Assessment of Deforestation using GIS & RS: A Case Study of Welmera Woreda West Shoa Zone Oromia Regional State

Abeje Asefa Jaleta

A Thesis Submitted in Partial Fulfillment of the Requirement for the Degree of Masters of Science in Geo Informatics Engineering

School Of Civil Engineering and Architecture

Presented in Partial Fulfillment of the Requirement for the Degree of Master of Science in Geomatics Engineering (specialization in Geo Informatics Engineering)

Office of Graduate Studies
Adama Science and Technology University

Adama,

Ethiopia

June, 2020

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We, the undersigned, members of the Board of Examiners of the final open defense by ___________________________________ have read and evaluated his/her thesis entitled ____‖ and examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirement of the Degree of ………………………………………..

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DECLARATION

I hereby declare that the thesis entitled “Assessment of Deforestation using GIS &RS in the case of Welmera Woreda West Shoa Zone Oromia Regional State” has been carried out by me under the supervision of Dr.Ir Tilahun Erduno, Department of Geomatics Engineering, Adama science and Technology University, Adama during the year 2020. It part of a Master of Science in Geomatics Engineering (specialization in Geo Informatics Engineering). I further declare that this thesis is my original work and has not been submitted to any other University or Institution for the award of any degree or diploma and that all sources of material used for the thesis have been dully acknowledged.

Abeje Asefa Jalet

Signature:

Date: 22/6/2020

This thesis have been submitted for examination with my approval as a university advisor

Name: Dr.Ir Tilahun Erduno

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Date____________

ACKNOWLEDGEMENTS

For the success of this work I would like thank all stake holders directly and indirectly, First and foremost, I would like to thank Almighty God who made everything to happen in time and change all my effort to result. Next, greatest thanks go to my advisor Dr.Ir Tilahun Erduno for his valuable comments and contributions of ideas as well as sharing of his precious time to read the earlier drafts of this paper.

For various data and information I received; my foremost thanks goes to Welmera Woreda Forest and environment conservation office and great thanks also go to Administrators, experts and staffs of *welmera* Woreda Office. People's in the study area, deserves acknowledgements for their kindness and hospitability during my stay in field work.

To all my best friends, for their cooperation during my stay in data collection and the university.

Finally, my heartfelt thanks go to all my families for assisting me both in ideas and in materials to accomplish this paper.

Abeje Asefa Jaleta

Adama, Ethiopia

June, 2020

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LIST OF ACCRONOMS

AAC	Allowable Annual Cut
DEM	Digital Elevation Model
EGA	Ethiopian Geo information Agency
FAO	Food and Agriculture Organization
GDEM	Global Digital Elevation Model
GIS	Geographic Information System
LULC	Land Use Land Cover
MONREP	Model-based Optimization for Nonlinear, Restricted Production Processes
NDVI	Normalized Difference Vegetation Index
NIR	Near Infrared
RS	Remote Sensing
SAVI	Soil Adjusted Vegetation Index
TLU	Tropical Livestock Units
UNCED	United Nation’s Conference on Environment and Development
UNRISD	United Nation Research Institute for Social Development
US	United States
USGS	United States Geological Survey
USSR	Union of Soviet Socialist Republics
UTM	Universal Transfers Mercator
VIS	Visible Red
WGS	World Global System
WRI	World Resource Institute
WRS	Worldwide Reference System

Abstract

The aim of this study was to assess deforestation acceleration change for the last 20 years from 2000 to 2020 using remote sensing and GIS in case of Welmera Woreda west shoa zone Oromia regional state. High resolution Landsat imagery of different three years is the main input data of the study.NDVI2 algorithm and unsupervised classification methods are used during data analysis. The study area divided in to four major land use land cover classes; Vegetation cover, Farmland, Urban area and Barrel and. Forest Priority Area that covers the total area around 21094.3ha in 2000 from the total area coverage 104719.5 ha and Post-classification comparison change detection methods and NDVI image differencing were employed. The major land use land cover types in the study area have been identified during unsupervised classification method by ERDAS imagine as: Vegetation cover, Farmland, Urban area, and Barre land. The study made use of Landsat7 image of the year 2000 and Landsat8 for 2013and 2020 to assess forest cover changes and rate of deforestation during the different periods and the type of land cover to which the forest is changed to Farmland and urbanization. In addition Multi Criteria Evaluation in a GIS environment was used to come up with the final deforested area map. The result of change detection analysis revealed that the area had remarkable land- use land cover changes in general and forest cover changed to farmland and urban area. Specifically, the forest cover land declined from 21094.3 ha in 2000 to 19413.2 ha in 2013and dropped to 18431.9 ha in the year 2020 in the study area. Based on the forest cover areas of the year2000, 2013and 2020 of study area, about 1680.4ha between 2000 to 2013, 981.9ha between 2013 to2020 and 2662.4 ha between 2000 to 2020 was cleared respectively. The problem of forest cover change according to the finding is directly linked with the activity of the society such as expansion of Farmland, Urbanization, and others. In order to understand the impact of forest cover change on environment corrective measures are suggested under recommendation.

Key Words: - Welmera Woreda, Deforestation, Remote sensing and GIS,

CHAPTER I. INTRODUCTION

1.1 Background

Deforestation is the conversion of forested areas to non-forest land use such as arable land, urban use, and logged area [12]. Its result from deliberate removal of forest cover for agriculture or urban development, or it can be an unintentional consequence of uncontrolled grazing which can prevent the natural regeneration of young trees. There are many root causes of deforestation in Ethiopia in the last three decades including corruption of government institutions, the inequitable distribution of wealth and power, population growth and overpopulation, and urbanization [8].The aim of this study was to assess deforestation acceleration change for the last 20 years from 2000 to 2020 using remote sensing and GIS in case of Welmera Woreda west shoa zone Oromia regional state. High resolution Landsat imagery of different three years is the main input data of the study.NDVI algorithm and unsupervised classification methods are used during data analysis. The study area divided in to four major land use land cover classes; Vegetation cover, Farmland, Urban area and Barrel and. Forest Priority Area that covers the total area around 21094.3ha in 2000 from the total area coverage 104719.5 ha and Post-classification comparison change detection methods and NDVI image differencing were employed. The major land use land cover types in the study area have been identified during unsupervised classification method by ERDAS imagine as: Vegetation cover, Farmland, Urban area, and Barre land. The study made use of Landsat7 image of the year 2000 and Landsat8 for 2013and 2020 to assess forest cover changes and rate of deforestation during the different periods and the type of land cover to which the forest is changed to Farmland and urbanization. In addition Multi Criteria Evaluation in a GIS environment was used to come up with the final deforested area map. The result of change detection analysis revealed that the area had remarkable land- use land cover changes in general and forest cover changed to farmland and urban area. Specifically, the forest cover land declined from 21094.3 ha in 2000 to 19413.2 ha in 2013and dropped to 18431.9 ha in the year 2020 in the study area. Based on the forest cover areas of the year2000, 2013and 2020 of study area, about 1680.4ha between 2000 to 2013, 981.9ha between 2013 to2020 and 2662.4 ha between 2000 to 2020 was cleared respectively. The problem of forest cover change according to the finding is directly linked with the activity of the society such as expansion of Farmland, Urbanization, and others. In order to understand the impact of forest cover change on environment corrective measures are suggested under recommendation. Ethiopia is an agrarian country with a great topographic range from 110m below sea level at Dalol Depression and 4620m above sea level at Mount RasDashin. Because of its topographic variation and location in the tropics, Ethiopia has diverse climatic conditions resulting diverse ecosystems. As a result, the country is well endowed in natural resources. However, deforestation has gone for the last five decades. Forests which were above 40% of the country's landmass in the beginning of 20th century are reduced into 2.36% in 2000. [1]Forest areas of the country have been reduced from 40% a century ago to an estimated less than3% today. The current rate of deforestation is estimated to be 160,000 to 200,000 ha per year. It is estimated that fertile topsoil is lost at a rate of one billion cubic meters per [2]. Tropical forest resources assessment project (GEME).Forest resources of Tropical Africa, Part 2, and Country Brief [3]. Ethiopian Highland Reclamation Study. Working Paper 24. [4]. Roots of Deforestation Problems in Ethiopia. [5] Deforestation or Development in the third World? Vol. III. [6]. Deforestation and Forest Plantations in Ethiopia. Sustainable Forestry Challenges for Developing Countries, 327-342.@1996 Kluwer Academic Publishers. Printed in the Netherlands.), resulting in massive environmental degradation and constituting a serious threat to sustainable agriculture and forestry [7].

In Ethiopia, the cause of deforestations are , Agricultural expansion; the increasing demand for construction material, industrial use, fuel wood and charcoal; lack of a forest protection and conservation policy; absence of a strong forest administration system capable of arresting the rapidly increasing rate of deforestation; lack of effort to ensure the participation of communities in forest protection and conservation and the sharing of benefits, and failure to clearly demarcate and enforce the boundaries of natural forest reserves[8]. Currently, the remaining forests are found in South Western Ethiopia. However, other areas have been completely destroyed and converted to farms and grazing lands. At present there are efforts that the government and local communities are employing. Establishment of protected forest priority areas, as well as protecting the sacred forest sites and introducing new energy efficient stoves are attempts taken to protect forests in the country. [1]

1.2 Statement of the Problem.

There are many root causes of deforestation in Ethiopia in the last three decades including corruption of government institutions, the inequitable distribution of wealth and power, population growth and overpopulation, and urbanization[8] .The degradation of forest ecosystems has also been traced to economic incentives that make forest conversion appear more profitable than forest conservation in Ethiopia [9].Welmera Woreda is one of the historic place where menagesha national forest and mount wechacha was found which is totally covered by forest and other natural resources. However, the major causes of deforestation in the Woreda was almost similar in anywhere in Ethiopia which is rapid population growth, which leads to an increase in the demand for crop and grazing land, wood for fuel and construction[10].Forest resource management in Ethiopia has been in the hands of the public sector. No sustainable forest management program has been put in place due to lack of adequate funding and stable structural set up for the forestry sector**.** Forest resources have not so far been managed properly in Ethiopia. So forest management plans are essential components of sustainable forest management. Deforestation reduces the quality of life of millions of people in Ethiopia. For the poorest living close to the land, their survival is threatened by the loss of the vegetation upon which they depend. As trees disappear, the sources of household energy and many other goods will also disappear as well at the same time [10]. Researcher estimated that the closed high forest of South West Ethiopia dropped from 40% between 1971 to 1975 only (around) 18% by 1997, which is loss of about 60%. Conversion of forestland to other land use types is the major cause of deforestation. Around 235,000 hectares of closed and slightly disturbed forest areas were deforested between 1971 and 1997, a loss of about 10,000 hectares of forest every year. [11]

Deforestation is ongoing and shaping climate and geography of Ethiopia. [11] It is a contributor to global climate change, and is often cited as one of the major causes of the enhanced greenhouse effect.. Only when actively growing can a tree or forests remove carbon over an annual or longer time frame. Welmera Woreda west shoa zone Oromia regional state was one of the affected area by deforestation for the last more than two decades. The cause of deforestation in welmera Woreda is similar to area in other part of Ethiopia which is lack of proper forest management trend and policy is a great problem even today [12]. The situation gradually become the reason of deforestation, land degradation and desertification that exposed many peoples and animals life to today’s problem in Ethiopia. According to [13]. States that according to the forest manager about 1428 ha of plantation forests were destroyed during the changes of government in 1991.)[13].So this study has been designed to assess the status of deforestation in welmera Woreda West Shoa zone Oromia Regional State using GIS and RS.

1.3 Significance of the Study

The result of the study tried to assess and identified the existence of deforestation and its causes in welmera Woreda Oromia regional state. According to the study deforestation is ongoing and changed the forest land to farm land and urbanization in the Woreda [14]. The study Helps to protect the remaining Forest resources from deforestation & land degradation and increases the afforestation trends in society by giving them awareness of forest treatment mechanisms for all Forest Affairs Ministries to prepare forest protection policy and mostly the community living around the forest has benefitted directly for wood, fuel, construction of houses and environmentally suitable climatic condition contribution as the national level. The advantages has not limited to human beings only but also for all wildlife, animals, mammals, Birds and all ecosystems lived around and in the forest indirectly benefited. Because, they get shelters, food and etc. Additionally, it encourages society to participate in forest treatment and increases the Ethiopian tree planting trends and finally the national advantage is protecting our country from climate change and desertification. Therefore Deforestation assessment is the best and important solution to evaluate and protect ongoing deforestation and reducing desertification at all.

1.4 Objectives of the study

1.4.1 The general objective

The general objective of this study is, to assess the status of deforestation acceleration rate in welmera Woreda West Shoa zone Oromia Regional State using GIS &RS.

1.4.2 The specific objectives is to:

Identify the specific deforested study Area and extract by mask from Landsat image

Classify Deforested area through Landuse land cover classification method from Landsat image

Access the Landsat data through GIS &RS analysis method

1.5 Research Questions

1.5.1 How to classify study area and extract from Landsat image?

1.5.2 What are the scientific mechanisms of image classification used in LULC to identify deforested area?

1.5.3 How GIS & RS used in accessing analysis to identified and classified data used?

1.6 Scope and Limitation of the Study

The scope of study was covered welmera Woreda West shoa zone Oromia regional state and focused on deforestation assessment. Data sources also based on the both primary and secondary up-to-date data available in case the research time bounded for the study. Data acquisition in terms of data availability was considered as it is prime importance when we used geographical information system GIS and RS.The study was limited in data quality and availability because there is no free available high resolution quality Landsat image on any data sources except payment. The company owners ask their customer payment in many dollars for the high resolution quality Landsat imagery. Therefore, the researchers in forced to use USGS cost-free Landsat imagery which enable the researcher to analysis and realize the assessment according to the aim of the study.

CHAPTER II. LITERATURE REVIEW

2.1 **Background**

Deforestation is the conversion of forested areas to non-forest land use such as arable land, urban use, and logged area [12]. It is the conversion of forest to another land use or the long-term reduction of tree canopy cover below the 10% threshold. Deforestation can result from deliberate removal of forest cover for agriculture or urban development, or it can be an unintentional consequence of uncontrolled grazing (which can prevent the natural regeneration of young trees). The combined effect of grazing and fires can be a major cause of deforestation in dry areas. It implies the long-term (>10 years) or permanent loss of forest cover. Deforestation defined broadly can include not only conversion to non-forest, but also degradation that reduces forest quality , the density and structure of the trees, the ecological services supplied, the biomass of plants and animals, the species diversity and the genetic diversity. Narrow definition of deforestation is: the removal of forest cover to an extent that allows for alternative land use. The United Nations Research Institute for Social Development (UNRISD) uses a broad definition of deforestation, while the Food and Agriculture Organization (FAO) Uses a much narrower definition. Definitions can also be grouped into those which refer to changes in land cover and those which refer to changes in land use. Land cover measurements often use a percent of cover to determine deforestation. Land use definitions measure deforestation by a change in land use. This definition may consider areas to be forest that are not commonly considered as such. An area can be lacking trees but still considered a forest. It may be a land designated for afforestation or an area designated administratively as forest. Land cover based definitions can be measured using remotely sensed data. Detailed ground survey is needed to monitor land use type deforestation processes.

2. 2 Global Causes of forest cover change or Deforestation

The causes of forest cover change are complex and dynamic in nature. There is stiff Competition on global economy which drives the need for more money in the economically challenged tropical countries, with the most of tropical forests. Deforestation is a result of the interaction of environmental, social, cultural and political forces in a given region. According to [14] the three main causes of deforestation in the world are; agriculture (including huge investment), Infrastructure expansion and wood extraction. He asserted that the action of human beings rather than natural forces is the sources of most contemporary change for this dynamic world. Population growth is another major cause for deforestation and obstacle for the achievement of sustainable development. Because, Population growth without considering environment by itself have great impact on sustainable development, so sustainable development must be environmentally friendly [15].Tropical forests are world's reservoir of ecosystem and biodiversity hotspots. Most of tropical forests are in developing countries and threatened with high rate of deforestation, hence it have major effect on global climate change and loss of plant and animal species. People have indigenous knowledge and information about nature, and also Forests are house of indigenous cultures. Transforming forest to wipe out indigenous people is a moral crime. Carbon trading/avoided deforestation, sustainable forest management and forest certifications are options in the world agenda for discussion as the possible ways of alleviating deforestation [16]. Regarding to [17]View, land cover transformation did not stop, but rather accelerated and diversified from the beginning of industrial revolution, due to the globalization of the world economy, the expansion of population and technological capacity. According to the study by [18] based on Earth observing satellite image 1990, there were some 115 million ha of tropical rain forest with the area of the humid tropics deforested annually estimated at 5.8 million ha.

A further 2.3 million ha of humid forest is apparently degraded annually through fragmentation, logging and/or fires. In the sub-humid and dry tropics, annual deforestation of tropical moist deciduous and tropical dry forests comes to 2.2 and 0.7million ha, respectively. The forests of Africa are being converted at a similar rate to those of Latin America 0.4 to 0.5% per year. (ibid)

Start from past millennium and still today humans have taken an immense role in the modification of the global environment. With increasing numbers and developing technologies, man has emerged as the major actor, most powerful and universal instrument of environmental change in the biosphere today. By 2005, deforestation rate was about 13 million hectares per year. This includes 6 million of primary or frontier forests. Frontier forests are defined as "forests where there are no clearly visible indications of human activity and where ecological processes are not significantly disturbed [19] Primary forests have no sign of past or present human activities and are considered to be the most biologically diverse ecosystems in the world [20]. The key drivers of forest biodiversity loss are: population and consumption growth; increasing trade in food and agricultural products; growing demand for forest products, including biomass for energy generation; expansion of human settlements and infrastructure; and climate change. [21] asserts that cutting trees for the various purposes such as: obtaining wood for construction, shelter and tool making; providing fuel to keep warm; cook food; and smelt metals; and above all, creating land for cultivation has culminated in one of the main processes where by human kind has modified the worlds surface cover of forest resources. There is substantial change in the magnitude of deforestation in the tropical areas, particularly it varies in developing countries, and large forests have been transformed for farm and settlement Developments. This shows people assumes that fertile soils under the forest cover which is rich in vegetation diversity was essential for crop growth and for human settlement, and this has led to rapid forest clearance for agriculture as well as timber supply.

