accuracy is assessed which also determines the quality of the map extracted from remotely sensed data.

An error matrix or confusion matrix is a common practice employed for assessment of classification accuracy. The matrix compares information obtained by reference sites to that provided by classified image for a number of sample areas.

The enough number of samples that represent the thematic classes and ensure good distribution across the map is important to test the attribute accuracy. Rule of thumb is 50 samples per map class or can be derived using the formula devised by Grenier *et al.* (2008).

$$n = \frac{B\pi(1 - \pi)}{b^2}$$

Where 'n' is total sample, 'B' is determined from a chi square table with 1 degree of freedom multiplied by $1 - \frac{\alpha}{k}$ where k is the number of classes ,
 'α' is the precision error tolerance,
 'b' is absolute precision of each cell ,
 'π' is the proportion of the class.

3.3.6 Land use/land cover change analysis

Change analysis was conducted using post classification image comparison technique. Post classification change analysis is selected in order to minimize possible effects of atmospheric variations and sensor differences. The post classification change detection method was found to be the most suitable for detecting land use/land cover change. Post-classification comparison can provide a complete matrix of change directions (Lu et al., 2003; as cited in Ashenafi Burqa, 2008).

The classified images were compared in two periods i.e. 1972-1986 and 1986-2013. Change statistics will be computed by comparing values of area of one data set with the corresponding value of the second data set in each period. The values will be presented in terms of kilometer square and percentage. Quantification of the rate of change has been applied to generate information about the land use/land cover dynamics of the study area. The rate of change of each land use and land cover can be calculated using the following formula:

$$\text{Rate of change} = \frac{X - Y}{Y}$$

, where X= recent area of land use land cover
 Y= Previous area of land use/land cover

Using the rate of change between the two periods, the rate of change per annum can also be computed by dividing it with the year difference between the two periods.

Slope and Agro ecological zone (AEZ) are also analyzed in relation to LULC change. The slope was calculated from DEM in ArcGIS environment. And for AEZ Traditional agro ecological zonation of Ministry of Agriculture was used. By overlaying the

classified maps of each reference year on top of the slope and AEZ map thematic information showing relationship between LULC distribution and changes in each category was extracted in ArcGIS.

3.3.7 Establishing the main drivers of Land use/Land cover Change

To assess the social and environmental impact of the change, socio economic survey was conducted on the selected kebeles. The assessment was done by interviewing households from high change area while 8 participants which includes development agents, Elders of the community, agricultural and land resource experts from the wereda were included in the focus group discussion. The data then analyzed using SPSS software.

3.3.8 Sampling Design for Household Surveys

Multi-stage stratified random sampling was used to select study divisions and households. The first round selection was made using an area where an extensive change in land use land cover was observed out of the total kebele's of the wereda under study. Based on the result of the first round as a sample frame, selection of the households for scheduled interview was made through random selection using localities of CSA census cartography work. The results were then analyzed descriptively and SPSS was used for the analysis.

3.3.9 Sample Size Determination

Sample size of the house hold survey was determined using a two formula derived from Cochran (1977). The first formula determined desired sample size while the second one the actual size of sample based on the house hold size of the selected kebele's with more than 60% of change.

$$n = \frac{Z^2 * P * (1 - P)}{E^2} \quad \text{(Equation 1)}$$

Where n= desired sample

Z= confidence level (1.96 or 95% confidence)

P= percentage of picking choice (0.5 as there is equal chance of picking)

E= tolerance error (0.05 for 95 % confidence)

The following formula was used to decide the actual sample size for the survey.

$$n! = \frac{n}{1 + \frac{n-1}{HHS}} \quad (\text{Equation 2})$$

Based on equation 1, the desired sample size was determined as 384 and using this value equation 2 was computed to get the actual sample size for the socio economic survey. For this equation, summation of the house hold size of the selected kebeles were collected from CSA 2007 census result to compute the actual sample size for the survey. This sample size was then distributed to selected kebeles proportional to house hold size.

The assigned sample size for each selected kebeles were randomly selected from all localities of the kebele.

3.3.10 Method of socio economic data analysis

Quantitative data analysis is helpful in evaluation because it provides quantifiable and it is easy to understand results. The first process carried out after data entry was tabulation of results for the different variables in the data set to get a comprehensive picture of what the data looks like and assist in identifying patterns. The best ways to do these are by constructing frequency and percent distributions of important variables.

After tabulating the data, exploring of the data by disaggregating it across different variables and subcategories of variables was carried out which allow disaggregation of the data across multiple categories. Then lastly variables which were relevant to the topic was presented in table and narration form.

CHAPTER FOUR

4 DATA ANALYSIS

4.1 Landsat Multi spectral scanner (MSS) data

MSS data has provided a historical record of the earth's land surface from the early 1970s to the early 1990s with a spatial resolution of 80 meter. The digital number of the raw MSS image was then bringing to ENVI software for changing DN to reflectance value. After four bands of the MSS were considered for layer stacking, MSS band 4, 2 and 1 were combined to make conventional false color composite images and ready for further analysis (Fig.4.1). This band combination makes vegetation appear as shades of red with brighter reds indicating more vigorously growing vegetation. Soil with sparse or no vegetation will range from white to green brown depending on moisture and organic matter content. Water appears dark blue to black in color while sediment or shallow waters appear lighter in color. Urban areas appear blue gray in color in all sensors of Landsat images (Lelisand and Kiefer, 1994).

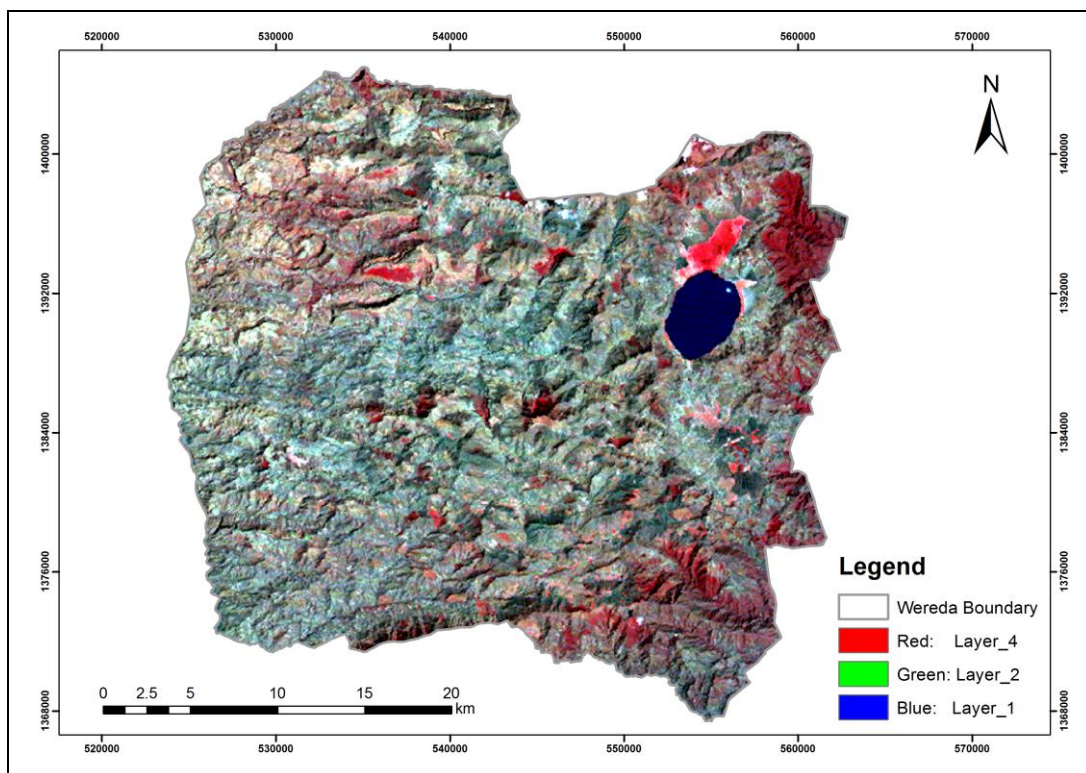


Figure 4. 1 Landsat MSS band 4, 2, 1 combination.

This Landsat MSS image was imported to e-cognition for segmentation using multi resolution and setting all parameters(scale, compactness and shape).The segmented image was then imported to MadCAT software(MaD-CAT Manual) for object based classification using the defined classes. Figure 4.2 shows the interpreted result of landsat MSS.

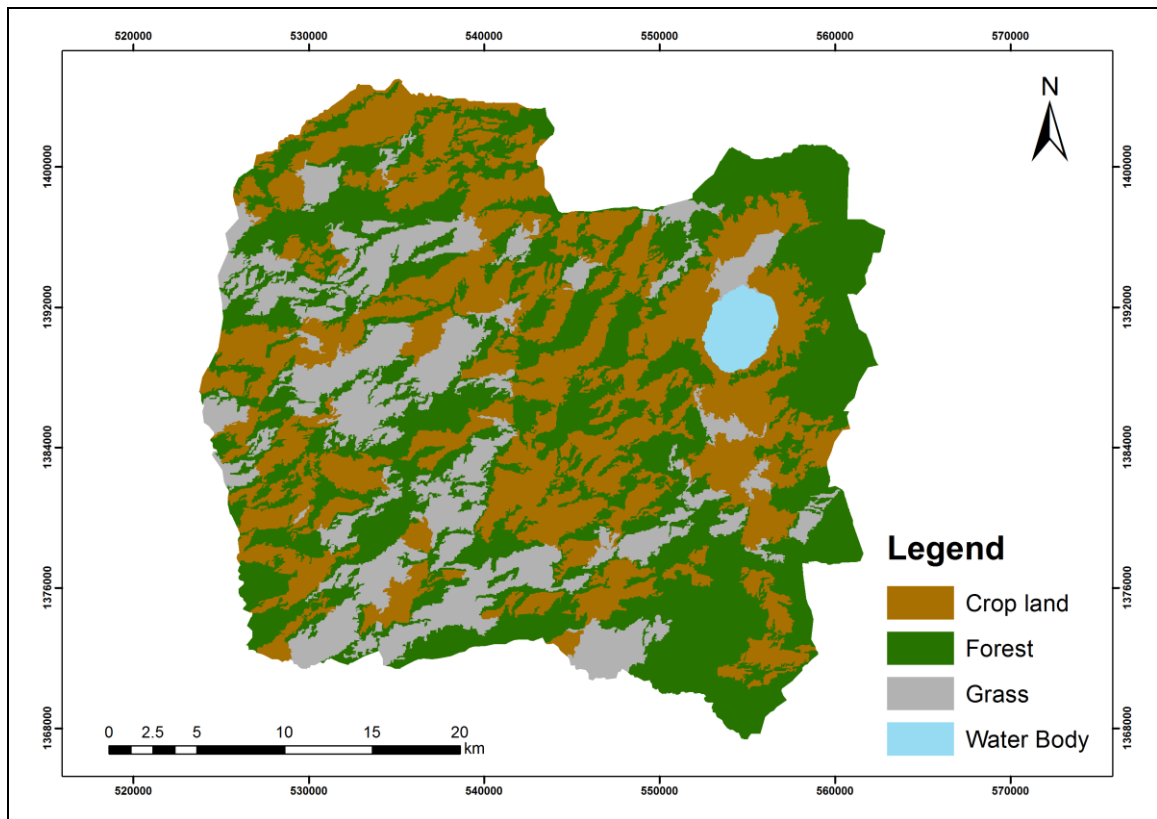


Figure 4. 2 Interpreted results of Landsat MSS, 1972.