2.3 Extents of forest cover in Ethiopia

Ethiopia owns diverse vegetation resources, from tropical rain and cloud forests in the southwest and on the mountains to the desert scrubs in the east and north east and parkland agroforestry on the central plateau [22]. The vast terrestrial land surface with biologically productive climate and soil indicates the country has a huge forestry development potential. The forest resources are an important endowment of the country. They contribute production, protection and conservation functions. Ethiopia's flora and fauna resources are uniquely diverse. The flora comprises about 6500-7000 species of higher plants out of which 12% are endemic and the countries natural forests and woodlands covered 15.1 million ha in 1990 [23]. In 2005, the forest cover had further declined and was estimated to cover 13.0 million ha. In other words, Ethiopia lost over 2 million ha of her forests, with an annual average loss of 140 000 ha between 1990 and 2005. In 2009, the area is estimated at 12.3 million ha, 11.9 % of the total land area. Of this, the remaining closed natural high forests are 4.12 million ha or 3.37% of Ethiopia's land [24].

This indicates that the coverage forest resources are declining in an alarming rate. The area of forest is unevenly distributed in the country. Oromia, Southern Nations and Nationalities Regional State and Gambella region account for 95% of the total high forest area [25].

2.4 The causes of forest cover change in Ethiopia

The causes for forest cover change accompanied by the loss of biodiversity can be explained on two different levels: the local level and the global one. The local level includes destruction of forests caused by local inhabitants. The rural poor living around forests heavily depend on biodiversity to satisfy their basic needs such as food, water, housing and social services. The economic dependency of the people on the forest which offers firewood and area that can be converted to agricultural land is one of the main reasons for deforestation. The global level of deforestation is formed by the worldwide demand for natural resources (e.g., timber, soil, gas, oil). Another aspect which has a negative impact on the ecological value of forests is conventional tourism. In Ethiopia, forests, woodlands and mixed-use landscapes are often targeted for agricultural expansion as a means to maximize benefits from land-based investments while avoiding the displacement of cropland. Increased investment is welcomed by host country governments for its opportunity to stimulate rural economies while fostering national economic development [26]. The major issue is the annual destruction of the natural forest for agricultural expansion. According to [27] the extent destruction of natural forest was estimated to currently total about 59,000 ha per annum in the three main forested regional states of Oromia, Southern nations, nationalities and Gambella only. The finding of [28] also illustrates that the absence of clear institutional authority and communication between concerned agencies further retarded transparency in forest management and leads to unwise use of forest resource in Ethiopia. For example, foreign investors work primarily with the Ethiopian Investment Authority in establishing their business operations, while government forestry specialists are housed in the Forestry Research Centre, a subdivision of the Ministry of Agriculture.

2.5 The Causes of Deforestation in Ethiopia

Deforestation and degradation of forest resources are typical symptom of an unsatisfactory socio-economic and political situation in most developing countries.in Ethiopia, the cause of deforestations are , Agricultural expansion; the increasing demand for construction material, industrial use, fuel wood and charcoal; lack of a forest protection and conservation policy; absence of a strong forest administration system capable of arresting the rapidly increasing rate of deforestation; lack of effort to ensure the participation of communities in forest protection and conservation and the sharing of benefits, and failure to clearly demarcate and enforce the boundaries of natural forest reserves. The majority of the proposals and concepts aimed at solving down or even reversing the general trend, tend only to treat symptom and not to heal the disease as such[29]. Environmental concerns of the poor are related to survival itself while it is unrealistic to expect poor people to conserve resources for the future when they are struggling for survival; the governments of these countries in turn have very scarce economic resources for any activities outside the provision of basics human needs[30] Since people in developing countries especially those of Africans depend on natural resource for their survival, it will result in waste full and over exploitations of natural resources. However according to Hummel [31] in many developing countries, hunger for land is the main cause of forest clearance. There is rapid growth of population every year, there are more mouth of feed and more land is needed to do so, the only available land is usually forests thus millions of hectares are cleared every year, the area is burned over and then used to feed and raise domestic animals, most of forest clearance is un planned and the methods of subsequent cultivation are primitive and lead to erosion with the result that after a few years the areas lost to both agriculture and forestry and the process is repeated elsewhere. For example, in Ethiopia as noted [32] encroachment in to forest and protected areas including to marginal lands cause accelerated land degradation resulting in a self-propelling down ward vicious cycle of degradation of natural resources, leading to declining crop yields, leading to expansion of cultivated land again leading to further natural resources degradation and to further decline in crop yields, thus substantially contributing to rural poverty and famine vulnerability.

In many developing countries grazing in the forest is still very important; the most frequent animal is in many cases the goat the damaging "GRAZER". It does not only graze on the ground, by browsing it damage and eventually kills the young trees at least up to man height. Millions of hectares of formerly good forest in the Mediterranean Basin the Near and Middle East and elsewhere are more or less bare rock land now and this was to a high degree due to the grazing of goats (Hummel, et al; 165). Ethiopian forest also face similar problem, as FAO (2003) [33] Indicate, with 35 million Tropical Livestock Units (TLU), equivalent to 80 million livestock heads, Ethiopia has one of the largest livestock population in Africa. It is estimated that over 80% of the livestock are found in the high land (with an estimated stocking rate of 160 TLU per km^2), causing widespread over grazing and degradation on both arable and grazing land. Moreover, the low survival rates of planted seedlings in re-afforestation programs are partly attributed to the free roaming dense livestock populations. In the low land areas over grazing by livestock leads to soil compaction and damage to natural regenerations [34] Another serious damage is the destruction or diminution of forestry substances by practices such as over cutting, too big clear cuts that cause soil erosion, and creaming; that is felling the best and most valuable tree only, but damaging here by the remaining stand or even destroying it. Commercial greed and corruption are generally the underlying motives, although they may be cunningly concealed indicate that the traditional tools of forest policy such as legislation, institutions, and forest policy alone unable to solve the problems as long as a number of political, education, economic, social and organization prerequisites do not exist in a country. [35] Also support the above ideas, legislation and supervision on one side and information plus education on the other, which must be invoked if the forest substance it to be protected. There may also have to be rules on how timber is sold, short term concessions in particular are liable to lead to over exploitation and ‘creaming’.

2.6 The Consequences of Deforestation in Ethiopia

As deforestation progress increases, it reduces the quality of life of millions of people in developing countries. For the poorest living close to the land, their survival is threatened by the loss of the vegetation upon which they depend. As trees disappear, so do their sources of household energy and many other goods. Worse, a chain of events is set in motion that leads to declining food production, land degradation, and in extreme cases, desertification [36]. There are various cost associated with deforestation, different reports and authors also indicate that there are too many consequence of deforestation both in developed and developing countries. More than 80% of the world forest resources harvested in developing countries is used as fuel wood**,** compared with less than 20% in developed countries. Much of the wood harvested in the world each year is used for energy production, of the estimated wood harvested in 1995, about 63% was used as fuel wood .In developing countries fuel wood accounted for 81% (91% in Africa, 82% in Asia and 70% in Latin America) of the wood harvested. Wood fuels remain significant sources of energy in developing countries, especially in the rural and domestic sectors. In rural areas, gathering and transporting fuel wood increasingly dominates the daily lives of millions of people. 100 to 300 work days, each year must be devoted to supplying a household. Women and children shoulder most of the burden for finding and caring home the wood needed to cook the day's meals. In Nepal, groups of villagers must leave at sunrise in order to return by sunset with a back breaking load of wood that will last only 3 to 4 days. The increasing time needed to collect fuel wood is disrupting family stability and shortens the time that can be devoted to weeding and tending crops, preparing food, and other domestic activities. Urban demand for fuel wood and charcoal is expanding, the economic distance for clearing and having wood, leading to ever widening circles of devastation around cities and towns (Ibid, 9). There is also a huge gap between demand and supply for fuel wood in Ethiopia. According to [37] the demand for fuel wood in 2020 will reach to 100 million m^3 against supply projection of only 7.7 million m^3. Without major policy changes that ensure better fuel wood conservation and increased supplies, by the year 2020 some 2.4.billion people (more than half people in developing countries) will face fuel wood shortage and will be caught in a destructible cycle of deforestation, fuel wood scarcity, poverty and malnutrition. The failure to renew soil fertility leads inevitably to declines in crop yields noted that, when wood become scarce, rural households switch to the use of crop residues and animal dung for fuel , there by significantly reducing the amount of nutrients returning to the soil, this in turn has negative effects on crop productivity and ultimately food security.

The annual burning of an estimated 400 million tons of dung to cook meals in areas where fuel wood is scarce decreases food grain harvests by more than 14 million tons, this loss in food supply is nearly double the amount of food aid annually provided to developing countries. The removals of tree cover can further reduce agricultural productivity by loss of vegetation; reduces the effectiveness of rain fall by decreasing the amount of water that percolates in to the ground. Forest exploitation and clearance can create inter linked problems, notably soil erosion, watershed destabilizations and microclimatic change. These threaten the soil and water base for agriculture, about half of the precipitations in the Amazon arise from forest Evapo transpiration, and already there are areas which are drying- out which can be correlated with deforestation [38]. Dry land is particularly sensitive to human abuse because of the fragility of the soil and low and erratic rain fall. Traditional production systems are breaking down in these areas under the combined pressure of population growth and poverty. As dry lands are striped of woody vegetation through agricultural clearing, overcutting for fuel wood, over grazing and bushfire, land degradation worsens and the spreads of deserts accelerates.

2.7 Remote Sensing and GIS

2.7.1 Remote Sensing

Remote Sensing is the science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area or phenomenon under investigation [39] The focus of remote sensing in scope of this study is to indicate areal extent of forest cover changes on map using resources of Landsat of various periods.

Remote sensing satellite images are immensely used in time to time study of changes due to its repetitive coverage, especially in forest resources estimation and monitoring, and natural resources monitoring and management.

2. 7.2 Geographic Information System (GIS)

Different authors defined GIS from different perspectives. [40] define "GIS is a Powerful tool for collecting, storing, retrieving, as well, transforming and displaying spatial data from the real world for a particular set of purpose". On the other hand, [41], define "GIS is a specific information system applied to geographic data and is mainly referred to as a system of hardware, software and procedures designed to support the capture, management, manipulation, analysis, modeling and display of spatially-referenced data for solving complex planning and management problems". What we understand from the above definitions is that, it relies mainly in a computer technology that realized digital data. Now, GIS is become popular tool because of its, rapid access to data, flexibility, easy update opportunity and other features that enable to analyze different databases [42]. GIS is an information system that is designed in the way compatible with referenced data to spatial or geographic coordinates. GIS is both a database system which has specific capabilities for spatially referenced data, and a set of operation for working with data. The functions of GIS include data entry, data display, data management, information retrieval and analysis. The applications of GIS include mapping locations, quantities, finding distances and mapping and monitoring change.

2.8 Forest cover change Monitoring using Remote Sensing and GIS

The potential of remote sensing and GIS in the field of forestry become established over many years through the use of aerial photos and satellite image interpretations in forest cover change detection analysis, for the generation of cover map and inventory analysis. Multi-temporal data provides for change detection analyses and remote sensing brings together a multitude of tools to better analyze the scope and rate of deforestation. Images of earlier years are compared to recent scenes, to tangibly measure the differences in the sizes and extents of forest cover change. Data from a variety of sources are used to provide complementary information. Satellite image data can be used to efficiently monitor the status of existing forest and emergence of new ones, and even assess regeneration condition. In countries where cutting is controlled and regulated, remote sensing serves as a monitoring tool to ensure companies are following cut guidelines and specifications. So, remote Sensing is a powerful technique for surveying, mapping and monitoring earth resources and GIS facilitates in storage, manipulation and analysis for Geographic information and Socio-economic data to provide a wider application. 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.

2.9 Change detection methods

Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times (Singh, 1989). And according to [43] Change detection involves the use of multi-temporal datasets to discriminate areas of land cover change between dates of imaging; In addition essentially, it involves the ability to quantify temporal effects using multi-temporal data sets. [44] also noted that change detection is useful in such diverse applications as land use change analysis, monitoring of shifting cultivation, assessment of deforestation, seasonal changes in pasture production, damage assessment, disaster monitoring, day/night analysis of thermal characteristics as well as other environmental changes. All digital change detections are affected by spatial, spectral, temporal and thematic constraints. The type of method implemented can profoundly affect the qualitative and quantitative estimates of the disturbance [45].never the less visual change detection is difficult

To replicate because different interpreters produce different results.

2.10 Forest resource conservation

2.10.1 Experience of other Countries on Forest Management

Canada's Experience

Canada is a forest nation, forests are part of Canada's heritage and history, and their current significance for its economic, social and environmental well-being is undeniable. The pulp and paper and wood industries as well as forest based tourism and recreation, are major components of Canada's economy. Forests provide a back drop for tourism reaction, hunting and fishing, employing thousands of Canadians [47] Of Canada total area of 1997 million hectares, 453 million hectares are forest however, not all this available or suitable for commercial timber production. Only about 233 million hectares or 5% is inventoried productive forest available for commercial purpose. Internationally, Canada is a leading producer of forest products ranking first in meal sprint production; second in pulp production (after US) and 3rd in soft wood lumber production (after USSR and US) (Ibid). The forest management techniques used on crown lands and to be recommended for use on privately owned land include to facilitate suitable natural regeneration wherever practical and involve selection cutting or the harvesting of individual trees or groups of trees with in a stand and the shelter wood harvest system involving one or more partial cuts curried out a decade or two before the final harvest, permit consideration of the size and configuration of areas to be clear cut where circumstances warrant; make provision for early speaking or cleaning where naturally regenerated stands contain too many seedlings for good diameter growth; provide for commercial thinning to enhance the future saw log harvest where stand and site conditions permit provide for weeding or the removal of unwanted competing vegetation in stands to be managed and provide for any silvic- culture technique designed to promote improved growth and vigor of forest stands.[48].Harvesting of Canada's forests is strictly controlled by provincial and territorial regulation, and all harvested areas must be reforested. Each province and territory sets an allowable annual cut based on the sustainable growth rate of the particular forest area. The goal is to maintain biological diversity while considering economic and social factors. About 900,000 hectares forest is harvested annually in Canada (accounting for approximately 0.22% of all forest and other wooded land). In 1994, about 425,000 hectares were replanted and 34,000 were seeded planting and seeding are reliable means of regenerating forests disturbed by harvesting or other influences when advanced or natural regeneration is not an option for a site. The proportions of area planted and seeded may change from year to year depending on the nature of the disturbance, species compassion, ages and structure of the forest, success of natural and arterial reoperation, government policies and other factors. The means of regeneration is less important than the end result-the long term functions, conditions and productivity of the forest ecosystems [49].

Swedish Forest Policy

In Sweden, legislation on forest ownerships and managements date back a long way, because of their major economic role; forests have been a topic of regulation ever since the provincial laws of the 13^{th} century. The national forest policy currently enacted by parliament in 1993 incorporates the commitments made by Sweden at the united nation's conference on environment and development (UNCED) at Rio de Janeiro.Underlying this policy is the convention that there will continue to be a demand for renewable products in the future and that Swedish forest can remain an important raw material based for processes that are based on principles of ecological cycles. Goals for both forest production and forest environment have been established, these two types of goals carry equal weight. The preservation of biological diversity is a key element of the new forest policy. The Swedish forest policy assigns "sectorial" responsibility for the environment. One consequence is that forest owners and forestry workers are responsible for obtaining the requisite knowledge to fulfilling environmental measures. A few years ago, major ecological and environmental training campaign was carried out known as richer forest. The campaign involved 100,000 participants and has already led to environmentally sound forest management in Sweden. Since 1903 there has been legislation which requires painting and cultivation of new forest after logging .Today's forest legislation contains provisions aimed at protecting key wood land habitats for flora and fauna, selected viewable broad-leafed deciduous trees, forests located near high mountains and wetland forests. There are also special regulations governing some 4 million hectares of low productive forest land. These regulations allowed only careful low-intensity utilization ensuring that the character of these woodlands alive remain unchanged, key wood land habitats functions as the houses of an ecological network, while forest wetlands and low-productive wood lands often comprise ectopically corridors in the landscape. (Ibid) The Swedish forest Agency work to implement the forest policy, supervision of the forestry Act is an important part of this work, as there are various forest survey advisory services and the administration of state subsidies to the forest owners. The forest Act sets out the demand placed on forest owners by society. These include the wood production level that was being shown to nature conservation and cultural heritage. The Swedish forest agency is pleased to offer advice on how to meet and exceed the minimum requirements of the Act, both for production and conservation. This include how to regenerate new forest in a way that better utilizes the production capacity of the land, or how to play grater consideration. As the Swedish forest Act indicate for sustained yield forest management new forest must be planted or naturally generated after felling when land's capacity to produce is not fully exploited.

2.11 Conceptual Framework

Deforestation is having serious impact on environmental degradation, failure of countries economy, loss of tourism profit income and all societies' food production. Even though this problem is very serious in our country Ethiopia, no national wise deforestation assessment study has been done for some decades which clearly shows the stake holders to encourage and enforce them for the implementation of the study's findings at the end. The above related field studies in this literature review objectives and methodology are tried to address the cause of deforestation in different ways however, it has some gaps. For this reason, this study is prepared to full fill that the former studies lacks using integration of geospatial soft wares like Geographic information system and remote sensing. So this Deforestation assessment study has also important in minimize time consuming during data collection and budget for transportation. For the purpose of assessment of forest resource conservation strategy in the study area to eliminate deforestation at regional and national level. The significance of compressive regional and national forest sector planning process and an enabling policy environment to sustainable forest management, increasing tree planting trends and conservation of existing forest resources. The causes for forest cover change accompanied by the loss of biodiversity can be explained on two different levels: the local level and the global one. The local level includes destruction of forests caused by local inhabitants. The rural poor living around forests heavily depend on biodiversity to satisfy their basic needs such as food, water, housing and social services. The economic dependency of the people on the forest which offers firewood and area that can be converted to agricultural land is one of the main reasons for deforestation. The global level of deforestation is formed by the worldwide demand for natural resources (e.g., timber, soil, gas, oil). Another aspect which has a negative impact on the ecological value of forests is conventional tourism.

2.12 Application of Geospatial technologies

2.12.1 Remote Sensing

Remote Sensing is the science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area or phenomenon under investigation. [50] The focus of remote sensing in scope of this study is to indicate areal extent of forest cover changes on map using resources of Landsat of various periods. Remote sensing satellite images are immensely used in time to time study of changes due to its repetitive coverage, especially in forest resources estimation and monitoring, and natural resources monitoring and management. Geographic Information System: Different authors defined GIS from different perspectives. [51] define "GIS is a Powerful tool for collecting, storing, retrieving, as well, transforming and displaying spatial data from the real world for a particular set of purpose". On the other hand, [52], define "GIS is a specific information system applied to geographic data and is mainly referred to as a system of hardware, software and procedures designed to support the capture, management, manipulation, analysis, modeling and display of spatially-referenced data for solving complex planning and management problems". What we understand from the above definitions is that, it relies mainly in a computer technology that realized digital data. Now, GIS is become popular tool because of its, rapid access to data, flexibility, easy update opportunity and other features that enable to analyze different databases [51]. GIS is an information system that is designed in the way compatible with referenced data to spatial or geographic coordinates. GIS is both a database system which has specific capabilities for spatially referenced data, and a set of operation for working with data. The functions of GIS include data entry, data display, data management, information retrieval and analysis. The applications of GIS include mapping locations, quantities, finding distances and mapping and monitoring change.

CHAPTER III. METHODOLOGY

3.1 Description of the Study Area

Welmera is one of the West Shoa zone Woreda' in the Oromia Region al state of Ethiopia. Part of the Oromia Special Zone Surrounding Finfinnee, it is bordered on the south by the Sebeta Hawas, on the west by Mirab Shewa Zone, on the north by Mulo, on the northeast by the Sululta, and on the east by the city of Addis Ababa. Towns in Welmera Woreda are Menagesha, Kolobo. And Holeta Genet. The highest point in this Woreda is Mount Wechacha (3191 meters), located in the southern part of the Woreda. The Menagesha National Forest covers the southern and western slopes of this mountain; it is 2500 hectares in size. [53] Other notable peaks include Mount Menagesha (between 2800 and 2900 meters).The Woreda land cover area was 80927hetare [53].

Demographics: The 2007 national census reported a total population for this Woreda of 83,823, of whom 42,115 were men and 41,708 were women; 3,352 or 4% of its population were urban dwellers. The majority of the inhabitants said they practiced Ethiopian Orthodox Christianity, with 86.72% of the population reporting they observed this belief, while 6.36% of the population practiced traditional beliefs, and 4.61% were Protestant.[54].Based on figures published by the Central Statistical Agency in 2005, this Woreda has an estimated total population of 161,117, of whom 81,470 are men and 79,647 are women; 52,252 or 32.43% of its population are urban dwellers, which is greater than the Zone average of 12.3%. With an estimated area of 736.88 square kilometers, Welmera has an estimated population density of 218.6 people per square kilometer, which is greater than the Zone average of 152.8.[55].The 1994 national census reported a total population for this Woreda of 108,457, of whom 53,412 were men and 55,045 women; 29,225 or 26.95% of its population were urban dwellers at the time. The four largest ethnic groups reported in Welmera were the Oromo (74.29%), the

Amhara (15.88%), the Sebat Bet Gurage (6.33%), and the Tigrayan (1.33%); all other ethnic groups made up 2.17% of the population. Afaan Oromo was spoken as a first language by 70.1%, 24.22% spoke Amharic, 3.56% spoke Sebat Bet Gurage, and 1.06% spoke Tigrinya; the remaining 1.06% spoke all other primary languages reported. The majority of the inhabitants professed Ethiopian Orthodox Christianity, with 93.72% of the population reporting they practiced that belief, while 3.8% of the population said they were Muslim, and 1.83% were Protestant [56].

Menagesha Monthly Climate Averages: Average high temperature in September: 22°C Warmest months (with the highest average high temperature) are March, April and May (25°C). The month with the lowest average high temperature is August (20°C). Average low temperature in September: 12°C The month with the highest average low temperature is May (13°C). Coldest months (with the lowest average low temperature) are November and December (8°C) Average humidity in September: 71.5%.The month with the highest relative humidity is July (79.5%). The month with the lowest relative humidity is December (45.5%). Average rainfall in September: 149mm the wettest month (with the highest rainfall) is August (290mm). Driest months (with the lowest rainfall) are November and December (7mm). Months with most sunshine are January, February, November and December (Average sunshine: 9h). Months with least Sunshine are July and August (Average [57]

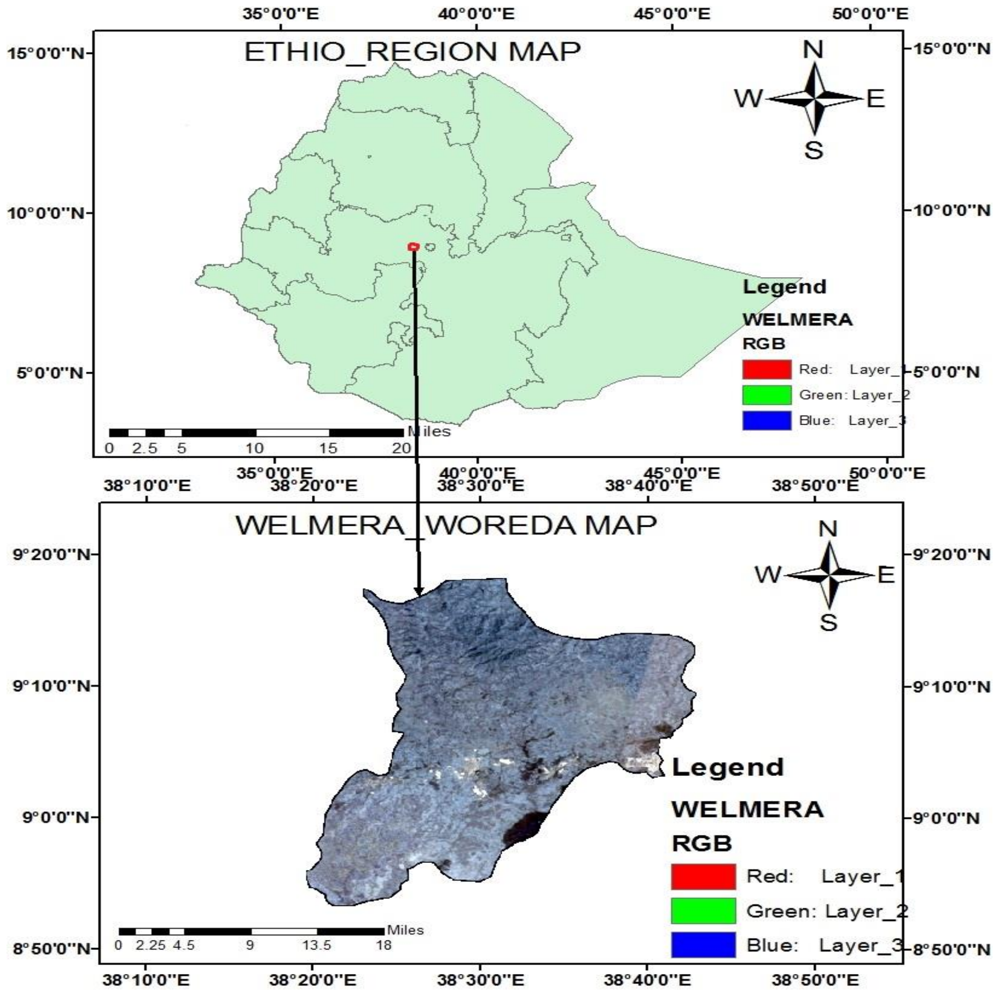

Figure 1: Location Map of the Study Area

3.2 Data Sources

3.2.1 Primary data sources

Collecting accurate and reliable data is the most determinant factor for any research as it determines the quality of the research. Accordingly, the necessary data will be collected from the respective secondary and primary data sources. The primary data were used Landsat imagery of different years of deforested area and land use/land cover of the study area and it will be downloaded from USGS Ethio quick bird satellite image with spatial resolution of (10 cm * 10cm) from EMA use to extract Digital Elevation Model (DEM) of selected research area to overlay with ground truth.

Table 1: data sources and types

NO_	Data sources	Data Type	duration
1	USGS	Land sat7	2000
2	USGS	Land sat8	2013
3	USGS	Land sat8	2020

United State Geology Surveying Company is my sources of input data for all data analysis and there are two types of land sat imagery data used in the study; Landsat 8 and landsat7 with full Meta data information and sources (see appendix A, B C)

Table 2 : List of software's involves in data analysis

No	Software's involve in the data Analysis	Version
1	Arc GIS	ArcMap 10.3
2	ERDAS	ERDASIMAGINE 2014

3.3 Data Analysis

3.3.1 GIS Analysis

A GIS is a collection of computer hardware, software, and trained personnel designed to capture, store, manage, manipulate, and communicate data that is spatially referenced Classification results and topographic information of the study area were subjected to GIS analysis in order to determine the relationship between topographic characteristics of the Deforested area spatial distribution and magnitude from GDEM data. Then, these maps were converted to feature classes to be suitable for overlay analysis.

3.3.2 Remote Sensing Analysis

Remote sensing is the gathering of information related to the Earth's surface and does not involve contact with the object under study. RS techniques include aerial photography, radar, and satellite imagery. Satellite imagery downloaded from USGS will be used as primary data in this study. Change prediction is the process of identifying differences and forecasting in the state of an object or phenomenon by observing it at different times.

3.3.3 Cartographic processing

Cartography is the science, art and technology of studying, mapping and using maps. Geographic information systems and remote sensing have established a beneficial synergy with cartography. In this study, Cartographic processing will be used to finalize by mapping with full map elements the result of GIS and RS analysis work of the study area

3.3.4 Description of Data processing

Data sources: Landsat image which secondary data is Input data during analysis of image processing which start from image enhancement to remove unclear cloud cover.

Geo referencing is the very important part which is used to overlay the image with ground truth.it is needs the coordinate of the real position of the study area.

Unsupervised classification: is also one part of image analysis process which used to classify pixel based image to analyze separately**.**

Overlaying is a GIS operation that superimposes multiple data sets (representing different themes) together for the purpose of identifying relationships between them. An overlay creates a composite map by combining the geometry and attributes of the input data sets.

Change Prediction, Predictive model is a simulation of a hypothesized explanation of a process, and is used to predict the current state of a study area. Typically, this prediction is then statistically compared to the actual state of the study area to test the validity of the hypothesis. *Cartographic processing* is the design and production of maps, or visual representations of spatial data. The vast majority of modern cartography is done with the help of computers, usually using GIS but production of quality cartography is also achieved by importing layers into a design program to refine it.

3.4 Methods of Data Analysis

3.4.1 Satellite Image Processing

Image selection: Image selection was one of the most difficult processes to extract from cloud cover. Two sets of cloud free images were selected that is for January and February 2000, 2010 and 2017 will be used in this analysis. This will be used for generation of land cover data for selected Woreda in study area. However, all images from 2000-2017 were used to extract data for the sensitive areas around the welmera Woreda which are highly affected by forest cover change induced by investment and other human related factors. And Successive land cover change processes will be identified accordingly.Geo referencing, Enhancement of Image and Resampling: Comparing images of different periods requires a series of image enhancement activities and needs increasing its quality through image enhancement [57]. All images were individually geocoded and geo referenced. Sufficient radiometric equalization will be performed in order to minimize misidentification problems during signature generation for older images. Since, 2000 Landsat image had 30x30 resolutions; resampling process will be performed using Data management tools in arc GIS software. So, it becomes equal resolution with the other two. As well as EMA‟s topographic maps was used as inputs to extract shapefiles like, road & rivers. The True color composite and false color composites of the MSS 22017 images were subset by the study area boundary. Classification and Reclassification of the image: As stated above, orthorectified (geo-referenced) satellite data downloaded from global land cover facility in tiff format compatible with Erdas imagine software. The figure below summarized all methodology and procedures that the data analysis must follow to meet the order and aim of the methodology designed for the study. Data sources are the first and main part of the study to achieve the goal. Data input is the important part of the process and the researcher never begin the study without data. The first activity of the researcher is collecting necessary data which is used as the raw material input for the process. The below methodological scheme contains all procedural steps that the study should follow to meet the designed aim and methodology. Data sources, primary data, Landsat, data process, image enhancement, Dereferencing, Normalized difference vegetation index, unsupervised classification, image reclassification, overlaying, accuracy assessment, change detection, evaluation, cartographic processing and final map.

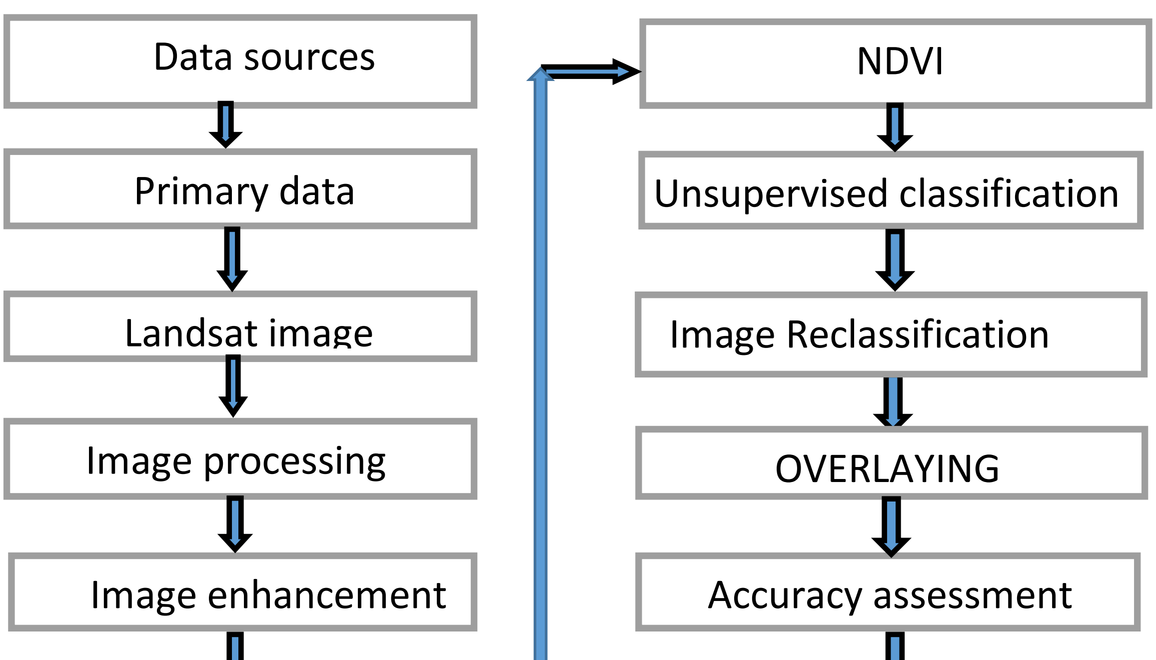

Figure 2: Technological scheme of the study

CHAPTER IV DATA ANALYS, RESULT AND DISCUSSION

4. 1 Data Analysis

Table 3: Input Data sources and types Information

No	Data Sources	Data Types	Acquisition Date YY-MM-DD	WRS		Output Category	Map projection	Datum	Ellipsoid	UTM Zone
				Path	Row					
1	USGS	Land Sat7	2000-02-12	169	54	GEO TIFF	UTM	WGS	WGS84	37N

2	USGS	Land Sat8	2013-12-01	168	54	GEO TIFF	UTM	WGS	WGS84	37N
3	USGS	Land Sat8	2020-02-27	169	54	GEO TIFF	UTM	WGS	WGS84	37N

Sources: From Landsat metadata see appendix A, B &C

4.1.1 Image processing

Image selection was one of the most difficult processes to extract from cloud cover. Geometric correction of image includes cloud cover enhancement, atmospheric reduction, haze reduction and histogram correction. Three sets of cloud free Landsat images were selected.Landsat7 of 2000, Landsat8 of 2013 and 2020 used in this analysis respectively. The figure below represent the true color map of 2000, 2013 and 2020 respectively of the study area which extracted from the stake layer processed by ERDAS IMAGINE2014. The change between seven years which is in the 2013 to 2020 clearly shown on the figure the expansion of urbanization which is one of the cause of deforestation stated in the problem statement. The figure below of the different years of the study area welmera Woreda Oromia regional state Ethiopia. The study consider the gap between the years of 2000, 2013and 2020 which is the time gap between 2000 to 2013 is thirteen (13) and 2013 to 2020 is seven (7) respectively. The below land sat imagery directly taken from the United Sate of Geological Survey with full metadata Information Sources and Geo tiff code. The below study area figure masked from land sat imagery by Geographical Information System software. It enables the researcher to classify the land use land cover of the study area as necessary as the methodology designed. It is georeferenced with welmera Woreda shape file.