Table 4. 1 Interpretation result of 1972.

Land use/Land cover class	Period	
	1972	
	Area in square km	Percent
Crop land	376.87	35.8
Grass	201.32	19
Forest	460.31	43.7
Water Body	15.37	1.5

As it is indicated in table 4.1, forest accounts for about 43.7 % of the total land area of the wereda followed by crop land and grass land (35.8 % and 19%) and water body about 1.5%.

4.2 Landsat Thematic Mapper (TM) data

The wave length range for the TM sensor ranges from the visible in to the thermal infrared portion of the electromagnetic spectrum and it has a spatial resolution of 30 meter (Hussein Ali, 2009). The digital number of the raw TM image was then bringing to ENVI software for changing DN to reflectance value. After six bands of the TM (excluding thermal band) were considered for layer stacking, TM band 4, 3 and 2 were combined to make conventional false color composite images (Fig 4.3).

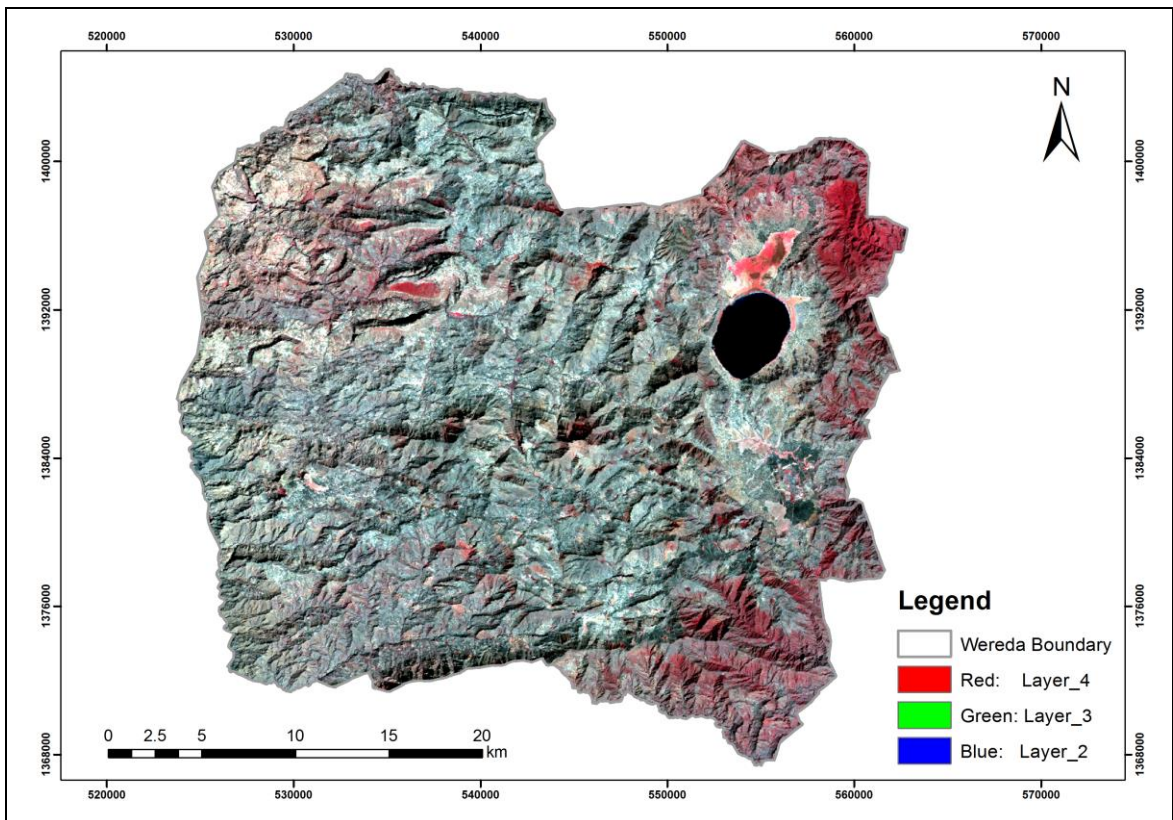


Figure 4. 3 Landsat TM bands 4, 3, 2 combinations.

This Landsat TM image was imported to e-cognition for segmentation using multi resolution and setting all parameters (scale, compactness and shape).The segmented image was then imported to MaDCAT software for object based classification using the defined classes. Figure 4.4 shows the interpreted result of landsat TM.

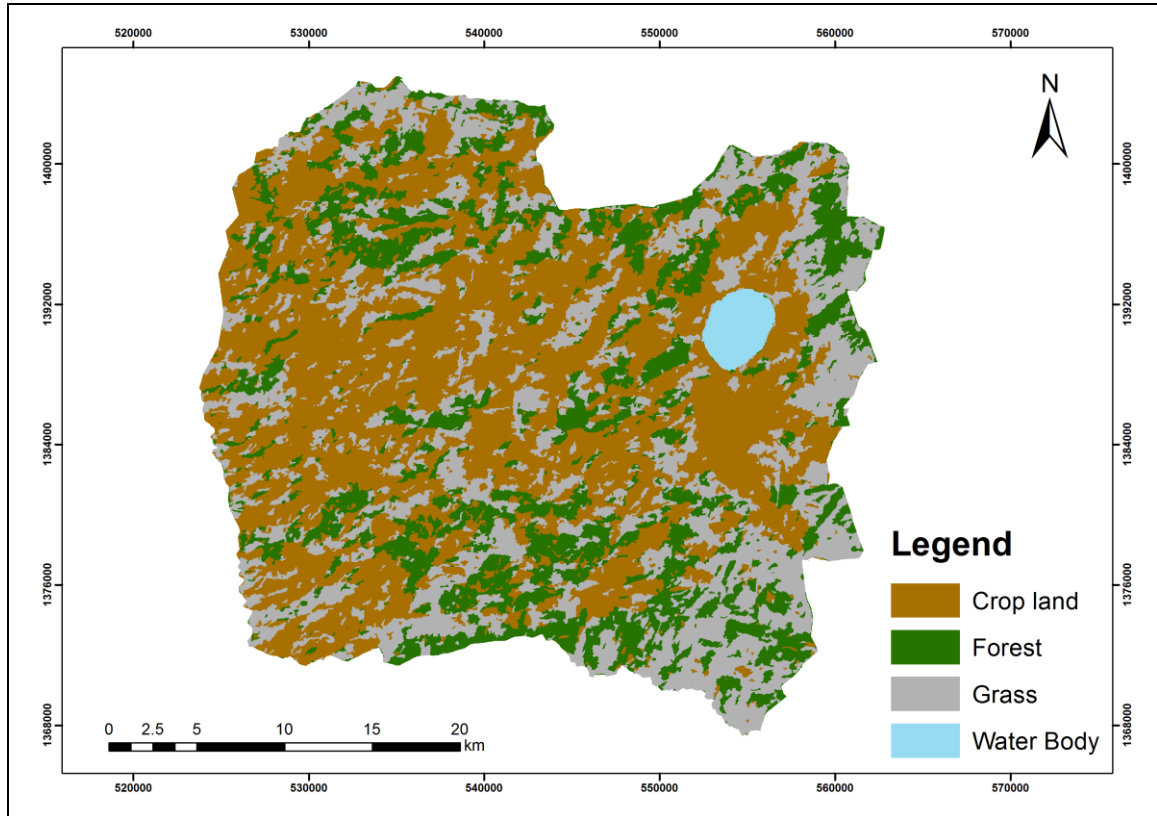


Figure 4. 4 Interpreted result of Landsat TM, 1986.

Table 4. 2 Interpretation result of 1986.

Land use/Land cover class	Period	
	1986	
	Area in square km	Percent
Crop land	496.48	47.1
Grass	309.79	29.4
Forest	233.61	22.2
Water Body	13.67	1.3

As it is indicated in table 4.2, crop land accounts for about 47.1 % of the total land area of the wereda followed by grass and forest land, 29.4 % and 22.2% respectively and water body about 1.3%.

4.3 Landsat 8 data

The raw Landsat 8 scenes are so dark because it's data, not merely an image: the numbers represent the precise amount of light reflected from the earth's surface in each wavelength, a quantity called reflectance (<http://www.eoearth.org/view/article/150964/>). To encode this information in an image format, the reflectance is scaled and the range of values found in the data is smaller than the full range of values in a 16 bit image. As a result the image has low contrast and only the brightest areas are visible. As a result, the images need to be contrast enhanced (stretched). Following this recommendation histogram equalization has run to enhance the image and a good result was found. After seven bands of the Landsat 8 (excluding thermal band) were considered for layer stacking, Landsat 8 band 5, 4 and 3 were combined to make conventional false color composite images with a spatial resolution of 30 meters (Fig. 4.5).

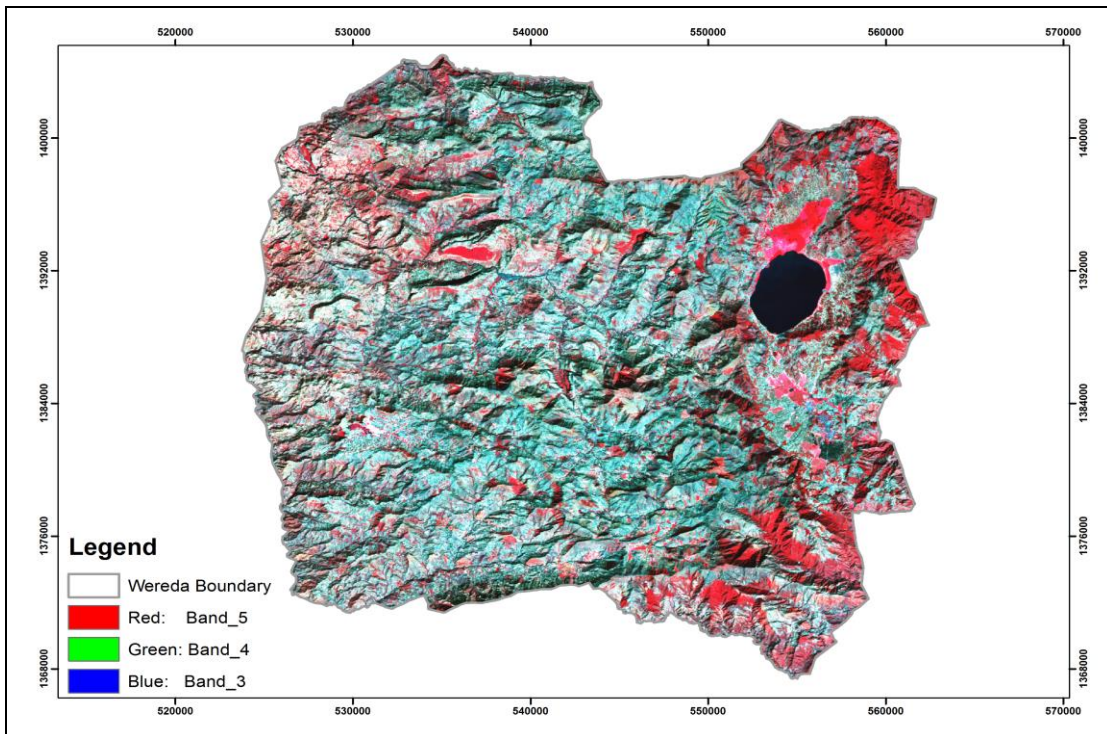


Figure 4. 5 Landsat 8 bands 5, 4, 3 combinations.

This Landsat 8 image was imported to e-cognition for segmentation using multi resolution and setting all parameters (scale, compactness and shape).The segmented image was then imported to MaDCAT software for object based classification using the defined classes. Figure 4.6 shows the interpreted result of landsat 8.

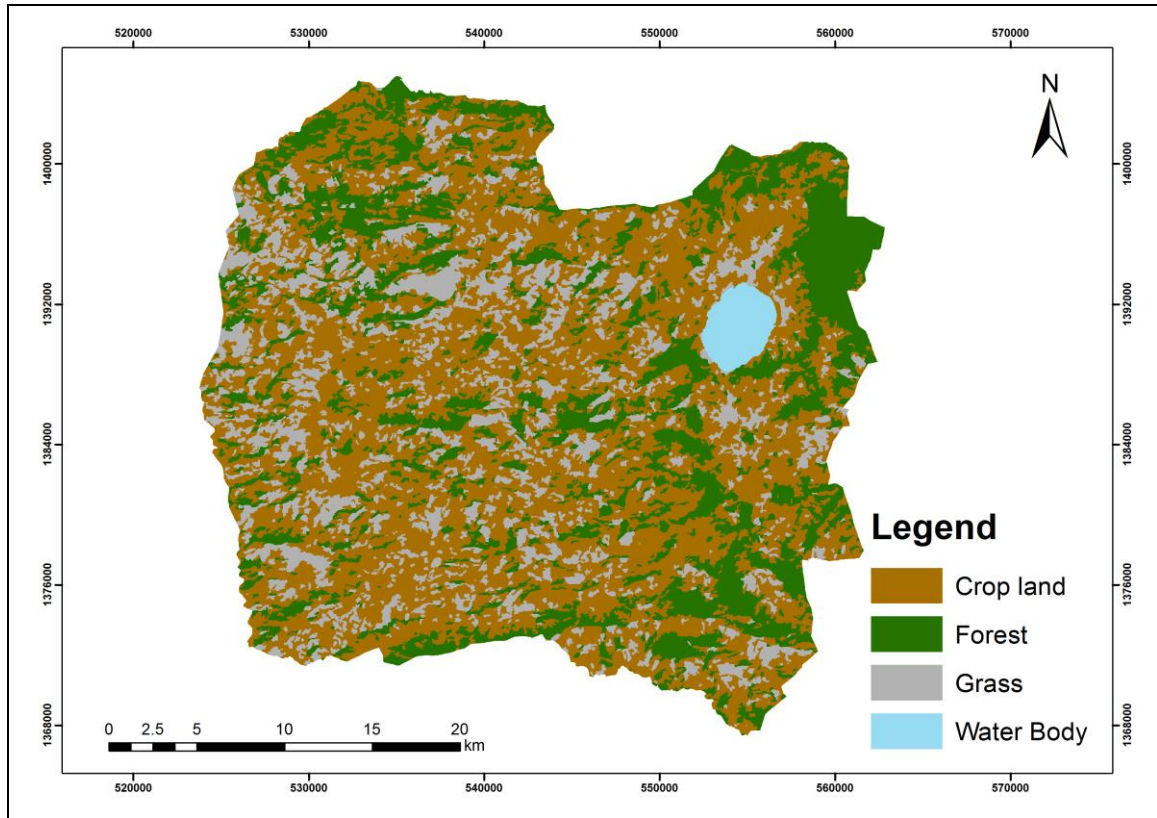


Figure 4. 6 Interpreted result of Landsat 8, 2013.

Table 4. 3 Interpretation result of 2013.

Land use/Land cover class	Period	
	2013	
	Area in square km	Percent
Crop land	564.74	53.6
Grass	198.1	18.8
Forest	275.76	26.2
Water Body	14.94	1.4

As it is indicated in table 4.3, crop land accounts for about 53.6 % of the total land area of the wereda followed by forest and grass land, 26.2 % and 18.8% respectively and water body about 1.4%.

4.4 Accuracy Assessment

Land cover accuracy is commonly defined as the degree to which the derived classification agrees with reality and the accuracy of the map in a larger part determines the usefulness of the map (Ashenafi Burqa, 2008).

Accuracy assessment was critical for a map generated from any remote sensing data. Error matrix is the most common way to present the accuracy of the classification results. Overall accuracy, user's and producer's accuracies, and the Kappa statistic were then derived from the error matrices.

Accordingly the sample size for the accuracy assessment is found to be 283. Those points which are accessible were checked on ground (Appendix 2) and others were checked using Google earth. Table 4.4 shows the result.

Table 4. 4 Accuracy assessment result.

		Ground truth data					
Map data		Cropland	Forest	Grass	Water body	Total	User Accuracy
	Crop land	82	4	16	0	102	80.39
	Forest	3	111	11	0	125	88.8
	Grass	12	0	37	0	49	75.51
	Water Body	0	0	0	7	7	100
	Total	97	115	64	7	283	
	Producer Accuracy	84.54	96.52	57.81	100		

The overall accuracy and kappa analysis were used to perform a classification accuracy assessment and accordingly over all accuracy of the data is 83.75% and over all kappa coefficient was computed which is 0.7527 and from the result the interpretation can be

taken as accurate result for further analysis. Detail calculation of user and producer accuracy and sample photos can be referred from the Appendix 3.

4.5 Change Detection Analysis

Change detection analysis was conducted using post classification image comparison technique. Accordingly, change of land use/ land cover between 1972-1986, 1986-2013 and 1972- 2013 were computed using post classification result and it is presented in table 4.5.

Table 4. 5 Change of classes in three time periods.

Land use/ Land cover	PERIOD											
	1972		1986		2013		1972-1986		1986-2013		1972-2013	
	Km ²	%	Km ²	%	Km ²	%	Km ²	%	Km ²	%	Km ²	%
Cropland	376.87	35.8	496.48	47.1	564.74	53.6	+119.61	+31.7	+68.26	+13.8	+187.9	+49.9
Grass	201.32	19	309.79	29.4	198.1	18.8	+108.47	+53.9	-111.69	-36.1	- 3.22	-1.6
Forest	460.31	43.7	233.61	22.2	275.76	26.2	-226.7	-49.2	+42.15	+18	- 184.5	-40.1
Water Body	15.37	1.5	13.67	1.3	14.94	1.4	-1.7	-11.1	+1.27	+9.3	- 0.43	- 2.8

Source: GIS analysis result

N.B ‘-’ indicates decrease

‘+’ indicates increase

For the 1972 Landsat MSS image, Forest land accounts for 43.7% of the landscape followed by crop land with a value of 35.8 %. Grassland and water body had coverage of 19% and 1.5 % respectively.

In 1986 Landsat TM, crop land and Grassland had increased in coverage to 47.1 % and 29.4 % respectively, while both forest and water body declined to 22.2% and 1.3 % respectively. In 2013 (Landsat 8), crop land accounted for about 53.6%, followed by forest land (26.2%) and grassland (18.8%). water body also accounted for about 1.4 %. The percentage of water body and forest has shown a slight increase in 2013.

When the change analysis for the last 40 years is observed, crop land showed an increase of 49.9% followed by a decrease in forest cover (40.1%)while grass and water body decreased by 1.6% and 2.8 respectively.

4.6 LULC Change Map

Jointly with post-classification comparison, a GIS approach has been combined, to efficiently integrate land use/Land cover maps and to quantitatively reveal the change dynamics in each category. The advantage of GIS techniques is not only linked to exploitation of database capabilities, but also to the ability to easily evaluate the amount of change and to identify the change from a class to a class (Fichera et al., 2011).