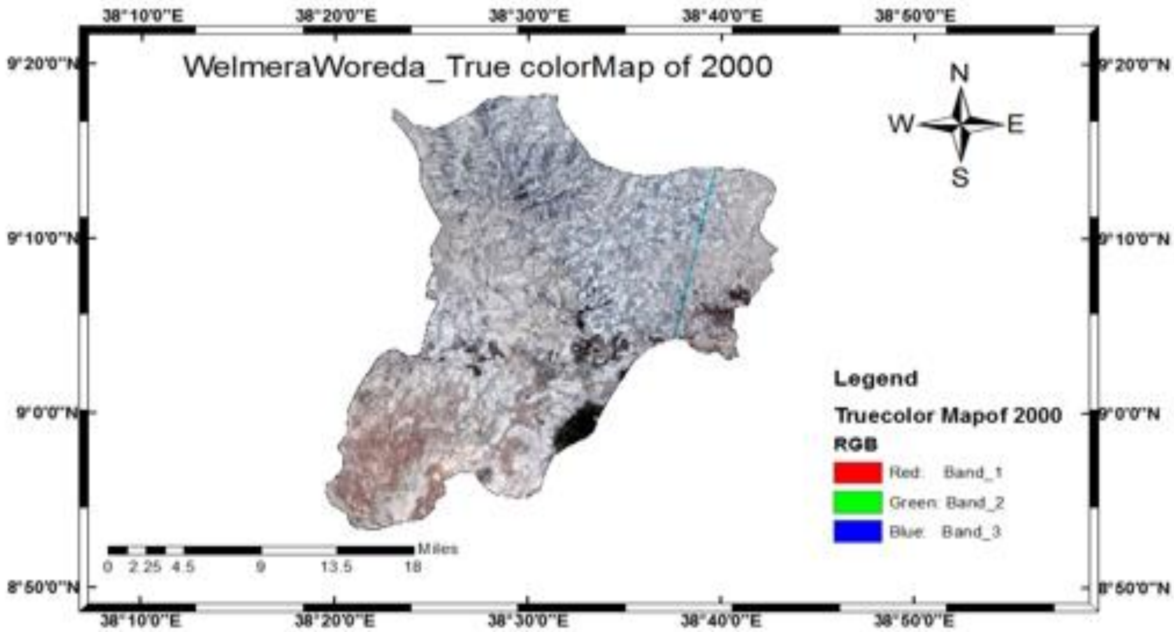

Figure 3: Welmera Woreda true color map of 2000

The below image figure4 is the 2013 year Landsat image of welmera Woreda taken after thirteen to compare the land use land cover change difference in the study area.it is impossible to determine the land use land cover change simply from the image because the image needs analysis to interpret the difference between the study area Landsat image.

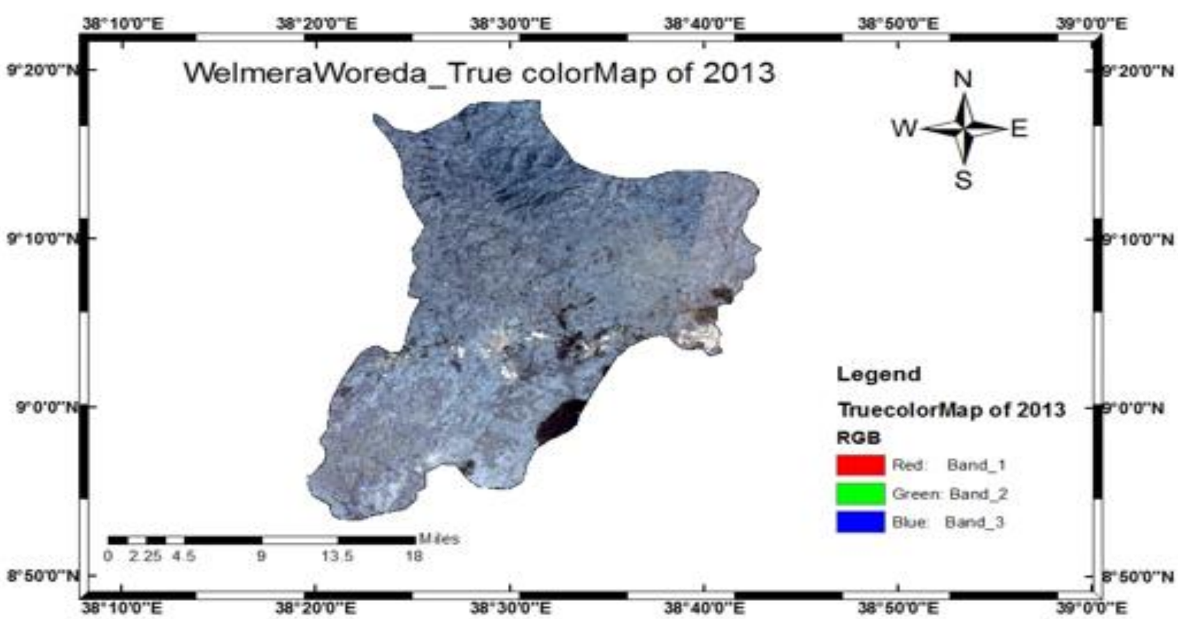

Figure 4 : Welmera Woreda true color map of 2013

The change between seven years which is in the 2013 to 2020 clearly shown on the figure the expansion of urbanization which is one of the cause of deforestation stated in the problem statement.

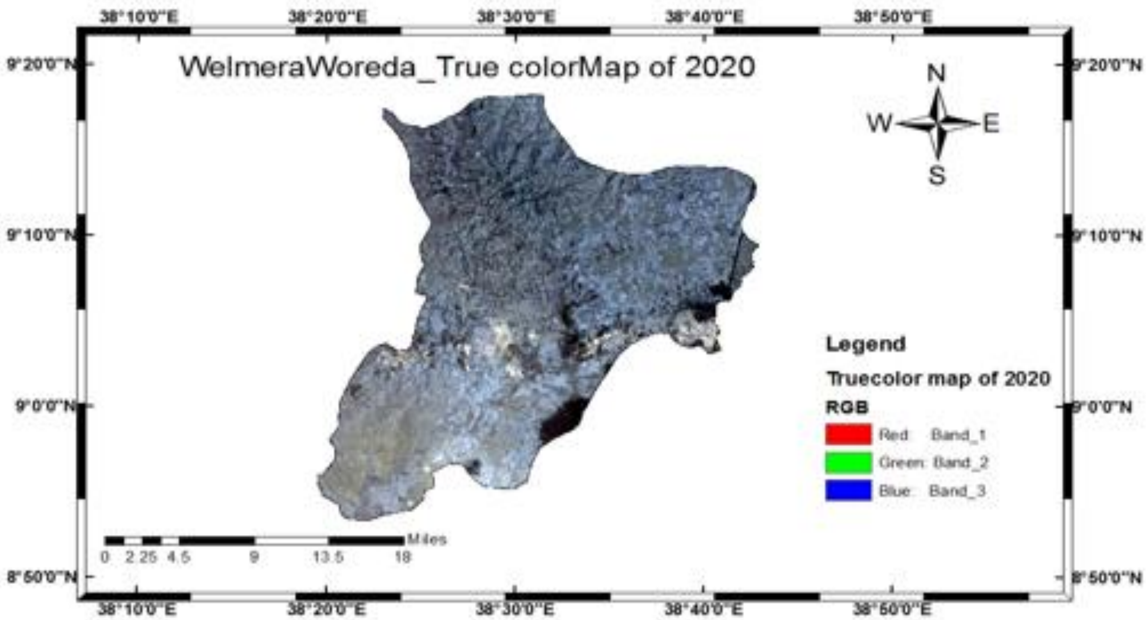

Figure 5: Welmera Woreda true color map of 2020

4.1.2 Normalized Difference Vegetation Index

Some of these studies were based on Normalized Difference Vegetation Index differencing Change Detection [58],[59] Soil-Adjusted Vegetation Index [60] Tasseled Cap and Subpixel classification [61] According to [62] the normalized difference vegetation index is the most used factor in vegetation studies. Kumar et al. [63] has used NDVI to monitor deforestation and forest degradation in India. NDVI gives an overview of the quality and density of vegetation [64] Nori et al. [65] integrated NDVI and SAVI to evaluate the potential for monitoring forest change in Sudan. The normalized difference vegetation index is a simple graphical indicator that can be used to analyze remote sensing measurements, often from a space platform, assessing whether or not the target being observed contains live green vegetation. Normalized Difference Vegetation Index quantifies vegetation by measuring the difference between near-infrared (which vegetation strongly reflects) and red light (which vegetation absorbs). *NDVI* always ranges from -1 to +1.Normalized Difference Vegetation Index (NDVI) uses the NIR and red channels in its formula.

NDVI The generic NDVI calculation is the following:

NDVI = (NIR — VIS)/ (NIR + VIS)

Where:

VIS = Visible Red

NIR = Near Infrared

Table 4 : The difference between Landsat 7& 8

Landsat 7			Landsat 8		
Banda	Ancho (µm)	Resolución (m)	Banda	Ancho (µm)	Resolución (m)
			Band 1 Coastal	0.43 – 0.45	30
Band 1 Blue	0.45 – 0.52	30	Band 2 Blue	0.45 – 0.51	30
Band 2 Green	0.52 – 0.60	30	Band 3 Green	0.53 – 0.59	30
Band 3 Red	0.63 – 0.69	30	Band 4 Red	0.64 – 0.67	30
Band 4 NIR	0.77 – 0.90	30	Band 5 NIR	0.85 – 0.88	30
Band 5 SWIR1	1.55 – 1.75	30	Band 6 SWIR1	1.57 – 1.65	30
Band 7 SWIR2	2.09 – 2.35	30	Band 7 SWIR2	2.11 – 2.29	30
Band 8 Pan	0.52 – 0.90	15	Band 8 Pan	0.50 – 0.68	15
			Band 9 Cirrus	1.36 – 1.38	30
Band 6 TIR	10.40 – 12.50	30/60	Band 10 TIRS1	10.6 – 11.19	100
			Band 11 TIRS2	11.5 – 12.51	100

Sources: from internet

ERDAS IMAGINE2014 used the same formula but different values for both bands. For Landsat7 used the band value (4, 3) that means, Near Infrared (4) and Visible Red (3)

NDVI = (NIR — VIS)/ (NIR + VIS Where:

VIS = Visible Red

NIR = Near Infrared

NDVI = (NIR — VIS)/ (NIR + VIS)

NDVI = (4— 3/ (4+ 3)

For Landsat8 used the band value (4, 3) that means, Near Infrared (5) and Visible Red (4)

NDVI = (NIR — VIS)/ (NIR + VIS Where:

VIS = Visible Red

NIR = Near Infrared

NDVI = (NIR — VIS)/ (NIR + VIS)

NDVI = (5— 4/ (5+ 4)

The result of this formula generates a value between -1 and +1. If you have low reflectance (or low values) in the red channel and high reflectance in the NIR channel, this will yield a high NDVI value. And vice versa. Overall, NDVI is a standardized way to measure healthy vegetation. When you have high NDVI values, you have healthier vegetation. When you have low NDVI, you have less or no vegetation. Generally, if you want to see vegetation change over time, then you will have to perform correction. Healthy vegetation (chlorophyll) reflects more near-infrared (NIR) and green light compared to other wavelengths. But it absorbs more red and blue light. This is why our eyes see vegetation as the color green. If you could see near-infrared, then it would be strong for vegetation too. The Figure below is the NDVI values of the study area calculated based on their band and Landsat data types.Fig6 below the result from Landsat7 and Fig7and Fig8Landsat8 respectively.it is possible to use other method of vegetation index like soil adjusted vegetation index which is used to minimize the soil reflection that reduce the quality of image during image classification. In the calculation of normalized difference vegetation index or soil adjusted vegetation index is similar to each other where the image soil reflection is equal to normal difference vegetation index. Soil adjusted vegetation index is very important in barrel and Landsat image is used for GIS and RS analysis of image classification. Normalized Difference Vegetation Index is the important ERDASIMAGINE algorithm method to difference the land use land cover classification especially vegetation cover of the study area.it is the first. The figure below is the first NDVI value of the vegetation cover classification calculation of 2000 year of the study area.as the map clearly shown us where dense vegetation cover and rare vegetation cover of the study area exist. The value categorized in to two high vegetation cover and low vegetation cover.

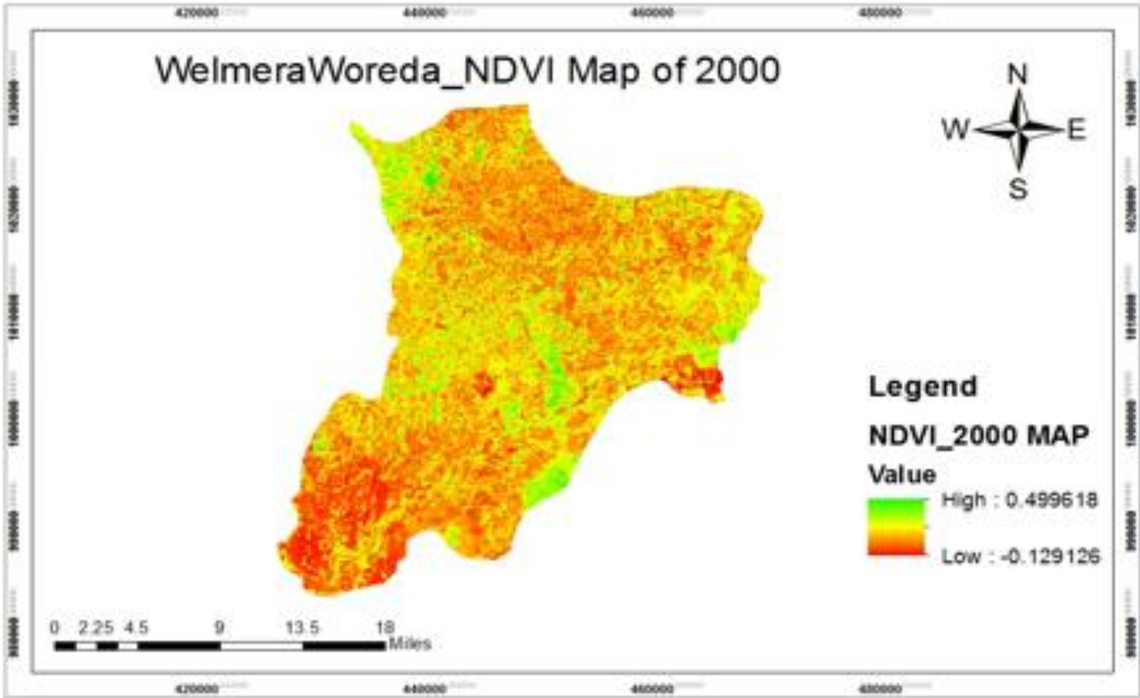

Figure 6: NDVI classification map of 2000

NDVI Value clearly indicate that the amount of vegetation cover highly decreased from time to time. The figure below shown as there is the clearance of vegetation from the area in many hectares within the time period of thirteen years from 2000 to 2013.The image analysis process of normalized difference vegetation index in 2000 Landsat image was used and the output result map indicated that the forest cover change during 2000 year is more dense than the next thirteen years 2013 which is very different in vegetation cover change of the same Landsat image of different years of the study area. As we have seen from above figure6 NDVI image classification map of 2000 year the study area of Landsat image after process.it is important to compare the different time Landsat images land use land cover change of specified study area for the needed purpose. Land use land cover change analysis always needs more than one image to identify compare the land cover change between the determined time gaps and also used to take action based on the report of land use land cover change image classification analysis. The change between the two image differences in thirteen years as the below figure7 clearly indicated that a lot of forest was removed in the Woreda.