There were 16 change categories, corresponding to the transition from each of the four classification categories of the one data to each one of the other data. Table 4.6 – Table 4.8 obtained through post classification image differencing of the periods from 1972-1986, 1986-2013 and aggregate 1972-2013 were displayed in tabular form indicating the change matrix. It describes the value of changing in kilometer square area for the mentioned years in the study area.

Table 4. 6 Land use/Land cover conversion matrix for the year 1972 - 1986.

Conversion matrix of 1972 to 1986		1986			
		Cropland (Km square)	Grass (Km square)	Forest (Km square)	Water Body (Km square)
1972	Cropland	(271)	52	49	0.14
	Grass	122	(39)	39	0
	Forest	101	217	(145)	0
	Water Body	1.15	0.3	0	(13.5)

Note: Figures in parentheses represent LULC that showed no change.

According to the above Table 4.6 conversion matrix for the year 1972 - 1986, the change in the land use/ land cover in the study area was by enlarge attributed to expansion of crop land area. This class has expanded at the expense of grass land (122 sq. km), forest land (101 sq. km) and water body (1.15 sq. km) classes. There was also significant change of forest land to grass in this period in 217 sq. km. Generally there is a sharp decrease of forest cover in this period which goes to grass and cultivated land.

Table 4. 7 Land use/Land cover conversion matrix for the year 1986 - 2013.

Conversion matrix of 1986 to 2013		2013			
		Cropland (Km square)	Grass (Km square)	Forest (Km square)	Water Body (Km square)
1986	Cropland	(303)	145	47	1.02
	Grass	165	(26)	119	0.2
	Forest	97	27	(109)	0
	Water Body	0.02	0.02	0	(13.61)

Note: Figures in parentheses represent LULC that showed no change.

According to Table 4.7 conversion matrix for the year 1986 - 2013, the change in the land use/ land cover in the study area was by enlarge attributed to expansion of crop land area. This class has expanded at the expense of grass land (165 sq. km), forest land (97 sq. km) and water body (0.02 sq. km) classes. There was also significant change of crop land to grass in this period in 145 sq. km and 119 square km of grass land was also changed to forest land. Generally forest cover showed increment in this period which mainly attributed to the change of grass to forest land.

Table 4. 8 Land use/Land cover conversion matrix for the year 1972 - 2013.

Conversion matrix of 1972 to 2013		2013			
		Cropland (Km square)	Grass (Km square)	Forest (Km square)	Water Body (Km square)
1972	Cropland	(227.44)	112.68	32.73	0.06
	Grass	124.67	(56.63)	19.7	0.04
	Forest	212.08	28.69	(223.25)	0
	Water Body	0.5	0.08	0	(14.44)

Note: Figures in parentheses represent LULC that showed no change.

According to table 4.8 conversion matrix, the change in the land use/ land cover in the study area was by enlarge attributed to expansion of crop land area. This class has expanded at the expense of forest (212.08 sq. km), grass (124.67sq. km) and water body (0.5 sq. km) classes.

The following Figure 4.7 shows the LULC change map of the study area for the year 1972-2013.

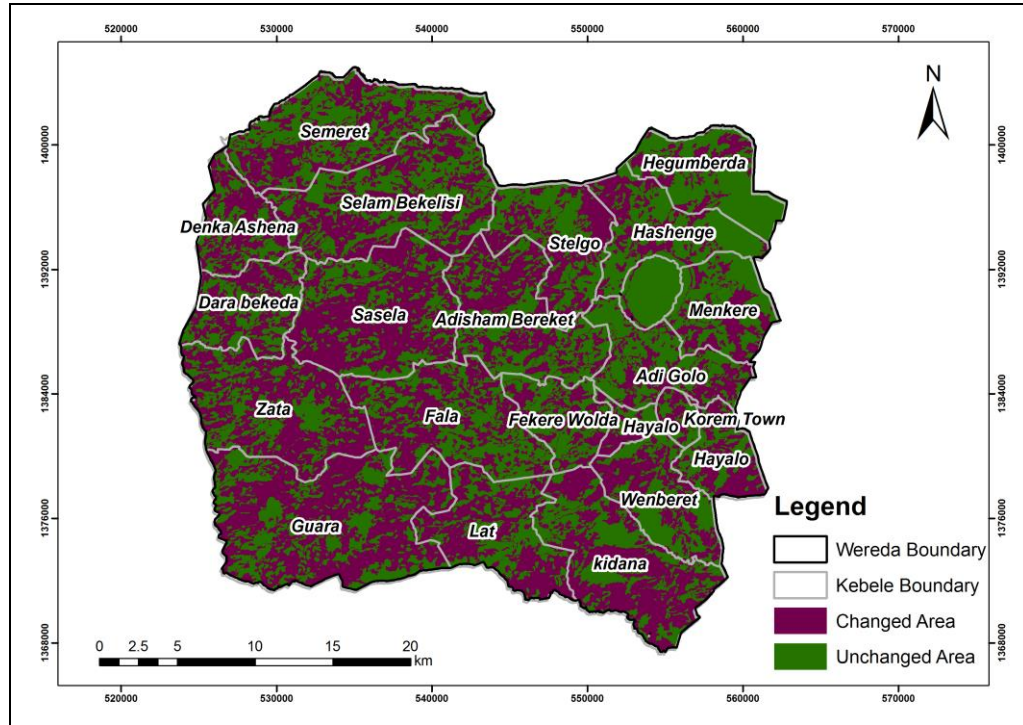


Figure 4. 7 Land use/Land cover change map(1972-2013).

The following table 4.9 shows a summarized area of change for the period of time (1972 to 2013) for the study area rural kebeles.

Table 4. 9 Percentage of change by kebele.

No.	Kebele Name	Kebele Area(sq.Km)	Change in Sq Km	Percentage of change
1	Sasela	77.05	49.77	64.59
2	Guara	113.67	68.51	60.27
3	Zata	71.38	42.98	60.20
4	kidana	70.08	39.85	56.86
5	Hayalo	32.37	18.13	56.02
6	Lat	51.14	28.59	55.91
7	Adisham Bereket	61.88	31.82	51.42
8	Fala	66.12	33.61	50.84
9	Stelgo	45.24	22.72	50.21
10	Selam Bekelisi	82.33	40.86	49.63
11	Korem Town	7.59	3.73	49.13
12	Wenberet	38.99	17.67	45.31

No.	Kebele Name	Kebele Area(sq.Km)	Change in Sq Km	Percentage of change
13	Semeret	70.88	31.25	44.08
14	Dara bekeda	44.45	18.29	41.15
15	Fekere Wolda	27.73	11.08	39.97
16	Adi Golo	40.47	15.44	38.15
17	Menkere	34.97	12.63	36.13
18	Hashenge	42.63	14.61	34.26
19	Hegumberda	39.38	9.56	24.27
20	Denka Ashena	75.44	16.62	22.03

According to the change matrix analysis, about 48% of the land within the study landscape experienced LULC changes in one way or another in the last 40 years (1972–2013).

Based on the percentage change of the wereda, kebele's with more than 60 % change were selected namely: Sasela, Guara and zata. In these kebeles socio economic survey was conducted to identify underlying causes for the change.

The desired sample size was found to be 384 and to compute the actual sample size for the selected kebeles house hold size data of each kebele were prepared (Table 4.10).

Table 4. 10 Household size of selected kebeles.

No	Kebele Name	House hold size
1	Sasela	2208
2	Guara	2037
3	Zata	1791
Total		6036

Using the household data and the desired sample size, the actual sample size was found to be 362. The actual sample size was then distributed proportional to the household size and the following Table 4.11 revealed the result.

Table 4. 11 Sample size of selected kebeles.

No	Kebele Name	Sample size
1	Sasela	133
2	Guara	122
3	Zata	107
Total		362

These 362 households were randomly selected from their respective kebeles to analyze their response regarding the underlying causes and effects of land use/land cover change.

4.7 Analysis of Socio-Economic Survey

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

4.7.1 Age - Sex Composition

The age - sex structure refers to the composition of the household head according to age and sex. The age - sex composition of the sampled household is presented in Table 4.12. Accordingly, the mean age of the respondent was about 44 years. While the median age was between 45 and 53. Respondents below age 40 constituted nearly 35.7 per cent of the total and above 40 the remaining 64.3 per cent. Sex wise the vast majority of the household heads nearly 68.4 per cent were males whereas females constituted the remaining proportion (31.6 per cent).

Table 4. 6 Age - Sex Composition of the study population.

Age Group	Sex		
	Male	Female	Total
28-35	65	10	75
36-44	43	40	83
45-53	108	40	148
54-62	16	17	33
Total	232	107	339

Source: Field Survey (2014)

4.7.2 Marital Status

Analysis of the data indicated that 67 percent of the respondents were currently married while divorced and widowed constitute 8.2 and 24.8 percent respectively. Table 4.13 presents data on the marital status of the respondents.

Table 4. 7 Percentage Distribution of Respondents by marital status.

Marital Status	Number	Percent
Currently married	227	67
Divorced	28	8.2
Widowed	84	24.8
Total	339	100

Source: Field Survey (2014)

4.7.3 Literacy Status of Respondents

Since the study was conducted in rural Ethiopia, where the majority of the people make a living from agriculture, 80.8 per cent of the respondents were illiterates, whereas 19.2 per cent were literates.

4.7.4 Off - Farm Income

During the survey, respondents were asked whether they had participated in off-farm activities or not. The data given in Table 4.14 show the percentage distribution of the sample household by off-farm income. Accordingly, 86.1 per cent of the respondents were not involved in off - farm activities while about 13.9 percent of the respondents had participated in off - farm activities in the last 12 months.

Table 4. 8 Percentage Distribution of Respondents by their monthly off farm income.

Off farm income status	Number	Percent
Participated	47	13.9
Not participated	292	86.1
Total	339	100

4.7.5 Land Size

The landholding of peasants in the study area varied from one timad to three timads. 51.3 percent of the respondents reported that they own less than 1.5 timad. The average land holding size of the area is less than 1.5 timad that is less than half hectare according to Table 4.15.

Table 4. 9 Percentage Distribution of Respondents by land holding size.

Land size	Number	Percent
0 – 1.5	177	52.2
1.5 – 3.0	165	48.7
Total	339	100

Source: Field Survey (2014)

4.7.6 Land condition

According to respondents response on the status of land compared to 20 years before, all of the respondents reported that has become scarce.

The respondents also asked to justify their reason and accordingly table 4.16 indicates that about 34 percent of the respondents reported that population increase is the main cause for land scarcity. Lack of off (non) farm activities, an increased land degradation followed by drop in soil fertility were recorded as causes of land scarcity. Land redistribution which was reported by about 10% of the respondents could have accentuated land fragmentation.

Table 4. 10 Percentage Distribution of Respondents reason for land scarcity.

Reason for scarcity of land	Number	Percent
Population growth	115	33.9
Decrease in fertile land	56	16.5
Non availability of off farm activities	79	23.3
Land degradation	56	16.5
Land redistribution	33	9.8
Total	339	100

Source: Field Survey (2014)

4.7.7 Land Productivity

The survey conducted also include the productivity of their farm in comparison with 20 years before. According to table 4.17, 50.4 percent of the respondents confirmed that there is decrease in land productivity while 25.1 and 24.5 percent replied increase and no change respectively.

Table 4. 11 Percentage Distribution of Respondents reason for land productivity.

Land productivity status	Number	Percent
Increased	85	25.1
Decreased	171	50.4
No change	83	24.5
Total	339	100

Source: Field Survey (2014)

4.7.8 Land use land cover change

According to the respondents response on land use land cover change on their area, and 95.3 percent of the respondents replied that there is land use land cover change while 4.7% stated that there is no change as such.

The respondents were also asked to mention the changes observed if they say there is a change, according to Table 4.18, 57.5 percent of the respondents say crop land is increased, 72.9 percent of the respondents replied that forest land is decreased, 77.9 percent said water body is decreased.

Table 4. 12 Percentage Distribution of Respondents on justification for land use/land covers change.

Land use land cover class	Increased	Percent	Decreased	Percent	No change	Percent
Change in crop land	196	57.5	136	40.1	8	2.4
Change in forest land	64	18.9	247	72.9	28	8.3
Change in water surface	48	14.2	264	77.9	27	8
Change in grass land	20	5.9	291	85.8	28	8.3
Change in degraded land	192	56.6	136	40.1	11	3.2
Change in Settlement infrastructure	327	96.5	12	3.5	0	0

Source: Field Survey (2014)

When we compare this result with satellite image analysis, the trend of change is similar with forest land, grassland and water body classes. Regarding the crop land area 57.5% of the respondents replied that crop land is increased while 40.1% believed decreased. This could be related with their understanding of personal crop land holding size decline.

4.7.9 Causes of Land use land cover change

Respondents were asked to identify the causes of this land use land cover change, according to Table 4.19, 34.2 percent of the respondents confirmed that population increase is the cause for the change followed by improved access to basic physical and social infrastructure which accounts for more than 23 percent.

Table 4. 13 Percentage Distribution of Respondents on causes of land use/land cover change.

Cause for change	Number	percent
Population growth	116	34.2
Land tenure insecurity	82	24.2
Lack of proper management	28	8.3
Improved access to basic infrastructure	78	23*
Improved access to extension service	29	8.6*
Expansion of market	6	1.8*
Total	339	100

Source: Field Survey (2014)

* It indicates physical and social infrastructure.

4.7.10 Effect of Land use land cover change

Respondents were asked to identify the environmental problems which are common in their localities following the land use/land cover change. According to Table 4.20, 45.1 percent of the sample household heads were replied that deforestation is the common effect followed by 40.1 percent respondents understanding that the effect is soil erosion.

Table 4. 20 Percentage Distribution of Respondents on the effect of land use/land cover change.

Effect of land use/land cover change	Number	Percent
Soil erosion	136	40.1
Degradation of watershade	44	13
Deforestation	153	45.1
Increase waste land	6	1.8
Total	339	100

Source: Field Survey, 2014

The respondents were asked to identify the causes separately for their choice on the effects of the land use/land cover change. Accordingly Table 4.21 indicates that out of the respondents who stated that soil erosion is the main consequence of land use land cover change. About 40 percent of the respondents are of the opinion that intensive use of land is the major cause for soil erosion followed by 31.6 percent for overgrazing.

Table 4. 21 Percentage Distribution of Respondents on the cause of soil erosion.

Cause for soil erosion	Number	Percent
Land fragmentation	12	8.8
Absence of fallowing	25	18.4
Overgrazing	43	31.6
Intensive use of land	54	39.7
Total	136	100

Source: Field Survey (2014)

Out of the 153 respondents who stated that deforestation is the major effect of land use land cover change, all respondents told that increasing demand for fire wood is the major cause for deforestation.

Out of the 44 respondents who stated that degradation of water shade is the major effects of land use land cover change, 79.5 percent of them said that increasing demand for local consumption is the major cause of degradation followed by change in cropping pattern covering 20.5 percent.

4.7.11 Land improvement measure

During the survey respondents were asked whether they invest on land improvement measure or not, according to Table 4.22 shows that 89.7 percent of the respondents said that they do invest on their land while the rest said they do not.

Table 4. 14 Percentage Distribution of Respondents on land improvement measure.

Investment of land Improvement measure	Number	Percent
Yes	304	89.7
No	35	10.3
Total	339	100

Source: Field Survey, 2014

35 of the respondents who replied that they did not invest on land improvement measures, 51.4 percent of them told their income is not sufficient to invest on their land and 31.4 percent replied that land tenure insecurity is their major problem (Table 4.23).

Table 4. 15 Percentage Distribution of Respondents reason on the failure to invest on land.

Reason for not investing on land	Number	Percent
My income does not allow me to do so	18	51.4
Land tenure insecurity	11	31.4
Other	6	17.2
Total	35	100

Source: Field Survey (2014)

For the rest of the respondents (304) who replied that they invest on their land, detail question were asked to identify which type of land improvement measures they had applied. As it is indicated in Table 4.24, the vast majority of respondents 92.1 percent were using soil bund followed by those using terracing accounted for 90%.

Table 4. 16 Distribution of Respondents Who participated in conservation activities.

Conservation activity	Number	Percent
Terracing	272	89.5
Contour ploughing	18	5.9
Traditional ditches	81	26.6
Bunds	280	92.1

Source: Field Survey (2014)

CHAPTER FIVE

5 RESULTS AND DISSCUSSION

5.1 Rate of change of land use/ land cover change (1972 - 2013)

Generally there is a continuous land use/land cover change taking place for most parts of the wereda in the last 4 decades. The land cover change from 1972 to 2013 has been discussed in two periods. The first period has 14years of gap i.e. from 1972 to 1986 and the second period is from 1986 to 2013 that has 27 years of gap. The cover dynamics discuss the rate of land cover change from 1972 to 1986 and 1986 to 2013. Table 5.1 clearly shows the land cover change rate for the past 40 years.

Table 5. 1 Rate of change in land use/ land cover class.

Land use/ Land cover Classes	PERIOD					
	1972	1986	2013	Annual rate of change (%) (1972-1986)	Annual rate of change (%) (1986-2013)	Aggregated Rate of change (%) (1972-2013)
	Km ²	Km ²	Km ²			
Crop land	376.87	496.48	564.74	+2.3	+0.5	+1.2
Grass	201.32	309.79	198.1	+3.8	-1.3	-0.04
Forest	460.31	233.61	275.76	- 3.5	+0.7	-1
Water Body	15.37	13.67	14.94	- 0.7	+0.3	-0.1

Forest land shows the highest annual rate of change for 1972 to 1986, by -3.5 % per annum decrease and the same scenario for water body by -0.7% per annum while crop land and grass land show +2.3% and +3.8% per annum increment for the same time period. But for the time period between 1986 and 2013, the rate of change shows significant decrease both in increment and decrease, that is, the maximum decrease is in grassland class with -1.3% per annum and maximum increment is +0.7% per annum for class of Forest followed by crop land and water body with +0.5% and +0.3% per annum respectively. The increment of rate of change in forest and water body in the second period from 1986-2013 may be attributed to the integrated water shade management implemented by the regional government of Tigray. When we see the general scenario (1972-2013), the rate of change indicates that only crop land has increased(+1.2%) per

annum while the rest classes namely grass, forest and water body showed decrease by – 0.04%, -1% and -0.1% respectively.

The finding of Zeleke and Humni (2001) reported an increase in crop land by 38 % in 38 years (1957-1995) in north western Ethiopian high lands and this result agrees with ofla findings while the result of Tegene (2002) as cited in Mengistie et al. (2013) that reports an increase in crop land was 5.5 % in 43 years in South Wello zone of Amhara region is by far different from this finding in magnitude but showed similar trend.

5.2 Analyzing LULC changes in relation to different factors (1972-2013)

Changes had taken place for most land cover types in the last 40 years in the study area. The land use/ land cover change has been triggered by different causative factors which may lead to environmental problems and natural resources degradation. On one way or another, the change in land use and land cover is the reflection of socio-economic condition of the surrounding community. The human activities and natural processes are the responsible factors for LULC change in the study area. The following sub sections of the paper deals with the results of the study in relation to slope and agro ecology.

5.2.1. Analyzing LULC changes in relation to Slope

The relationship between land use\land cover and topography, in the time period between 1972-2013, was analyzed using Digital Elevation Model (DEM) 30 meter resolution derived slope data. Accordingly, the steepness of the study area was found to be between 0 and 71.1 degrees. Before all else, how land use\land cover was changed in the course of time was determined according to slope thus the analysis shows that more than 75.6 % of the change is associated with less than 30° of slope (Figure 5.1) in the study area.