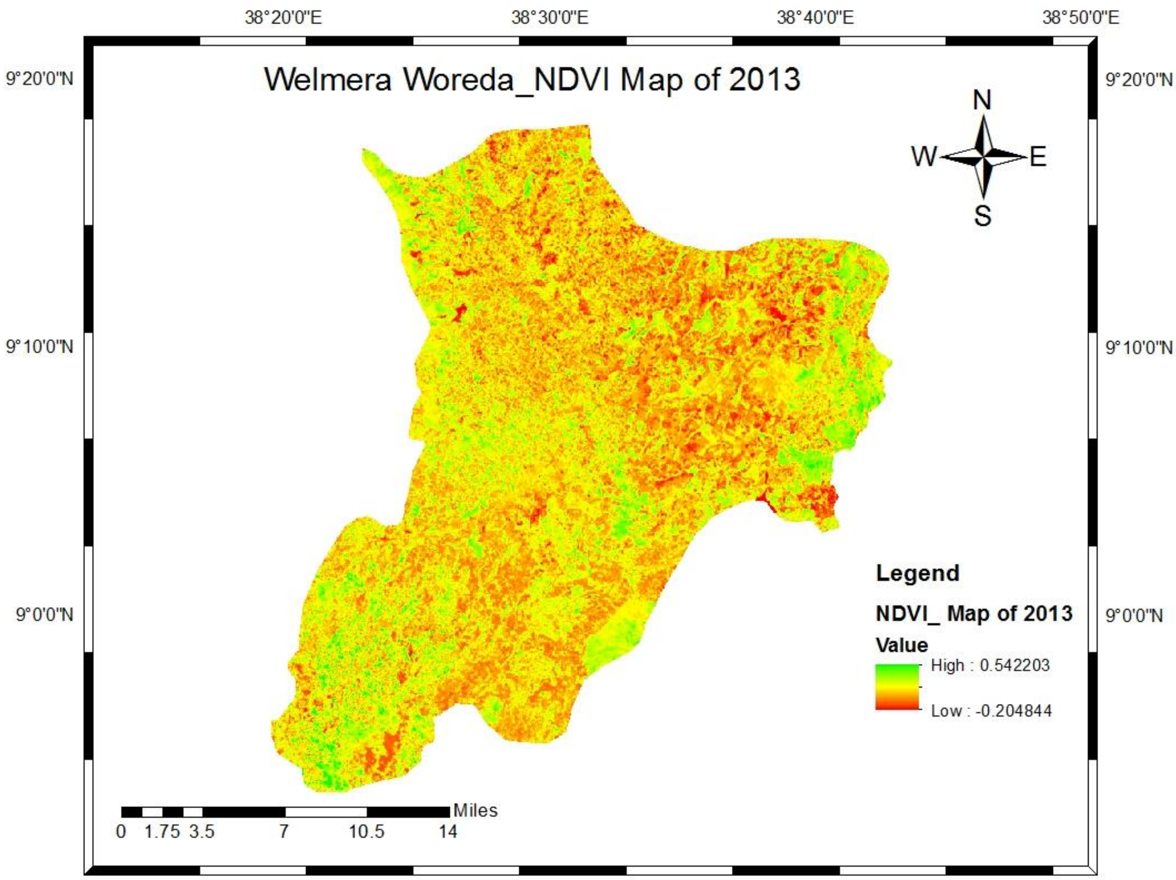

Figure 7: NDVI classification map of 2013

The amount of vegetation cover continuously decreased again as we observed from the NDVI value scientifically calculated of each data. Figure 8 below clearly indicate that the vegetation coverage in the same area decreased in many hectares from 2013 to 2020.Normal difference vegetation indices calculate the vegetation cover of the study area based on the Landsat band value which is Red, Green, and Blue, which is different in different Landsat example, in Landsat7 the NDVI formula uses (Band4, Band3) as NIR infrared and Red while Landsat8 uses (Band5, Band4) as NIR infrared and Red Respectively. The figure below tells us that there is very serious removal of vegetation in the study area in 2020 rather than the previous two different years over the study area which is 2000 and 2013 respectively. This finding also confirm that the others previous study on the same title and study area confirm the existence of deforestation in welmera Woreda Oromia regional state Ethiopia. Normalized difference vegetation index algorism clearly identify where dense vegetation low vegetation cover over the study area.

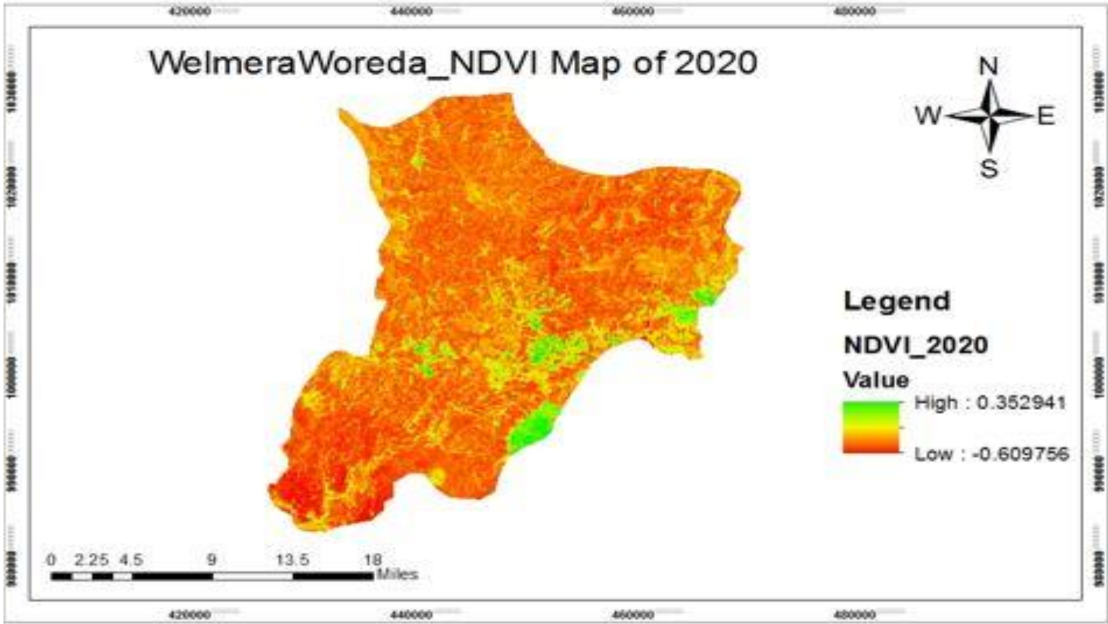

Figure 8: NDVI classification map of 2020

4.1.3 Unsupervised Image Classification

During unsupervised image classification methods, land cover types were identified. In this study the forest cover played important role than other types of land cover found in the study area. Based on the characteristics of Landsat satellite image of the year 2000, 2013 and 2020 a number of land cover types were determined to run unsupervised classification, which aided the preliminary field visit. Therefore, in this study area the same procedure followed to classify the study area before the process held. There are four the major land cover type classes for all three Landsat images of different times; Vegetation cover, Urban, Farmland and barrel and with the support of ERDAS Imagine 2014 Software. The map of unsupervised classification of Landsat 2000, 2013 and 2020 image classification was produced accordingly as figure below. As the unsupervised Landsat image classification of 2000 indicated that the vegetation cover in the study area was comparatively denser than that of 2013 and 2020. The figure below is the first unsupervised classification of the 2000 year Landsat map of the study area and the classification based on the major classification of the study area land use land cover. Normalized difference vegetation index algorism clearly identify where dense vegetation low vegetation cover over the study area. Landsat 7 and landsat8 image calculation used different values for different Landsat image because both data have different Bands.

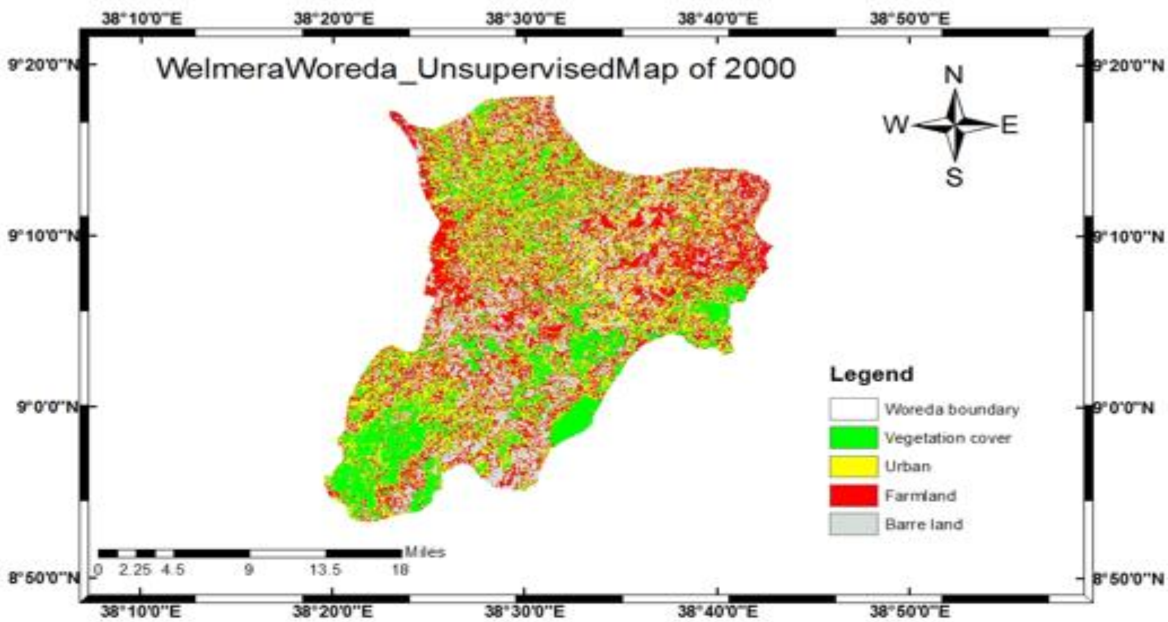

Figure 9: Unsupervised classification map of 2000

In the same manner and procedure There are four the major land cover type classes for all three Landsat images of different times;, Vegetation cover, Urban area Farmland and Barre land With the support of ERDAS Imagine 2014 Software. The map of unsupervised classification of Landsat 2000, 2013 and 2020 image classification was produced accordingly as figure below. As the unsupervised Landsat image classification of 2013 indicated that the vegetation cover in the study area was comparatively almost denser than that of 2020 even though it is smaller in hectare than that of in 2000.As the value obtained from the attribute table of all figures shown as there was decreasing of vegetation coverage area as we have seen from the figure below. The map of unsupervised classification of Landsat 2000, 2013 and 2020 image classification was produced accordingly as figure below. As the unsupervised Landsat image classification of 2000 indicated that the vegetation cover in the study area was comparatively denser than that of 2013 and 2020. The figure below is the second unsupervised classification of the 2013 year Landsat map of the study area and the classification based on the major classification of the study area land use land cover. Unsupervised image classification method is also used to classify identified specific study area. This study more focuses on deforestation assessment but causes of deforestation also identified to seek solution for deforested area.

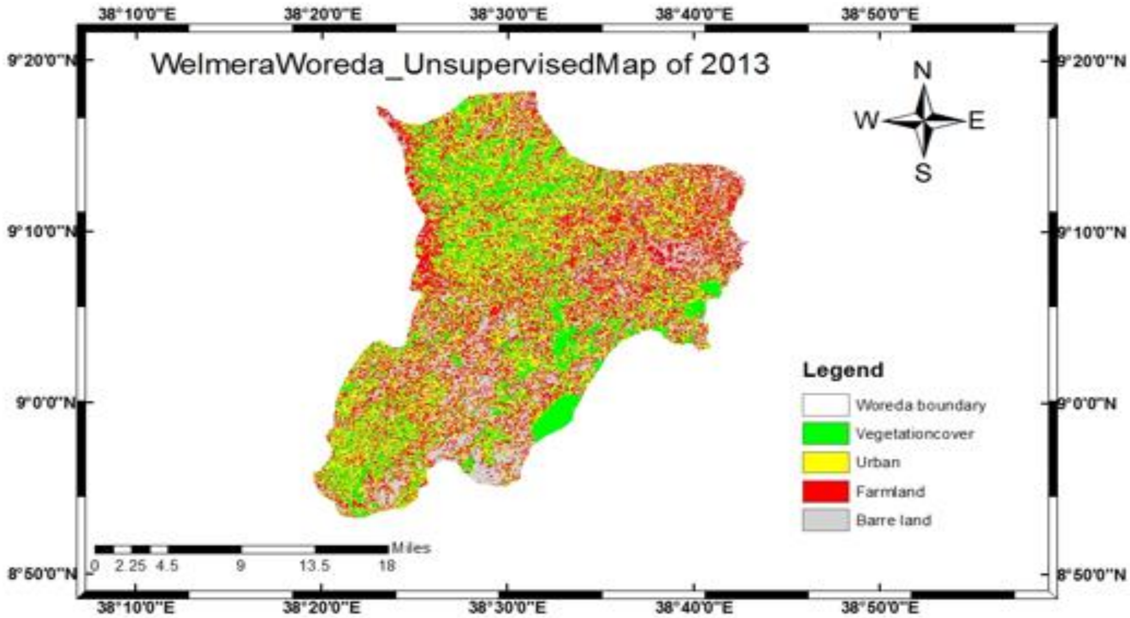

Figure 10: Unsupervised classification map of 2013

The figure itself indicated that the difference between the three Landuse land cover un supervised classifications clearly shown the difference of the vegetation coverage decreased from time to time within the period of seven years in hectares. Unsupervised classification is the software based classification of Landuse land cover of the study area .the finding clearly computed the total area coverage of the Landuse land cover of the area in the same ratio of the data input.un supervised classification also compute all the necessary computation based on the area classified on the study area.fig9 indicate that the vegetation coverage decreased when compared with fig10 above. The map of unsupervised classification of Landsat 2000, 2013 and 2020 image classification was produced accordingly as figure below. As the unsupervised Landsat image classification of 2000 indicated that the vegetation cover in the study area was comparatively denser than that of 2013 and 2020. The figure below is the third unsupervised classification of the 2020 year Landsat map of the study area and the classification based on the major classification of the study area land use land cover of four major category; vegetation cover, Farmland, urban area and barre land.as the figure below indicate deforestation more increase from time to time in the study area.

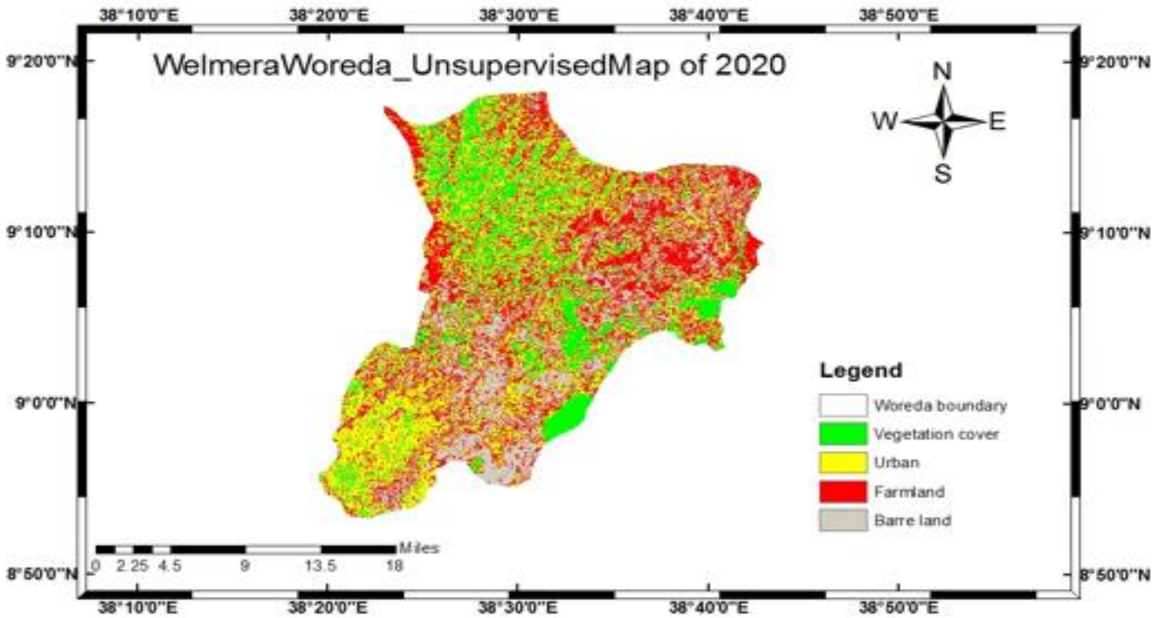

Figure 11: Unsupervised classification map of 2020

Finally, as the whole data analysis indicated as there is very variation vegetation cover change and decreased in many hectares difference in the last two decades. According to the finding, the Landuse land cover change in the period of 20years deforestation was held in welmera Woreda.as the computed values of computer software based shown around 2662.4hectares completely destroyed between 2000 to 2020 in welmera Woreda (see table14).

4.1.4 Accuracy Assessment

Accuracy Assessment of Classification of land use land cover with ground truth sufficient numbers of randomly distributed sample plots was selected for ground observation with vegetation cover and farm land area on 2000 year of map of welmera Woreda. The error matrix in attribute table and kappa method was used to assess the mapping accuracy. The overall accuracy only considers the correction of diagonal elements in the matrix, while the kappa method takes the other element in the matrix into account, which can compensate the disadvantage of error matrix method. Land cover maps derived from remote sensing always contain some sort of errors due to several factors which range from classification technique to method of satellite data capture. In order to wisely use the land cover maps which are derived from remote sensing and the accompanying land resource statistics, the errors must be quantitatively explained in terms of classification accuracy. Whether the output meets expected accuracy or not is usually determined by the users themselves depending on the types of applications and the map product. Accuracy levels that are acceptable for certain task may be unacceptable for others. The common means of expressing accuracy of classification is the preparation of classification error matrixes. According to [66] an error matrix (confusion matrix) is a square array of numbers organized in rows and columns which express the number of sample units assigned to a particular category relative to the actual category as indicated by reference data.

Table 5: Over all Accuracy assessment matrix

Classification	reference1 reference2	reference2		reference3	reference4 ground truth	Ground truth
Forest cover	64	0		0	24	88
farm land	0	77		0	27	104
urban	0	0		80	0	80
barrel and	0	0		0	0	0
Total	64	77		80	51	282

These values are based on a sample of error checking pixels of known land cover that are compared to classifications on the map. Errors of commission and omission can also be expressed in terms of user's accuracy and producer's accuracy (ibid).

Table 6: Diagonal kappa coefficient matrix value

Classification	reference1 reference2	reference2		reference3	reference4 ground truth	Ground truth
Forest cover	64	0		0	24	88
farm land	0	77		0	27	104
urban	0	0		80	0	80
barre land	0	0		0	0	0
Total	64	77		80	51	282

User's accuracy represents the probability that a given pixel will appear on the ground as it is classed, while producer's accuracy represents the percentage of a given class that is correctly identified on the map. One of the problems with the confusion matrix and the kappa coefficient is that it does not provide a spatial distribution of the errors (Foody, 2002) [67]. The quality and sufficiency of reference data are important if reliable accuracy assessment is required.