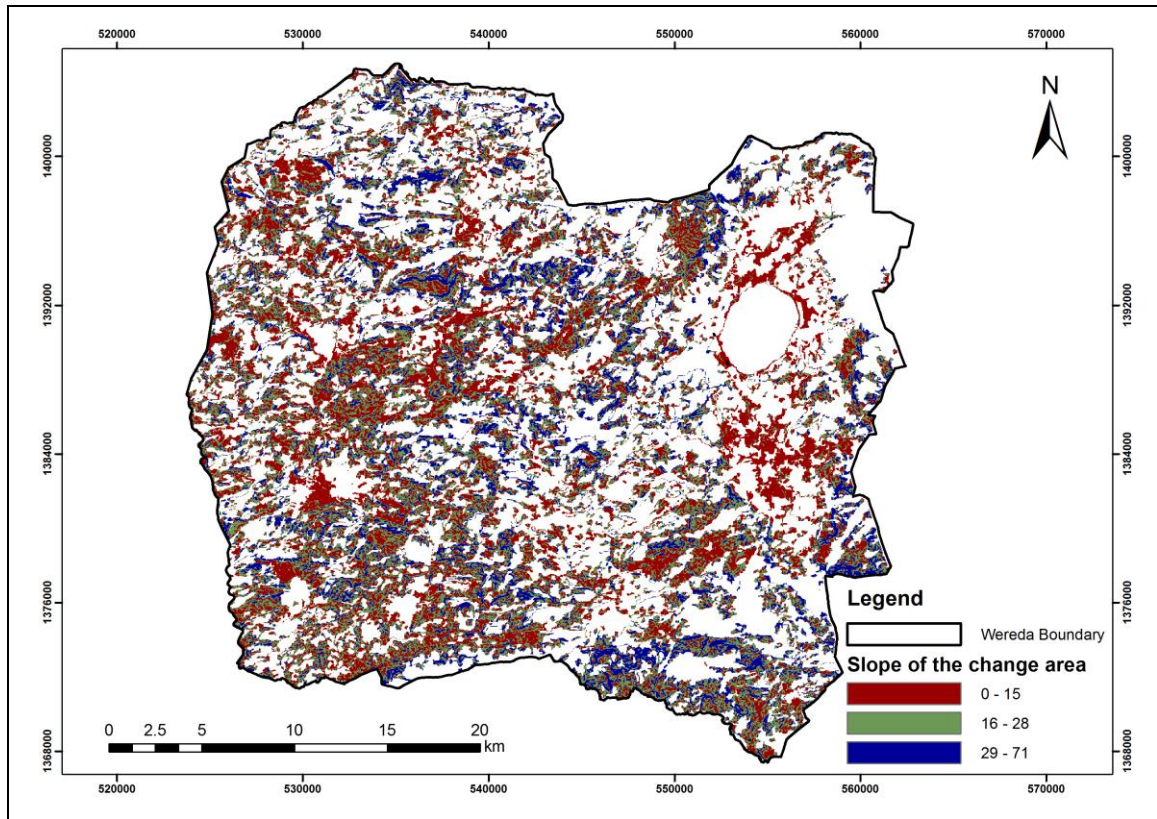


Figure 5. 1 Slope of the LULC change area in degrees.

Results of the analysis reveal that the agriculture class, which was expanded at the expense of forest and grass land areas, indicates that in 1972, more than 69.2 % of the crop areas fall below 20° slope but in 2013 the percentage declined to 54.5% with the same slope indicating crop land is expanding to the steep slopes too.

Mengistie et al., 2013 had also got similar results in land use/land cover changes along slopes. They stated that, area covered by croplands increased continuously from 15% to 52%, 16% to 55%, 4% to 24%, and 0.6% to 8% on gentle, moderate, steep, and very steep slopes, respectively in Munesa area of Ethiopia.

5.2.2 Analyzing LULC changes in relation to agro ecology

Agro ecology of the study area was also seen in relation to LULC changes. Ofla wereda falls in two traditional agro ecological zones; namely Woinadega (76.8%) and Dega (23.2%).

It was in the sub-humid highland zone(woina dega), about 78 % of the changes occurred while the rest 22 % of the changes happened in humid high land (Dega) area. In other words about 50 % of woina dega area of ofla wereda was changed while 45 % for dega area.

The analysis reveals that even though there is 5 % difference between the two agro ecological zone change percentages, there is no as such significant relation between agro ecology and LULC change for this study area.

Other research in Munesa showed a relation between different agro ecology zone and LULC, stating the changes observed over the study period also differed notably along the agro-ecological zone associated with the elevation range in the study landscape (Mengistie et al.,2013).

5.3 Result of Socio-Economic Survey

The land use and land cover changes were triggered by different causative factors which may lead to an irreversible environmental problems and natural resources degradation. In one way or another, the change in land use and land cover is the reflection of socio-economic condition of the surrounding community. The human activities and natural processes are the responsible factors for LULC change in the study area.

Land use/ land cover change is always caused by multiple interacting factors. The mix of driving forces of land-use change varies in time and space according to specific human-environment conditions. Accordingly the underlying causes operate at the local level were identified from the household survey conducted in the relatively high change Kebeles.

There are conditions which were identified as important points before discussing the results of the underlying causes of land use/land cover change to link the result with the underlying facts.

The survey result showed that about 44% of the respondents were in the age group 45-53 and 24% were in the age group of 36-44 and these groups can actually have a good understanding of the change in their localities and it is sounding to consider the responses for the identification of the underlying causes.

Analyzing off farm income of the respondents is also vital to see the burden on the agricultural sector and hence land use land cover change. Accordingly, about 86.1% of the respondents did not participated in off farm activities in the last 12 months which shows there is more dependency on agriculture since they don't have any source of income other than agriculture. In addition to their dependency on agriculture, the land holding size of the household is low in that 52% of the respondents land holding is less than 1.5 timad (0.4 hectare).

All of the respondents agreed that land is becoming scarce and they were asked to reason out the cause for the scarcity, about 33.9% indicates that population growth is the main cause for scarcity followed by 23.3% which states that non availability of off-farm activities is the major factor. The other related issue which respondent's response was collected is on land productivity, half of the respondents (50.4%) indicate that land productivity is declining in their localities.

All the above stated facts indicate that there is a need for the farmers in the study area to look for another land to feed their increasing population which may lead to land use land cover change.

About 95.3% of the respondents believe that there is land use/ land cover change in their localities. The respondents were also asked to mention the changes observed and 96.5% and 57.5% of the respondents indicated that there is an increase in settlement and crop land respectively. While 85.8% and 77.9% said that there is a decrease in grass land and water surface. When we compare this result with the LULC change analysis done by remote sensing, there is similarity in the trend of the change.

Regarding the underlying causes of land use land cover change, about 34.2% of the respondents replied that the major cause is population growth and about 24.2% mentioned land tenure insecurity right as the major cause.

From the above analysis, it is clear that population growth is the major cause for both land scarcity and land use land cover change in the study area.

Deforestation and soil erosion were the major effects of the change inland use land cover according to the socio economic survey conducted in the study area (45.1% and 40.1% respectively).

Land improvement measures were another area where the respondent's attitudes were collected. Accordingly, 89.7 % of the respondents replied that they invest on land improvement measure while the rest 10.3% did not, these respondents response also agrees with the image analysis result in that the period 1986-2013 showed improvement or rehabilitation both in forest and water body classes. Those 35 respondents who did not invest on their land was asked to explain their reason and 51.4% responded that there income is not sufficient to do so while 31.4% replied that lack of ownership right is their reason. For those who invest on their land further question was asked about their land improvement measures and 92.1% of the respondents participated in soil bunds while 89.5% on terracing activity. This land improvement measure analysis is fairly related with the land improvement measures the regional government was implementing and which are also considered by the federal government as a model. The result also supports the analysis of LULC using remote sensing in that the rate of change in land use and land cover is declined in 1986-2013 period compared to 1972-1986.

A focus group discussion was also employed to get insight of the underlying causes of land use / land cover change in the study area. Accordingly the members of the focus group discussion underlined that generally there is a decrease in forest land and water regimes while increase in crop land and settlement. This discussion result also supports the LULC change analysis. The group also discusses the cause for the change and underlined that population growth is the major factor for the change but there are some who argued that it is mismanagement and poor agricultural practices which were responsible for the change.

The last issue discussed was community participation in conservation activity and they replied that the populations of the wereda are actively participating in conservation activities having the kebele officials in front line as their day to day activity with support from the wereda administration as one of their priority areas. This result also reveals similarity with the image analysis result in that the positive rate of change in forest and water body classes could be a result of these activities.

CHAPTER SIX

6 SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary

This study was conducted in Ofla wereda, Tigray region. The basic data used in this study were generated from the land use/land cover change detection using landsat imagery in order to identify the high change area.

Based on the result of the land use/land cover change, kebeles with more than 60% change in the last 40 years(1972-2013) were selected and the main causes and consequences of the change in the study area were generated from a household survey.

The land use/ land cover change analysis for the three periods time (1972-1986), (1986-2013) and (1972-2013) depicts that in the first period of change analysis (1972-1986), the analysis showed high change in the study area with increment in crop land at the expense of other classes in a significant area coverage. While the second period (1986-2013) showed a decrease in magnitude plus register an increment in the class of forest and water body classes which may be related with the integrated water shade management of the regional government implementing in the region. When we see the general trend for the last 4 decades (1972-2013), crop land were increased by +1.2% per annum and the rest grass, forest and water body classes were decreased in -0.04%, -1% and -0.1% per annum respectively.

This increment in crop land was also analyzed with slope and it revealed that in 1972, 69.2% of the crop land falls below 20° slope while in 2013 the percentage declined to 54.5% with the same slope indicating crop land is expanding to the steep slopes besides the high percentage of increment in crop land (+1.2% per annum for about 40 years).

Regarding the result of the household survey, about 95.3% of the respondents believe that there is land use/land cover change in their localities. They were also asked to mention the changes observed and 57.5% say crop land is increased, 73% and 78% replied forest land and water body decreased respectively. This perception of the respondents agrees with what was found from the analysis of satellite imagery in their trend.

The socio economic survey conducted also revealed that about 34% of the respondents replied that the major cause of the land use/land cover change were population growth followed by 24% which stated land tenure insecurity is the major cause.

The effect of the land use/land cover change was the other concern of the study and the analysis of the survey indicates that deforestation was found as the major effects by about 45% while 40% replied that soil erosion was the major effect of the change.

6.2 Conclusion

Land use/land cover are very dynamic in nature and have to be monitored at regular intervals for sustainable development thus it has become a central component in current strategies for managing natural resources. The advancement in the concept of vegetation mapping has also greatly increased research on land use/ land cover change.

The results of this study revealed the existence of significant land use and land cover changes in the last 40 years. Especially the expansion of crop land at the expense of forest land.

Attempt was made to capture as accurate as possible four land use land cover classes as they change through time. Thus, remote sensing results showed the changes in the last 40 years, crop land has shown a significant increase in area (+49.9%) while forest land shows decrease (-40.1%) in the study area. The rest Grass land and water body's shows decrease in -1.6 and -2.8 respectively for the whole period. This change analysis was observed using post classification image comparison technique. Accordingly, the 1972-1986 change analysis showed high change in land use land cover that is crop land increased in +31.7% and forest decrease in -49.2% while 1986-2013 change analysis showed relatively less change in that crop land increased by +13.8% and forest increased by 18%. Despite the periodic variations in change of all classification classes, the overall rate of change during the whole period of the analysis (1972-2013) is found to be higher in 1972-1986 than 1986-2013.

Jointly with post-classification comparison GIS was employed to identify the change from a class to a class. The land cover dynamics with a span of 40 years experienced significant rates of conversion of land cover types. Accordingly there were 16 change categories, corresponding to the transition from each of the four classification categories of the one year data to each one of the other data in another date. The analysis revealed that the change in the land use/ land cover in the study area is largely attributed to the expansion of crop land area. This class has expanded at the expense of Forest (212.08 sq. km), grass (124.67sq. km) classes and water body (0.5 sq. km) respectively.

The socio economic survey conducted also revealed that population growth is the major cause for land use/ land cover change and this factor is also supported from the analysis that land scarcity was happening in the study area following the growth of population.

Deforestation and soil erosion were identified as the major effects of the change in the study area according to the socio economic survey conducted. Land improvement measures were being carried out in the study area which will improve the situation in land use/land cover changes.

6.3 Recommendations

Land use/land cover mapping and detection of changes shown here may not provide the ultimate explanation for all problems related to land use/land cover changes but it serves as a base to understand the patterns, trend of changes and possible causes and consequences of land use/land cover changes in the area.

Since most important factor of the land use / land cover change in the study area was an increase in population, continuing the efforts of introducing family planning to make the people aware of consequences of population pressure on land resources should be carried out intensively.

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

Remote sensing satellite imagery are widely applicable for land use and land cover classification and change detection. This is an important input in land use planning and other development activity. Hence, remote sensing and GIS should be utilized for natural resource management to acquaint the managers and decision makers themselves with up-to-date information and experts at the wereda level should be trained on a skill of remote sensing and GIS to provide tangible timely information to the decision makers at the lowest administrative level.

Land use/land cover mapping and detection of changes shown here may not provide the real figure of classes due to low resolution of the imagery but it serves as a base to understand the patterns and magnitude of land use/land cover changes in the area. Therefore such land use/cover detections using high resolution satellite images would be more dependable.

Reference

- Asenafi Burqa. (2008). Landuse/landcover dynamics in prosopis juliflora invaded area of Metehara and the surrounding districts using remote sensing and GIS techniques. Unpublished MSc Thesis, Addis Ababa University, Addis Ababa, Ethiopia, 88pp.
- Bahru Shikur. (1993). Farmers' Perception of Soil Erosion Problems and their attitude towards Soil Conservation in Guraghe Highlands of Butajira Awraja, South Shoa. Unpublished M.A. Thesis. Addis Ababa University, Addis Ababa, Ethiopia.
- Bernard, B., Anthony, E. and Patrick, O.(2009). Analysis of Landuse/cover trends inkirimasub/countyKanunguDistrict.IN:
http://www.fao.org/fileadmin/templates/ess/documents/meetings_and_workshops/ICAS5/PDF/ICASV_1.3_096_Paper_Barasa.pdf
- Billah, M. and Anisur, R. (2004). Landcover mapping of Khulna city applying remote sensing technique. IN: *proceeding of the 12th International Conference on Geoinformatics – Geo Spatial information Research*,University of Gavle,7-9 June 2014, Seweden.
- Campbell, J.B. (1987). *Introduction to Remote Sensing*. The Guilford Press, New York, USA.
- Campbell, D.J., Lusch, D.P., Smucker, S. and Wangui, E.E. (2003). *Root causes of Landuse change in the Loitokitok Area, Kajiado District, kenya*. Department of Geography, Michigan state University, USA.
- Cochran, W.(1977). *Sampling Techniques*. 3rd Edition. 442pp.

- Codjoe, S.N.A., 2007. Integrating Remote Sensing, GIS, Census, and Socioeconomic Data in Studying the Population–Land Use/Cover Nexus in Ghana: A Literature Update. *Africa Development*, Vol. XXXII, No. 2, pp. 197–212.
- Dagnew Belay. (2007). Assesment of causes and extent of land degradation in Hashenge Catchement , southern Tigray. Unpublished MSc Thesis, Addis Ababa University, Addis Ababa, Ethiopia, 75pp.
- Daniel Ayalew. (2008). Remote sensing and GIS based Land use and Land cover change detection in the upper Dijo river catchement, Silti zone, southern Ethiopia. Unpublished MSc Thesis and Report, NTNU and Addis Ababa University, Norway, 37pp.
- Daniel Ayalew Mengistu. (2008). Remote sensing and GIS based Land use and land cover Change detection in the upper Dijo river Catchment, Silite zone, Southern Ethiopia. Working papers on population and land use change in central Ethiopia, nr. 17 NTNU and Addis Ababa University, Addis Ababa, Ethiopia, 37pp.
- Dewan, A.M. and Yamaguchi, Y. (2009). Using remote sensing and GIS to detect and monitor landuse and landcover change in Dahaka Meteropolitan of Bangladesh during 1960-2005. *Environ. Monit. Assess.* **150**:237-249.
- Ephrem Haile. (2008). Landuse/landcover dynamics and Erosion susceptibility Analysis: A case study of Basso werena wereda. Unpublished MSc Thesis, Addis Ababa University, Addis Ababa, Ethiopia, 93pp.
- FAO (2000). Land Cover Classification System (LCCS): Classification Concepts and User Manual. <http://www.fao.org/>

- Fichera,C.R., Modica,G. and Pollino, M. (2012).Land cover classification and Change detection analysis using multi temporal remote sensed imagery and landscape metrics. *European Remote sens.***45**:1-18.
- Gedion Asfaw. (2003). Breaking the Cycle of Recurrent Famine in Ethiopia: Natural Resource Management and Drought Related Famine Prevention. *Economic Focus Bulletin of Ethiopian Economic Association.* 5:5
- Giri, C., Defourny, P. and Shrestha, S. (2003). Land cover characterization and mapping of continental Southwest Asia multi-resolution satellite sensor data. *International Journal of Remote Sensing.* 24(21): 4181-4196.
- Girmay Kassa. (2003). GIS based Analysis of Land use /Land Cover, Land Degradation and Population Changes. Unpublished MSc Thesis, Addis Ababa University, Addis Ababa, Ethiopia,153pp.
- Grenier, M., Labrecque, S., Benoit, M. and Allard, M. (2008). Accuracy assessment method for wet land object based classification.**In:** *Proceedings of the XXXVIII-4c1.* ISPRS, Aug 5-8,2008.Calgary,Canada.
- Hussein Ali Oumer.(2009). Landuse and landcover change, Drivers and its Impact: A comparative Study from Kuhar Michael and Lenche Dima of Blue Nile and Awash Basins of Ethiopia. Unpublished MSc Thesis, Cornel University, Bahirdar, Ethiopia,139pp.
- <http://www.csa.gov.et/index.php/2013-02-20-13-43-35/national-statistics-abstract/141-population> accessed on 12/09/2013.
- <http://www.eoearth.org/view/article/150964/> accessed on 12/23/2013.
- <http://landsat.gsfc.nasa.gov> accessed on 12/09/2013.

<http://www.isric.org/about-soils/world-soil-distribution/leptosols> accessed on
12/09/2013

<http://www.cals.uidaho.edu/soilorders/vertisols.htm> accessed on 12/09/2013.

Katana, S.J.S., Vcakuwun, E.K. and Munyao, T.M. (2013). Detection and prediction of Land cover changes in upper Athi river catchment, Kenya: A Strategy towards Monitoring Environmental Changes. *Greener Journal of Environmental Changes. Greener Journal of Environmental Mgt and Public safety*. **2**(4) pp.146-157.

Lambin, E.F., Geist, H.J. and Lepers, E. (2003). Dynamics of Landuse and Landcover change in Tropical Regions. *Annu.Rev. Environ. Resour.* **28**:205-41.

Liang, S., Fang, H., Morisette, J.T, Chen, M., Shuey, C.J., Walthall C.L. and Daughtry, C.S. (2002). Atmospheric Correction of Landsat ETM+ Land Surface Imagery: II. Validation and applications. *IEEE Transactions on Geoscience and Remote Sensing*.1-5.

Lillesand, T. and Kiefer, R.W. (1994). *Remote sensing and Image interpretation*. Third ed., John Wiley & Sons, Inc., 750pp.

Lu, D., Mausel, P., Brondi'zio, E. and Moran, E. (2003). Change detection techniques. *INT. J. Remote Sensin.* **25**(12), 2365-2407.

MaD CAT Manual.(2011). Mapping Device and Change Analysis tool. Version 3.3.12.