A reference data that is not verified thoroughly should not be expected to set accuracy standard. Insufficient number of verified data also affects the quality of the assessment ([66].

In this study, an error matrix was generated based on the year 2000 forest cover classification and area of interest data

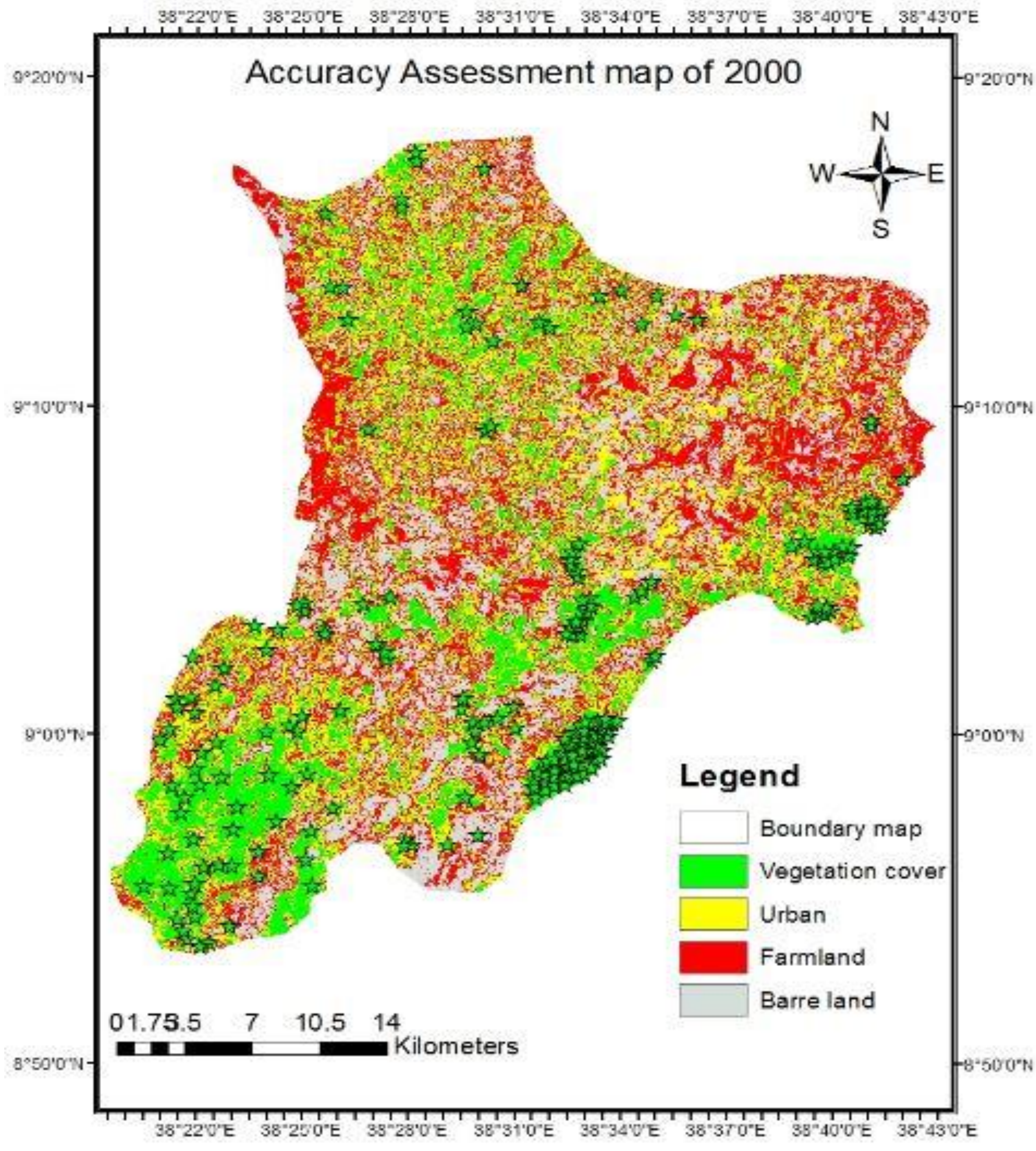

Figure 12: Vegetation cover accuracy assessment map

The accuracy is essentially a measure of how many ground truth pixels were classified correctly.

The kappa value is a measure of the agreement between classification and reference data with the agreement due to chance removed. None of the kappa values in any of the images were very high. The ranked the kappa values, ranging from -1 to 1, into 3 groups: 1) those greater than 0.80 represented as strong agreement between the classification and reference data; 2) those between 0.40 and 0.80 represented as moderate agreement; and 3) those less than 0.40 represented as poor agreement [69]. The low kappa also was a product of classifying the imagery into just 2 classes. If there had been more classes, the kappa values probably would have been higher. The Kappa coefficient lies typically on a scale between 0 and 1, where the latter indicates complete agreement, and is often multiplied by 100 to give a percentage measure of classification accuracy. This implies that the Kappa value of 0.84 represents a probable 84% better accuracy than if the classification resulted from a random assignment. The result obtained in this study fits to the view of [70] who stated the minimum level of accuracy in the identification of Land cover categories from remote sensor data should be at least 80 %.

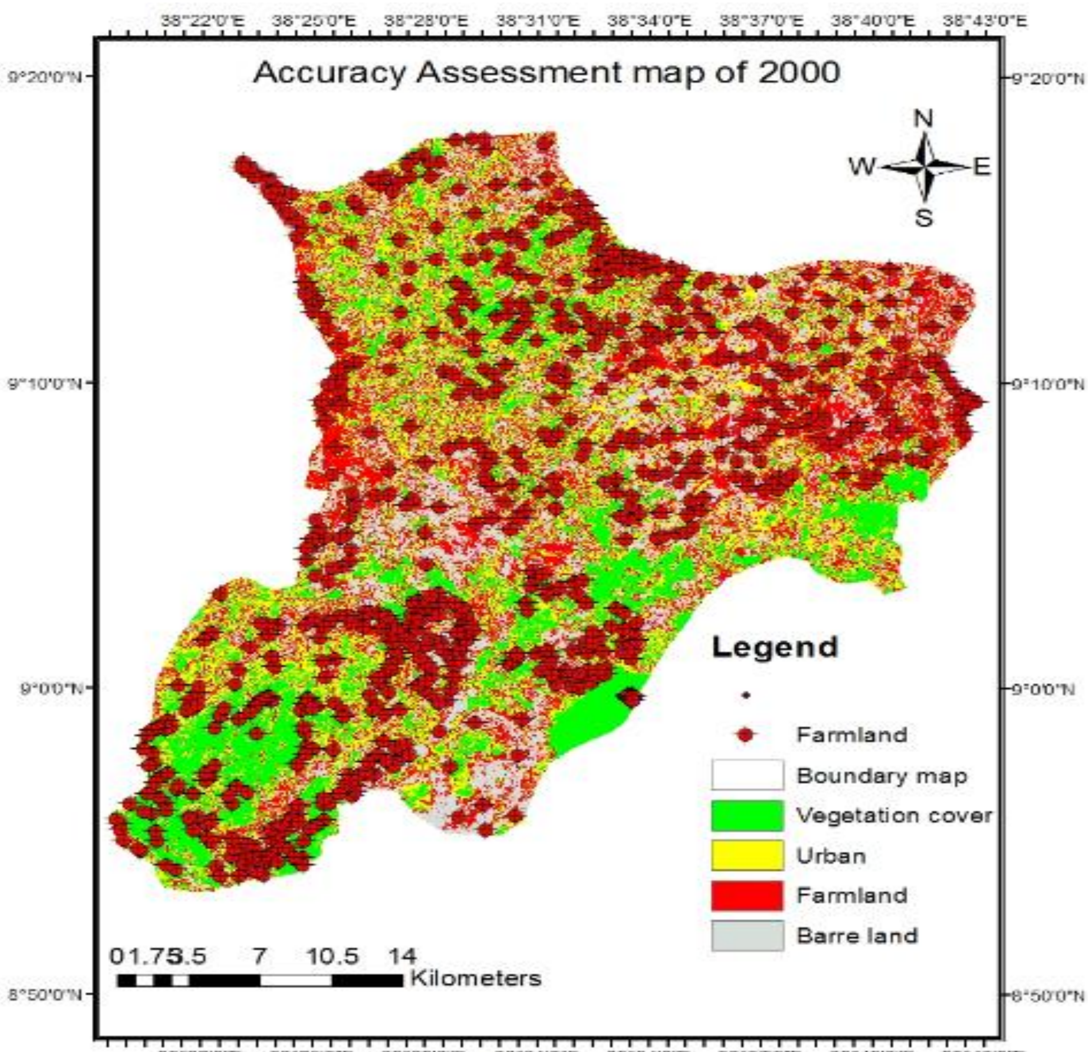

Figure 13: Farmland accuracy assessment map

4.2 Result

4.2.1 Land use Land cover Change

4.2.2 Change Detection and Weighted Overlay Analysis

Change detection evaluates and identifies any difference changes between two images in the same study area at different dates [70]. In this study Image differencing is used by subtracting the recent image from the old one to know the extent of the change. The change detection was calculated using the first and last outputs of the indices and classification. The results were combined with the Weighted Overlay [71] all Change detection indices and classification each factor was classified into three classes: increase, decrease and unchanged; and was applied at the same percentage influence The deforestation susceptibility map is obtained by overlaying all maps in terms of weighted over-lay methods using the spatial analysis tool in ArcGIS 10.4. Unsupervised classification Attribute tables values expression by tables and graphs[72].

No	Land Class Name	Area covered
1	Vegetation cover	21094.3
2	Urban	27192.8
3	Farmland	32200.8
4	barre land	24231.6

Table 7: Study Area classification and Area by hectare of 2000

The Unsupervised classification of 2000 year of land use land cover change indicated that there are many change between vegetation cover, Farmland, urbanization and Barre land when compared with other classification means the change in urban and vegetation cover change the figure below clearly shown as the difference between the land use land cover classifications. The above table is the first result of the first data process based on the land use land cover major classification of the study area shown us among the land cover of the study area total cover the vegetation cover covers the large number of the study area by 21094.3and the second large number is the farmland which is 32200.8 and Barre land is the least area cover over the study area by 24231.6 the attribute table value calculated by software itself.

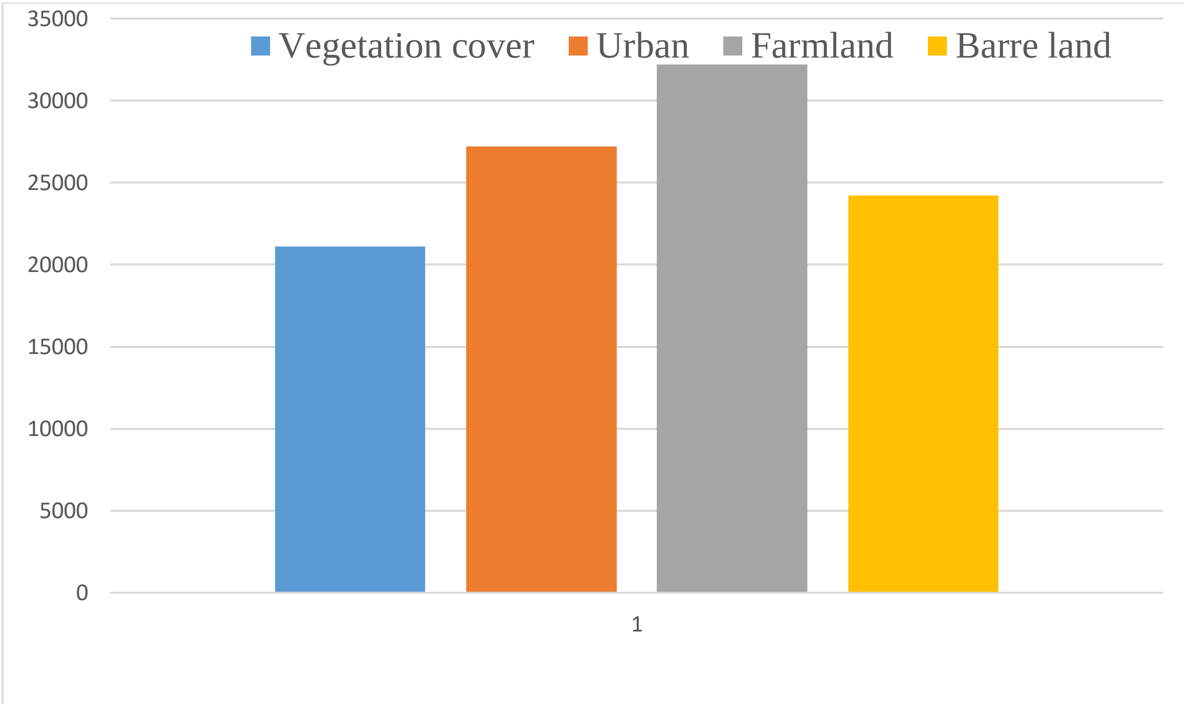

Figure 14: land cover classification of 2020 year

The above figure clearly indicated that the forest clearance increased more than other past thirteen years. It is possible to understand the difference between the land classification at each year the farm land and urban area increased while forest area in other hand decreased.

Table 8 : Study Area classification and Area by hectare of 2013

No	Land Class	Area covered in ha
1	Vegetation cover	19413.5
2	Urban	31053.2
3	Farmland	32304.5
4	Barre land	21948.4

The un supervised classification of 2013 year of land use land cover change was indicated that there are many change between vegetation cover and Farmland when compared with other classification means the change in urban and barrel and land cover change how ever doesn't means that there is no change completely. The above table shown us the attribute table value of data processed result of each land use land cover area classification. The major unsupervised classification is the very important classification which has direct relationship with decreases of forest cover area as a causes.

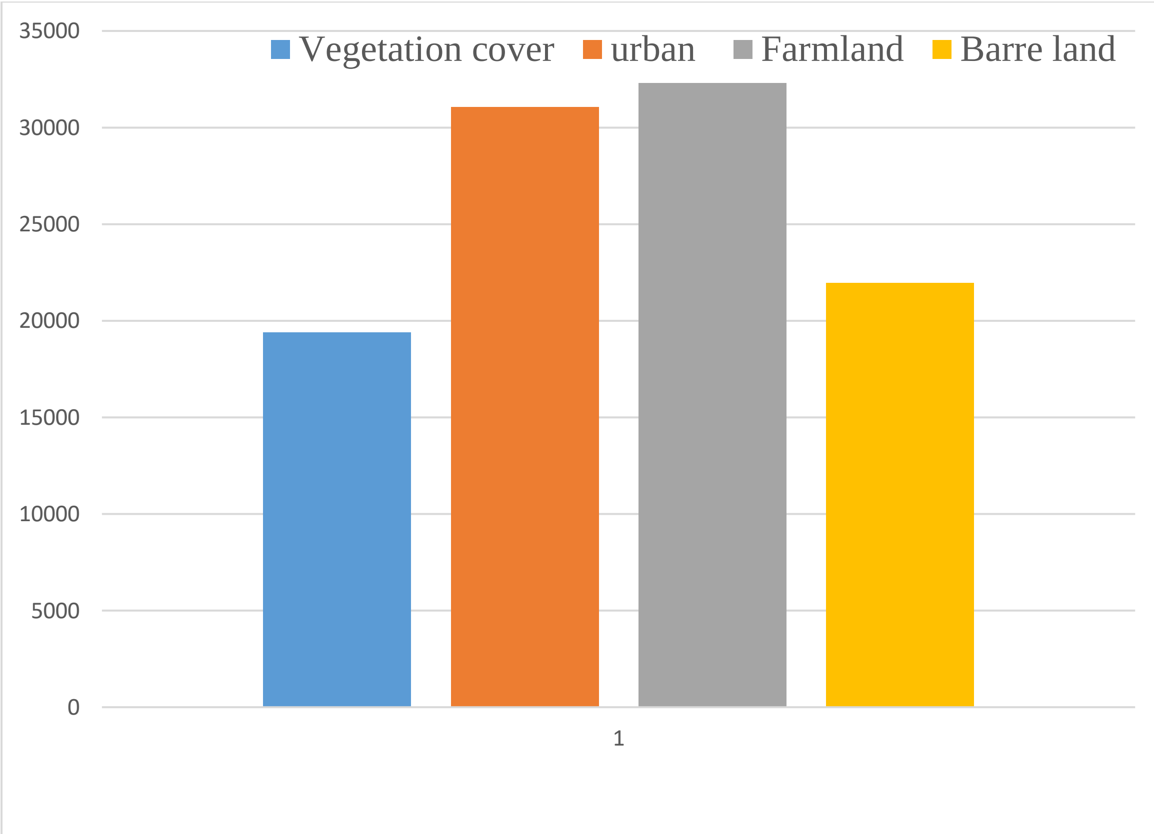

Figure 15: land cover classification of 2013 year

Table 9: Study Area classification and Area by hectare of 2020

No	Land Class Name	Area covered
1	Vegetation cover	18431.9
2	Urban	31835.3
3	Farmland	33966.2
4	barre land	20486.2

The above figure shows the last value of the the data process and the final finding of the study.vegetation cover value 18431.9 indicated the decreasing amount of the vegetation cover becomes low rather than the other area like Urban area which is inceased in the other hand by 31835.3 and Farm land also more increased from time to time the value reached 33966.2 and barre land increased in the same way up to 20486.2The major classes of land use landcover of the study area has direct relation ship with the main causes of deforestation in the study area because increasing farl land,increasing population causes urban growth .

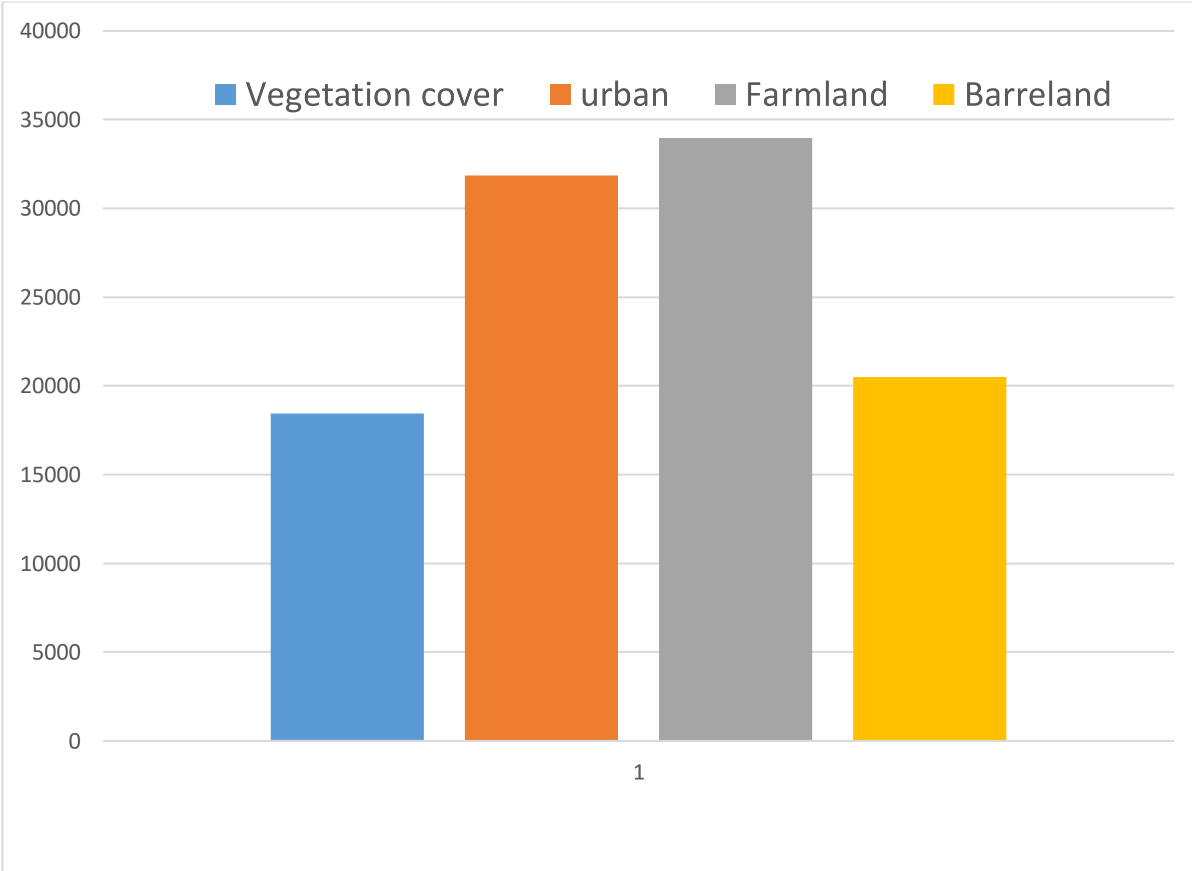

Figure 16: land cover classification of 2020 year

Table 10: Land use and land cover change area from the year 2000, 2013 and 2020

No	Land Class Name	2000	2013	2020
1	Vegetation cover	21094.3	19413.5	18431.9
2	Urban	27192.8	31053.2	31835.3
3	Farmland	32200.8	32304.5	33966.2
4	Barrel and	24231.6	21948.4	20486.2
	Total	104719.5	104719.6	104719.6

Table 11: Number of pixel size (30*30) multiplied by the individual area land classes

No	Land Class Name	2000	2013	2020
1	Vegetation cover	18984870	17472150	16588710
2	Urban	24473520	27947880	28651770
3	Farmland	28980720	29074050	30569580
4	Barre land	21808440	19753560	18437580
	Total	94247550	94247640	94247640

Table 12: Land use land cover change by percentage

No	Land Class Name	2000	2013	2020
1	Forest cover	20.14362	18.53855	17.60119
2	Urban	25.96727	29.65367	30.40052
3	Farmland	30.74957	30.84857	32.43538
4	barre land	23.13953	20.95921	19.56291

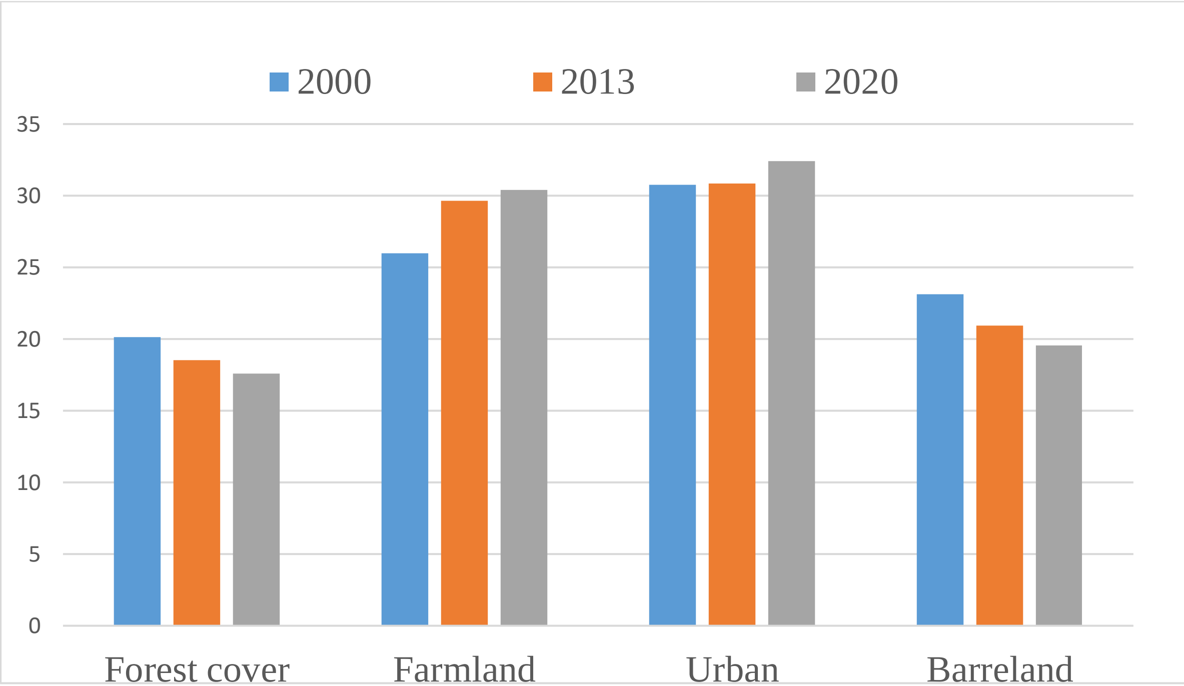

Figure 17: Land cover classification

Comparison between vegetation cover and farmland based on one of the reason of cause of deforestation is the increase of farm land while vegetation cover in the other hand decreases.

Table 13: Comparison between vegetation cover and farmland.

No	Land class	2000	2013	2020
1	Forest cover	21094.3	19413.5	18431.9
2	Farmland	27192.8	31053.2	31835.3

As the finding clearly shown as Forest land and Farm land of the study area covers a large number of total land of the Woreda. Among the land use land cover classification Farm land increased from time to time while forest cover decreased in the other hand.

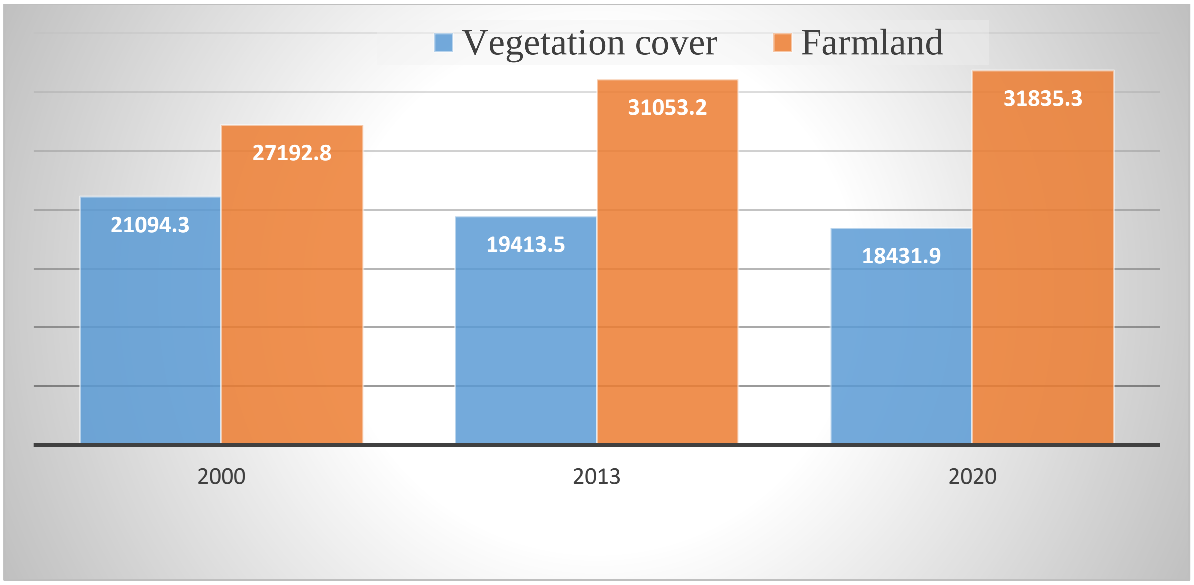

Figure 18: Change Comparison between Vegetation and Farmland

The reason why vegetation cover and farm land chosen to describe the inverse relationship between deforestation and increased farm land because, farmland increased when vegetation is cleared or destroyed and changed to farmland

Table 14: Forest area cover change between this three different years

No	Class Name	2000	2013	2020
1	Vegetation cover	21094.3	19413.5	18431.9

As the above table14 clearly described that there is a lot of vegetation loss within the last 20 year. Vegetation clearance is increased from time to time, especially from 2000 to 2013 as the time gap is also different with three years which means thirteen years while the time between 2013 to 2020 is seven years. Graphical presentation of forest cover area change from the year 2000, 2013, and 2020 respectively. The causes of change from forest cover to farm land is population growth, investment, wood, fuel and charcoal.

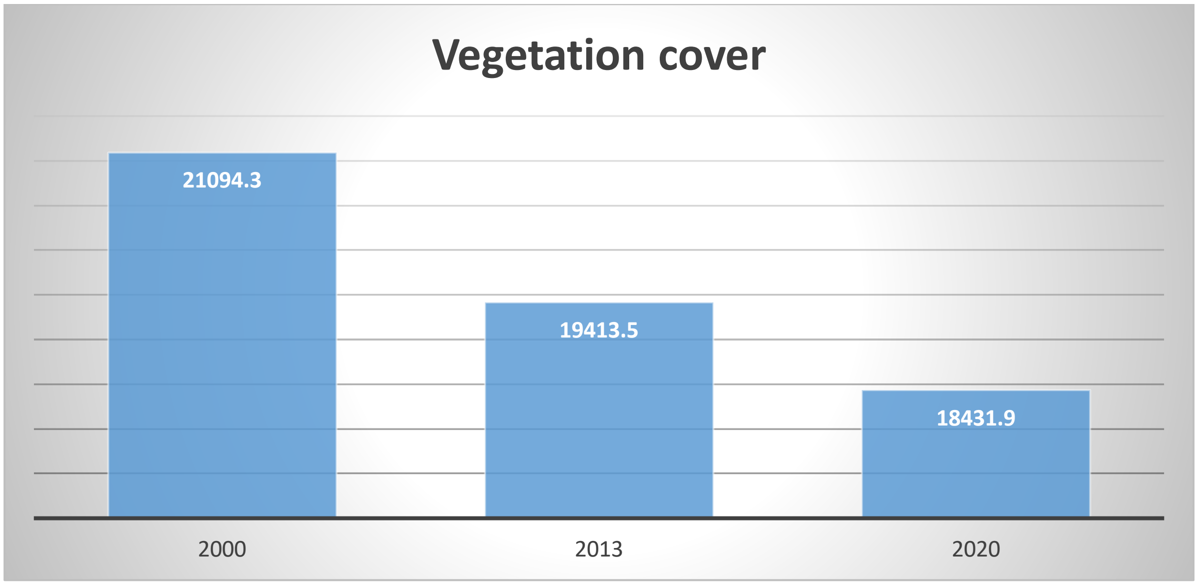

Figure 19: Vegetation cover in 2000, 2013&2020 years area in hectares

Data analysis and all procedures which the researcher must be follow to address and analysis the data accordingly to fulfill the gap in the statement of the problem using methodology designed in the proposal is completed

4.2 Discussion

Deforestation Assessment deals about rate of forest cover change in space and time in a particular area by different environmental problems. Based on the above basic concept the researcher tries to forward spatial extent and timely variation of forest cover change in welmera Woreda west shoa zone Oromia regional state for the year 2000, 2013 & 2020. As stated in problem identification part the pertaining clues or initiating factor for this research report was vast clearance of forest resource or deforestation in past more than two decades for many reasons like population growth, agriculture expansion, urbanization and land grazing purpose without considering Indigenous and environmentally feasible nature protection of local community and another reason was Lack of reliable data (map) which indicate spatial extent forest cover in the study area[1]. Therefore, this research study emphasized on mapping deforested area using remote sensing algorithm like NDVI and Image unsupervised classification process due various manmade and natural factors using the integrated techniques of RS and GIS in Oromia Regional state, west shoa zone welmera Woreda. In this work, the general objective was “Deforestation Assessment Using GIS and RS in welmera

Woreda west shoa zone Oromia regional state. The study from the very beginning emphasizing on: identifying the risk area through the uses of high resolution Landsat7 for the year 2000 and Landsat8 for 2013and 2020 images of the study area based on data collection methodology held before the analysis has started and making maps of 2000.2013 & 2020 by using GIS tools & analyzing differences and quantifying rate of deforestation acceleration, producing disturbance risk graphs. The above mentioned targeted objective was successfully fulfilled accordingly following all the methodology designed in proposal. The result of the study clearly identified and shown us the currently situation of the deforestation acceleration in welmera Woreda west shoa zone Oromia regional state and confirmed that the reality of the others work used as a references in the body of this study. The previous researcher's work on the same topic and same study area is specific to one area almost all researchers' gives attention to sub a menagesha national forest only [14].However, this study go further in detail to address the overall rate of deforestation acceleration change in the study area from the year 2000-2020. Finally the finding improved that deforestation acceleration change was indicated in a number of tables, graphs and Maps. Lastly, the research result leads to conclusion and recommendation.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1. Conclusion

This finding tries to give emphasis on using integrated techniques of GIS and RS for Deforestation assessment in welmera Woreda Oromia regional state start from data collection up to Final map generation. In order to explain quantitatively and qualitatively forest cover change using NDVI algorithm and image unsupervised classification techniques was used. And for deforested area map generation multi-criteria comparison and weighted overlay method were used including micro excel tables and graphs which used the value of data analysis result of attribute tables of each image data analysis. The study area is classified in to five major land use land cover types; Vegetation cover, Farmland, Urban area, and Barre land. From the analyzed results, the magnitude of land-use land cover in general and forest cover change in particular was observed between the year 2000, 2013 and 2020 in the study area. Particularly, expansion of Farm land and Urbanization which is the reason for decline of forest land area. In relation to this, currently, from overall condition of the forest cover land area is reduced from time to time. The findings indicated that from the total area of the Vegetation cover 21019.4ha in the year 2000, 19413.5ha in the year of 2013, 18431.9 ha in the year of 2020 respectively. There is high decrease of vegetation cover in hectares shown on table8 and figure 19, as the result indicates the difference between 2000 to 2013 is 1680.8ha and between 2013 - 2020 is 2662.4ha.it is easy to imagine that how the decreasing of forest land was decreased in many hectares in the thirteen and seven years totally 20years gaps. Yet, the rate of forest cover change between 2013 and 2020 is 2662.4ha show that more declining as compared with the first period gap change between 2000 to 2013 which is about 1680.8ha. The overall result of this finding improved that the continuation of rate of forest cover change or deforestation in welmera Woreda west shoa zone Oromia regional state.

5.2 Recommendation

From the whole study, GIS and RS are important tools for the activities of deforestation assessment and change detection. It had been recognized that the forest cover land in welmera

Woreda west shoa zone Oromia regional state area has declined; the rate was different in different period as already discussed in the finding. For future application of this tools for multi-purpose including deforestation assessment and change detection in general and to protect the forest resources of the study area from further depletion in particular, and to use these resources in a sustainable basis, the following feasible suggestions are forwarded based on the findings and the conclusions drawn.

- Classification and delineation of all areas into different land use categories using GIS and RS tools based on their ecological sustainability, potential for economic uses and social justice.
- To protect the forest resources from further destruction, to realize the impact of deforestation as well as how to use this resource with a sustainable manner, awareness creation campaigns especially for the farmers who are dwelling along the margin and inside the forest areas should be an indispensable phenomenon.
- Expanding farm land and cutting Trees for charcoal and etc. are known practice and even considered as tradition, but their impacts on biodiversity and local livelihood must be evaluated, and corrective measures should be taken to avoid further damages.
- Give priority to give awareness for society lives around the forest the importance of forest specially, the contribution of forest in keeping the whole climatic condition, and in the protection of soil erosion as well as land degradation.
- Suba menagesha forest potential is considered as one of remaining known forest in Ethiopia. More research should be carried out on deforestation assessment and forest cover change and forest degradation mapping using RS and GIS.
- So, this kind of research will benefit the forest cover change detection efficiently as well as in order to provide sound information to take appropriate measures to combat the problem of forest cover change or deforestation.