- Mengistie Kindu, Thomas,S., DemelTeketay, Thomas, K.(2013). Landuse/Landcover change analysis using Object based classification approach in Munesa Shashemene Landscape of the Ethiopian highlands. *Remote sens.***5**:2411-2435.
- Milanova, E. and Telnova, N. (2007). Land use and Land cover Change Study in the trans boundary zone of Russia- Norway. **In** *Proceeding of MAN IN THE LANDSCAPE ACROSS FRONTIERS- IGU-LUCC CENTRAL EUROPE CONFERENCE,2007.*
- Misgina Gebrehiwot.(2006). An assesement of chanllenges of sustainable rural water supply : The case of Ofla wereda in Tigray region. Unpublished MA thesis, Addis Ababa University, Addis Ababa,Ethiopia,125pp.
- Quentin, F. B., Jim, C., Julia, C., Carole, H., and Andrew, S.(2006). Drivers of land use change, Final report: Matching opportunities to motivations, ESAI project 05116, Department of Sustainability and Environment and primary industries, Royal Melbourne Institute of Technology. Australia.
- Ramankutty, N., Foley, J.A. and Olejniczak, N.J. (2002). People on the land: Changes in global population and croplands during the 20th century. *Ambio.***31**: 251-257
- Sisay Worku. (1998). The Ethiopian Population in the 90s and Beyond. **In**: *Population and Development.* **4**(4). Addis Ababa: National Office of Population.

- Tegene, B. Land-cover/land-use changes in the derekolli catchment of the South Welo Zone of Amhara Region, Ethiopia. *East. Afr. Soc. Sci. Res. Rev.* **18**: 1–20.
- Thadiparthi, B.R. and Mekonnen Aregai. (2004). Analysis of landcover changes and major driving forces assessment in middle highland tigray, Ethiopia: The case of areas around Laelay Koraro. *Bio.Envnt.***1**(6):22-29.
- U.S EPA., 1999. A Summary of Models for Assessing the Effects of Community Growth and Change on Land-Use Patterns. EPA/600/R- 00/098. U.S. Environmental Protection Agency, Office of Research and Development, Cincinnati, Ohio. John Wiley & Sons, Inc., 750pp.
- Woldeamlak Bewket, Sterk, G. (2005). Dynamics in landcover and its effect on stream flow in the chemoga watershed, Bluenile basin, Ethiopia. *Hydrol.process.* **19**:445-458.
- Zelege, G. and Hurni, H. (2001). Implications of land use and land cover dynamics for mountain resource degradation in the northwestern Ethiopian Highlands. *Mt. Res. Dev.* **21**: 184–191
- Zubair, A.O. (2006). Change detection in land use and land cover using remote sensing data and GIS: A case study of Illorin and its environs in Kwara state. Unpublished MSc Thesis, University of Ibadan, Ibadan, 54pp.

APPENDIX 1: Questionnaires

Questionnaire No. 1: To be completed by household Head

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

Thank you in advance for your cooperation.

I. Identification

1. Administrative Unit: Region: *Tigray* Zone: *South Tigray* Wereda: *Ofla*
2. Name of Rural Kebele(Tabia) _____
3. Village Name _____

II. Household Head Characteristics

201. Name of the household head _____
202. Sex
 1. Male
 2. Female
203. Age _____
204. Marital Status
 1. Never Married
 2. Currently Married
 3. Divorced
 4. Separated
 5. Widowed
205. Education
 1. Illiterate
 2. Read Only
 3. Write Only
 4. Read and Write only
 5. Primary (1 - 8)
 6. Secondary (9 - 12)
 7. Tertiary (12+)

III. Household Income and Business Activities

301. In the last 12 months, did you or any member of the household participated in off-farm activities?

Yes = 1

No = 2

302. If yes, please specify the amount of off farm income earned (birr/month) _____

IV. Landholding and Property Ownership

401. Current total land holding in (timad i.e 0.25 hectare). _____

407. Do you feel that land is becoming scarce or it is still abundant in your community?

1. Yes, it is becoming scarce

2. No, it is still abundant

3. No change

408. If your answer for question number 407 is yes, why?

1. Because of population growth

2. The proportion of fertile land is diminishing

3. The non-availability of off-farm activities

4. The portion of land become waste land because of degradation

5. Because of land re distribution

6. Other, Specify _____

409. Do you consider your crop production from your plots has increased over the past 20 years?

1. Increased

2. Decreased

3. Remains the same

V. Land use/Land cover change

501. Have you noted any change in the land use/land cover in your area over the past 20 years or so?

1. Yes

2. No

502. If your answer to question number 501 is yes, what changes did you observe?

Changes in:

No.	Change in	Increased	Decreased	No Change
1.	Crop land			
2.	Forest cover			
3.	Water surface			
4.	Proportion of arable land			
5	Grass land			
6	Degraded land			
7	Settlement and infrastructure			

VI. Causes of the land use/land cover change

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

1. Population growth
2. Property ownership
3. Increased application of input
4. Lack of proper management
5. Improved access to basic infrastructure, market and social services
6. Improved access to Extension service
7. Increased modern application
8. Expansion of Town

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

1. Soil erosion
2. Degradation of watersheds
3. Deforestation
4. Increased waste land
5. Other, Specify _____

603. If your choice for question number 602 is soil erosion, what are the major causes?

1. Land fragmentation
2. Absence of fallowing
3. Overgrazing
4. Increasingly intensive use of land
5. Expansion of agriculture onto marginal areas
6. Other, specify _____

604. If your choice for question number 602 is deforestation, what are the major causes?

1. Expansion of agriculture onto forest areas
2. An increasing demand for firewood
3. Cutting of trees for construction
4. Cutting of trees to generate income
5. Wild fire
6. Other, specify _____

605. If your choice for question number 602 is degradation of watersheds, what are the major causes?

1. Change in cropping pattern from annual to perennial crops
2. An increasing demand for local consumption
3. Water withdrawal for irrigating chat and other annual crops
4. Change in the local climate (decline in annual rainfall & an increase in temperature)
5. Water withdrawal for the nearby urban areas
6. Other, specify _____

VII. LAND RESOURCE MANAGEMENT

701. Do you invest on land improvement measures?

1. Yes
2. No

702. If your answer to question Number 701 is No, why?

1. My subsistence income will not allow me to do so
2. Fear of further redistribution
3. Lack of belongingness on my land
4. Other, specify _____

703. If your answer to question number 701 is yes, please indicate the detail on the following

No.	Conservation measure/s used	Currently in use		Total area in Timad/hectare
		1. Yes	2. No	
1.	Terracing			
2.	Contour ploughing			
3.	Traditional ditches			
4.	Bunds			
5.	Tree Planting			
6.	Crop rotation			
7.	Intercropping			
8.	Strip cultivation			
9.	Using compost/fertilizer			
10.	Other ,Specify _____			

704. Do you perceive any gain in the future from conserving the land at present?

1. Yes

2. No

705. Do you think that the productivity of your land has decreased over the past 20 years?

1. Yes

2. No

706. If your answer to question number 705 is yes, what is/are the main reason/s?

(Multiple answers is possible)

1. lack of proper land use management

2. Loss of nutrients

3. Little and/or no use fallowing

4. Over (continuous) cultivation

5. Overgrazing

6. Land Degradation

7. Not able to buy modern input

8. Lack of access to

information

9. Other, specify _____

Questionnaire No. 02

Questionnaire No. 1: To be completed by elderly and focus group participants

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

Thank you in advance for your cooperation.

1. Is there any change in your area with regard to vegetation cover, surface water and land use pattern over the past 40 years? If any please indicate them accordingly. A change in: -
 - A) Forest cover
 - B) Degraded land
 - C) Crop land
 - D) Grass land
 - E) Water regimes
 - F) Settlement
2. What are the major reasons/causes for all these changes?
3. Do the individuals or the community actively participating in the conservation activities?

Appendix 2: Sample pictures from field



Agricultural land area in steep slope



Agricultural land area in plane area



Grass land area around Ashenge Lake



Terrace for conservation

Appendix 3: - CLASSIFICATION ACCURACY ASSESSMENT REPORT

 Image File : c:/thesis sidist
 kilo/download_data/2013/2013_new/unsup.img
 User Name : user
 Date : Wed Apr 23 16:20:32 2014

ERROR MATRIX

Classified Data	Reference Data			
	Unclassifi	WaterBody	Forest	Agricultur
Unclassified	0	0	0	0
WaterBody	0	7	0	0
Forest	0	0	111	3
Agriculture	0	0	4	82
Grass	0	0	0	12
Column Total	0	7	115	97

Classified Data	Reference Data	
	Grass	Row Total
Unclassified	0	0
WaterBody	0	7
Forest	11	125
Agriculture	16	102
Grass	37	49
Column Total	64	283

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

ACCURACY TOTALS

Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users
Unclassified	0	0	0	---	---
WaterBody	7	7	7	100.00%	
Forest	115	125	111	96.52%	
Agriculture	97	102	82	84.54%	
Grass	49	49	49	100.00%	
Overall	283	283	259	91.52%	

75.51% Grass 64 49 37 57.81%

Totals 283 283 237

Overall Classification Accuracy = 83.75%

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

KAPPA (K^) STATISTICS

Overall Kappa Statistics = 0.7527

Conditional Kappa for each Category.

Class Name	Kappa
-----	-----
Unclassified	0.0000
WaterBody	1.0000
Forest	0.8113
Agriculture	0.7017
Grass	0.6835

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

DECLARATION

I hereby declare that the thesis entitled. *Detecting Landuse/Landcover Change using Remote Sensing & GIS Techniques and Analysis of its Causes, Consequences and trends in Ofla wereda,Tigray Region,Ethiopia.* has been carried out by me under the supervision of Dr. Muluneh Woldetsadik, Department of Geography and Environmental Studies, Addis Ababa University, Addis Ababa during the year 2013/14 as a part of Master of Art in Geography and Environmental studies specialized on Land Resource Management. I further declare that this work has not been submitted to any other University or Institution for the award of any degree or diploma.

ABIY WOGDERES ZINNA

Signature: _____

Addis Ababa University

Addis Ababa

Date: June, 2014

CERTIFICATE

This is certified that the thesis entitled. *Detecting Landuse/Landcover Change using Remote Sensing & GIS Techniques and Analysis of its Causes, Consequences and trends in Ofla wereda, Tigray Region, Ethiopia.* is a bonafied work carried out by Abiy Wogderes Zinna under my guidance and supervision. This is the actual work done by Abiy Wogderes Zinna for the partial fulfillment of the award of the Degree of Master of Art in Geography and Environmental studies specialized on Land Resource Management from Addis Ababa University, Addis Ababa, Ethiopia.

Dr. Muluneh Woldetsadik

Signature: _____

Department of Geography and Environmental studies

Addis Ababa University