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APPENDEX A: LO7- 2000 METTA DATA

```
  LANDSAT_SCENE_ID = "LE71680542000036EDC00"
  SPACECRAFT_ID = "L7_ETM"
  WRS_PATH = 168
  WRS_ROW = 54
  MODE = "SLC_ON"
  FIRST_SCAN_DIRECTION = "R"
  NUMBER_OF_BANDS = 9
  BAND_LIST = (1, 2, 3, 4, 5, 61, 62, 7, 8)
END_GROUP = FILE_HEADER
GROUP = PROJECTION
  ELLIPSOID_AXES = (6378137.000000, 6356752.314200)
  MAP_PROJECTION = "UTM"
  PROJECTION_UNITS = "METERS"
  DATUM = "WGS84"
  ELLIPSOID = "WGS84"
  UTM_ZONE = 37
```

MAP_PROJECTION = "UTM"
DATUM = "WGS84"
ELLIPSOID = "WGS84"
UTM_ZONE = 37
GRID_CELL_SIZE_PANCHROMATIC = 15.00
GRID_CELL_SIZE_REFLECTIVE = 30.00
GRID_CELL_SIZE_THERMAL = 30.00
ORIENTATION = "NORTH_UP"
RESAMPLING_OPTION = "CUBIC_CONVOLUTION"
END_GROUP = PROJECTION_PARAMETERS
ORIGIN = "Image courtesy of the U.S. Geological Survey"
REQUEST_ID = "0501702123441_04627"
LANDSAT_SCENE_ID = "LE71690542000043SGS02"
LANDSAT_PRODUCT_ID = "LE07_L1TP_169054_20000212_20170213_01_T1"
COLLECTION_NUMBER = 01
FILE_DATE = 2017-02-13T13:10:57Z
STATION_ID = "SGS"
PROCESSING_SOFTWARE_VERSION = "LPGS_12.8.3"
DATA_CATEGORY = "NOMINAL"
END_GROUP = METADATA_FILE_INFO
GROUP = PRODUCT_METADATA
DATA_TYPE = "L1TP"
COLLECTION_CATEGORY = "T1"
ELEVATION_SOURCE = "GLS2000"
OUTPUT_FORMAT = "GEOTIFF"
EPHEMERIS_TYPE = "DEFINITIVE"
SPACECRAFT_ID = "LANDSAT_7"
SENSOR_ID = "ETM"

SENSOR_MODE = "SAM"

WRS_PATH = 169

WRS_ROW = 054

DATE_ACQUIRED = 2000-02-12

SCENE_CENTER_TIME = "07:39:18.4123975Z"

CORNER_UL_LAT_PRODUCT = 9.62351

CORNER_UL_LON_PRODUCT = 36.61183

CORNER_UR_LAT_PRODUCT = 9.63168

CORNER_UR_LON_PRODUCT = 38.74936

CORNER_LL_LAT_PRODUCT = 7.73108

CORNER_LL_LON_PRODUCT = 36.62377

CORNER_LR_LAT_PRODUCT = 7.73762

CORNER_LR_LON_PRODUCT = 38.75061

CORNER_UL_PROJECTION_X_PRODUCT = 237900.000

CORNER_UL_PROJECTION_Y_PRODUCT = 1064700.000

CORNER_UR_PROJECTION_X_PRODUCT = 472500.000

CORNER_UR_PROJECTION_Y_PRODUCT = 1064700.000

CORNER_LL_PROJECTION_X_PRODUCT = 237900.000

CORNER_LL_PROJECTION_Y_PRODUCT = 855300.000

CORNER_LR_PROJECTION_X_PRODUCT = 472500.000

CORNER_LR_PROJECTION_Y_PRODUCT = 855300.000

PANCHROMATIC_LINES = 13961

PANCHROMATIC_SAMPLES = 15641

REFLECTIVE_LINES = 6981

REFLECTIVE_SAMPLES = 7821

THERMAL_LINES = 6981

THERMAL_SAMPLES = 7821

FILE_NAME_BAND_1 = "LE07_L1TP_169054_20000212_20170213_01_T1_B1.TIF"

FILE_NAME_BAND_2 = "LE07_L1TP_169054_20000212_20170213_01_T1_B2.TIF"

FILE_NAME_BAND_3 = "LE07_L1TP_169054_20000212_20170213_01_T1_B3.TIF"

FILE_NAME_BAND_4 = "LE07_L1TP_169054_20000212_20170213_01_T1_B4.TIF"

FILE_NAME_BAND_5 = "LE07_L1TP_169054_20000212_20170213_01_T1_B5.TIF"

FILE_NAME_BAND_6_VCID_1 = "LE07_L1TP_169054_20000212_20170213_01_T1_B6_VCID_1.TIF"

FILE_NAME_BAND_6_VCID_2 = "LE07_L1TP_169054_20000212_20170213_01_T1_B6_VCID_2.TIF"

FILE_NAME_BAND_7 = "LE07_L1TP_169054_20000212_20170213_01_T1_B7.TIF"

FILE_NAME_BAND_8 = "LE07_L1TP_169054_20000212_20170213_01_T1_B8.TIF"

FILE_NAME_BAND_QUALITY = "LE07_L1TP_169054_20000212_20170213_01_T1_BQA.TIF"

GROUND_CONTROL_POINT_FILE_NAME = "LE07_L1TP_169054_20000212_20170213_01_T1_GCP.txt"

ANGLE_COEFFICIENT_FILE_NAME = "LE07_L1TP_169054_20000212_20170213_01_T1_ANG.txt"

METADATA_FILE_NAME = "LE07_L1TP_169054_20000212_20170213_01_T1_MTL.txt"

CPF_NAME = "LE07CPF_20000101_20000331_01.02"

END_GROUP = PRODUCT_METADATA

GROUP = IMAGE_ATTRIBUTES

CLOUD_COVER = 0.00

CLOUD_COVER_LAND = 0.00

IMAGE_QUALITY = 9

SUN_AZIMUTH = 125.90163504

SUN_ELEVATION = 51.79916296

EARTH_SUN_DISTANCE = 0.9870740

SATURATION_BAND_1 = "Y"

SATURATION_BAND_2 = "Y"

SATURATION_BAND_3 = "Y"

SATURATION_BAND_4 = "N"

SATURATION_BAND_5 = "Y"

SATURATION_BAND_6_VCID_1 = "Y"

SATURATION_BAND_6_VCID_2 = "Y"

SATURATION_BAND_7 = "Y"

SATURATION_BAND_8 = "N"

APPENDEX B: LO8-2013 METTA DATA

ORIGIN = "Image courtesy of the U.S. Geological Survey"

REQUEST_ID = "0501704288949_00035"

LANDSAT_SCENE_ID = "LC81680542013335LGN01"

LANDSAT_PRODUCT_ID = "LC08_L1TP_168054_20131201_20170428_01_T1"

COLLECTION_NUMBER = 01

FILE_DATE = 2017-04-28T06:58:39Z

STATION_ID = "LGN"

PROCESSING_SOFTWARE_VERSION = "LPGS_2.7.0"

END_GROUP = METADATA_FILE_INFO

GROUP = PRODUCT_METADATA

DATA_TYPE = "L1TP"

COLLECTION_CATEGORY = "T1"

ELEVATION_SOURCE = "GLS2000"

OUTPUT_FORMAT = "GEOTIFF"

SPACECRAFT_ID = "LANDSAT_8"

SENSOR_ID = "OLI_TIRS"

WRS_PATH = 168

WRS_ROW = 54

NADIR_OFFNADIR = "NADIR"

TARGET_WRS_PATH = 168

TARGET_WRS_ROW = 54

DATE_ACQUIRED = 2013-12-01

SCENE_CENTER_TIME = "07:42:01.0620680Z"

CORNER_UL_LAT_PRODUCT = 9.72309

CORNER_UL_LON_PRODUCT = 38.20230

CORNER_UR_LAT_PRODUCT = 9.72165

CORNER_UR_LON_PRODUCT = 40.27534

CORNER_LL_LAT_PRODUCT = 7.62299

CORNER_LL_LON_PRODUCT = 38.20672

CORNER_LR_LAT_PRODUCT = 7.62186

CORNER_LR_LON_PRODUCT = 40.26828

CORNER_UL_PROJECTION_X_PRODUCT = 412500.000

CORNER_UL_PROJECTION_Y_PRODUCT = 1074900.000

CORNER_UR_PROJECTION_X_PRODUCT = 639900.000

CORNER_UR_PROJECTION_Y_PRODUCT = 1074900.000

CORNER_LL_PROJECTION_X_PRODUCT = 412500.000

CORNER_LL_PROJECTION_Y_PRODUCT = 842700.000

CORNER_LR_PROJECTION_X_PRODUCT = 639900.000

CORNER_LR_PROJECTION_Y_PRODUCT = 842700.000

PANCHROMATIC_LINES = 15481

PANCHROMATIC_SAMPLES = 15161

REFLECTIVE_LINES = 7741

REFLECTIVE_SAMPLES = 7581

THERMAL_LINES = 7741

THERMAL_SAMPLES = 7581

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FILE_NAME_BAND_3 = "LC08_L1TP_168054_20131201_20170428_01_T1_B3.TIF"

FILE_NAME_BAND_4 = "LC08_L1TP_168054_20131201_20170428_01_T1_B4.TIF"

FILE_NAME_BAND_5 = "LC08_L1TP_168054_20131201_20170428_01_T1_B5.TIF"

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FILE_NAME_BAND_7 = "LC08_L1TP_168054_20131201_20170428_01_T1_B7.TIF"

FILE_NAME_BAND_8 = "LC08_L1TP_168054_20131201_20170428_01_T1_B8.TIF"

FILE_NAME_BAND_9 = "LC08_L1TP_168054_20131201_20170428_01_T1_B9.TIF"

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FILE_NAME_BAND_11 = "LC08_L1TP_168054_20131201_20170428_01_T1_B11.TIF"

FILE_NAME_BAND_QUALITY = "LC08_L1TP_168054_20131201_20170428_01_T1_BQA.TIF"

ANGLE_COEFFICIENT_FILE_NAME = "LC08_L1TP_168054_20131201_20170428_01_T1_ANG.txt"

METADATA_FILE_NAME = "LC08_L1TP_168054_20131201_20170428_01_T1_MTL.txt"

CPF_NAME = "LC08CPF_20131026_20131231_01.01"

BPF_NAME_OLI = "LO8BPF20131201072729_20131201081342.01"

BPF_NAME_TIRS = "LT8BPF20131201072335_20131201081435.01"

RLUT_FILE_NAME = "LC08RLUT_20130211_20150302_01_11.h5"

END_GROUP = PRODUCT_METADATA

GROUP = IMAGE_ATTRIBUTES

CLOUD_COVER = 0.01

CLOUD_COVER_LAND = 0.01

IMAGE_QUALITY_OLI = 9

IMAGE_QUALITY_TIRS = 9

TIRS_SSM_MODEL = "ACTUAL"

TIRS_SSM_POSITION_STATUS = "NOMINAL"

TIRS_STRAY_LIGHT_CORRECTION_SOURCE = "TIRS"

ROLL_ANGLE = -0.001

SUN_AZIMUTH = 144.43563458

SUN_ELEVATION = 52.33209137

EARTH_SUN_DISTANCE = 0.9860855

SATURATION_BAND_1 = "N"

SATURATION_BAND_2 = "N"

SATURATION_BAND_3 = "N"

SATURATION_BAND_4 = "N"

SATURATION_BAND_5 = "N"

SATURATION_BAND_6 = "Y"

SATURATION_BAND_7 = "Y"

SATURATION_BAND_8 = "N"

SATURATION_BAND_9 = "N"

APPENDEX C: LO8-2020 METTA DATA

ORIGIN = "Image courtesy of the U.S. Geological Survey"

REQUEST_ID = "0702003135513_00005"

LANDSAT_SCENE_ID = "LC81690542020058LGN00"

LANDSAT_PRODUCT_ID = "LC08_L1TP_169054_20200227_20200313_01_T1"

COLLECTION_NUMBER = 01

FILE_DATE = 2020-03-13T17:51:34Z

STATION_ID = "LGN"

PROCESSING_SOFTWARE_VERSION = "LPGS_13.1.0"

END_GROUP = METADATA_FILE_INFO

GROUP = PRODUCT_METADATA

DATA_TYPE = "L1TP"

COLLECTION_CATEGORY = "T1"

ELEVATION_SOURCE = "GLS2000"

OUTPUT_FORMAT = "GEOTIFF"

SPACECRAFT_ID = "LANDSAT_8"

SENSOR_ID = "OLI_TIRS"

WRS_PATH = 169

WRS_ROW = 54

NADIR_OFFNADIR = "NADIR"

TARGET_WRS_PATH = 169

TARGET_WRS_ROW = 54

DATE_ACQUIRED = 2020-02-27

SCENE_CENTER_TIME = "07:46:33.1827010Z"

CORNER_UL_LAT_PRODUCT = 9.72152

CORNER_UL_LON_PRODUCT = 36.67126

CORNER_UR_LAT_PRODUCT = 9.72936

CORNER_UR_LON_PRODUCT = 38.74928

CORNER_LL_LAT_PRODUCT = 7.61753

CORNER_LL_LON_PRODUCT = 36.68419

CORNER_LR_LAT_PRODUCT = 7.62365

CORNER_LR_LON_PRODUCT = 38.75068

CORNER_UL_PROJECTION_X_PRODUCT = 244500.000

CORNER_UL_PROJECTION_Y_PRODUCT = 1075500.000

CORNER_UR_PROJECTION_X_PRODUCT = 472500.000

CORNER_UR_PROJECTION_Y_PRODUCT = 1075500.000

CORNER_LL_PROJECTION_X_PRODUCT = 244500.000

CORNER_LL_PROJECTION_Y_PRODUCT = 842700.000

CORNER_LR_PROJECTION_X_PRODUCT = 472500.000

CORNER_LR_PROJECTION_Y_PRODUCT = 842700.000

PANCHROMATIC_LINES = 15521

PANCHROMATIC_SAMPLES = 15201

REFLECTIVE_LINES = 7761

REFLECTIVE_SAMPLES = 7601

THERMAL_LINES = 7761

THERMAL_SAMPLES = 7601

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FILE_NAME_BAND_2 = "LC08_L1TP_169054_20200227_20200313_01_T1_B2.TIF"

FILE_NAME_BAND_3 = "LC08_L1TP_169054_20200227_20200313_01_T1_B3.TIF"

FILE_NAME_BAND_4 = "LC08_L1TP_169054_20200227_20200313_01_T1_B4.TIF"

FILE_NAME_BAND_5 = "LC08_L1TP_169054_20200227_20200313_01_T1_B5.TIF"

FILE_NAME_BAND_6 = "LC08_L1TP_169054_20200227_20200313_01_T1_B6.TIF"

FILE_NAME_BAND_7 = "LC08_L1TP_169054_20200227_20200313_01_T1_B7.TIF"

FILE_NAME_BAND_8 = "LC08_L1TP_169054_20200227_20200313_01_T1_B8.TIF"

FILE_NAME_BAND_9 = "LC08_L1TP_169054_20200227_20200313_01_T1_B9.TIF"

FILE_NAME_BAND_10 = "LC08_L1TP_169054_20200227_20200313_01_T1_B10.TIF"

FILE_NAME_BAND_11 = "LC08_L1TP_169054_20200227_20200313_01_T1_B11.TIF"

FILE_NAME_BAND_QUALITY = "LC08_L1TP_169054_20200227_20200313_01_T1_BQA.TIF"

ANGLE_COEFFICIENT_FILE_NAME = "LC08_L1TP_169054_20200227_20200313_01_T1_ANG.txt"

METADATA_FILE_NAME = "LC08_L1TP_169054_20200227_20200313_01_T1_MTL.txt"

CPF_NAME = "LC08CPF_20200101_20200331_01.04"

BPF_NAME_OLI = "LO8BPF20200227072712_20200227090740.01"

BPF_NAME_TIRS = "LT8BPF20200223110021_20200310034739.01"

RLUT_FILE_NAME = "LC08RLUT_20150303_20431231_01_12.h5"

END_GROUP = PRODUCT_METADATA

GROUP = IMAGE_ATTRIBUTES

CLOUD_COVER = 0.06

CLOUD_COVER_LAND = 0.06

IMAGE_QUALITY_OLI = 9

IMAGE_QUALITY_TIRS = 9

TIRS_SSM_MODEL = "FINAL"

TIRS_SSM_POSITION_STATUS = "ESTIMATED"

TIRS_STRAY_LIGHT_CORRECTION_SOURCE = "TIRS"

ROLL_ANGLE = -0.001

SUN_AZIMUTH = 120.11394674

SUN_ELEVATION = 56.50909666

EARTH_SUN_DISTANCE = 0.9902131

SATURATION_BAND_1 = "Y"

SATURATION_BAND_2 = "Y"

SATURATION_BAND_3 = "Y"

SATURATION_BAND_4 = "Y"

SATURATION_BAND_5 = "Y"

SATURATION_BAND_6 = "Y"

SATURATION_BAND_7 = "Y"

SATURATION_BAND_8 = "N"

SATURATION_BAND_9 = "N"