ASSESSMENT OF FOREST COVER CHANGE IN THE CENTRAL HIGHLANDS OF

ETHIOPIA: THE CASE OF WALMARA WEREDA: CENTERAL OROMIA: ETHIOPIA

Deforestation in Walmara Woreda

Afforestation in Walmara Woreda

M.Sc. THESIS

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ASSESSMENT OF FOREST COVER DYNAMICS IN THE CENTRAL HIGHLANDS OF ETHIOPIA: THE CASE OF WALMARA WEREDA: CENTERAL OROMIA: ETHIOPIA

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A THESIS SUBMITTED TO THE SCHOOL OF FORESTRY, WONDO GENET COLLEGE

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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

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APPROVAL SHEET I

This is to certify that the thesis entitled "***Assessing Forest Cover Dynamics in the Central Highlands of Ethiopia: The Case of Walmara Wereda: South West Shewa: Central Oromia: Ethiopia (1985-2017)***" submitted in partial fulfillment of the requirement for the degree of master's with specialization in Forest Resource Assessment And Monitoring, the graduate program of school of forestry, and has been carried out by Tokuma Urgessa Gondore Id.No MSc/FRAM/R007/09, under my supervision. Therefore, I recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the department.

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Name of graduate coordinator	Signature	Date

APPROVAL SHEET II

We the undersigned members of the board of examiners of the final open defense by Tokuma Urgessa have read and evaluated his thesis entitled ***"Assessment of Forest Cover Dynamics in the Central Highlands of Ethiopia: The Case of Walmara Woreda: South West Shewa: Central Oromia: Ethiopia (1985-2017)"*** and examined the candidate. Accordingly, this is to certify that the thesis has been accepted in partial fulfillment of the requirement for the degree of Masters of Science.

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DECLARATION

I hereby declare that this thesis entitled **"*Assessment of Forest Cover Dynamics in the Central Highlands of Ethiopia: The Case of Welmera Wereda: South West Shewa: Central Oromia: Ethiopia (1985-2017)*"** submitted to the school of forestry is my original work and any work taken from other authors is duly acknowledged within the text and references chapter. It is my own responsibility to declare that it has not been previously submitted or accepted for the award of any degree of the university or institutions.

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June, 2018

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Abstract

In Ethiopia, forest cover changes were registered at local level that adds up to the changes observed at the national level. The rapid advance of deforestation over recent decades has resulted in the conversion of the majority of the Walmara woreda's forest in isolated patches, endangering not only their continuity but the biodiversity within them. Geographic information system (GIS) techniques and remote sensing (RS) from satellite platforms offer a best way to identify forest cover change. The main objectives of the study were to examine and map the trends and extents of the forest cover changes and to identify the possible proximate causes during the study periods. To attain the objectives both social survey data and remote sensing and GIS techniques were utilized. Socioeconomic data collection in form of Household and key informant interview was used in disclosing the major driving forces of the change. Quantum GIS and SPSS 16.0 are respectively used for the analysis of the spatial and temporal forest cover change and the socioeconomic data. A supervised image classification technique with Maximum likelihood classification algorism was applied on Landsat 5, 7 and 8 satellite images of 1985, 2000 and 2017. Six main land use land cover classes namely, Agriculture, Forest, Cropland, Grassland, Settlements and Water body were identified. The results showed that the area of Forest, Grass Land, Crop Land, Waterbody, Wet Land and Settlement in year 1985 forest cover of the woreda showed an area augmentation with 1719ha while non-forest experienced with area downfall with 1719ha in period I. In contrast to period I, area boost of non-forest and area shrinkage to forest cover were identified. Due to the area increment of settlement and agricultural land were registered at the outgoings of forest land of the woreda, it is recommended that Implementing effective Strategies to reduce deforestation should be launched in the study area to protect and conserve this forest from further deforestation.

Key words

Walmara wereda, Landsat, QGIS, major driving force, supervised classification.

1. INTRODUCTION

1.1 Background

Accurate and up-to-date information on the extent of the world's forests, and the way they are changing is becoming an important issue than ever before (Freeman III, *et.al*, 2014). There were significant global historical changes in forest cover between 1700 and 1990 when the area of cropland expanded from about 3.5 million km^2 to some 16.5 million km^2 (Lambin & Geist, 2006). Much of this expansion occurred at the expense of forests which has decreased from about 53 million km^2 to 43.5 million km^2 (Gidey, *et.al*, 2017).

The world's forests are critical for human livelihoods. Increasingly they are being recognized for the wide range of products and essential ecosystem services they provide (Hecht and Cockburn, 2010). Holdren (2008) stated that, forest ecosystems around the world are immeasurably important. Forests and the benefits they provide in the form of wood, food, income, and watershed protection have an important and critical role in enabling people to secure a stable and adequate food supply (Rasmussen, *et.al*, 2017). Further, they provide ecosystem services that are critical to human welfare which may in compose absorbent of harmful greenhouse gasses that produce climate change.

The Ethiopian people used trees for lumber, for construction, and to fuel their cooking fires. Forests are also important in Ethiopian religious beliefs; the people believed in holy spirits in the forest that they treat in the same way as human beings (Aderibigbe, 2015). Besides providing habitats for animals and livelihoods for humans, forests also offer watershed protection, prevent soil erosion and mitigate climate change (El Tahir, 2015).

According to WWF (2016), in tropical forests alone, a quarter of a trillion tons of carbon is stored in above and below ground biomass, providing clean water for drinking, bathing, and other household needs. Moreover, the forest provides protecting watersheds and reducing or slowing the amount of erosion and chemicals that reach waterways, providing food and medicine, serving as a buffer in natural disasters like flood and rainfalls, providing habitat for more than half of the world's land-based species (FAO, 2011).

The rapid advance of deforestation over recent decades has resulted in the conversion of the majority of the world's forest in isolated patches, endangering not only their continuity but the biodiversity within them (Ponte *et.al*, 2015). As it is demonstrated by Tadesse *et.al* (2014), that due to population growth and dependency on agriculture in sub-Saharan Africa, deforestation practices have been intensified across the region (Tadesse *et.al*, 2014). Most of the registered LULC changes were the result of the practices done to satisfy the immediate needs of human being (Sherbinin, 2002).

In Ethiopia, forest cover changes were registered at local level that adds up to the changes observed at the national level. Most of these changes were from the natural forest to other non-vegetative land uses in which settlement and agricultural land are the most common and was due to human intervention (Woldeamlak, 2002; Daniel, 2008). These rapid forest cover changes in Ethiopia exert detrimental and adverse impacts on the environment and livelihood. Holdren; (2008) elaborated that historically, forests have been very important for the livelihoods of the people of Ethiopia.

In Ethiopia, deforestation for farmland and other purposes which in turn brings soil erosion and soil degradation is emanated from population pressure (Gebretsadik, 2016). This is because of natural forests are the main sources of wood for fuel and construction materials in the country.

Ethiopia is at a crossroad and need to improve its biophysical resources in order to feed its growing population.

Deforestation and the resulting environmental degradation are a common problem in Ethiopia and a key factor challenging food security, community livelihood and sustainable development

According to Ofcansky & LaVerle (1991) between 1955 and 1979, over 77 percent of Ethiopian forested area disappeared and it continues to lose 8 percent or 140,000 hectares of its remaining forests annually. Despite the importance of the forest economy to subsistence livelihoods through the provision of timber, fruit, honey and bush meat products. In the central part of the country different factors like deforestation, over-harvesting, illegal cutting, overgrazing, settlement and permanent conversion to other forms of land use are leading to shrinkage of forest resources.

The natural Forest resource of the country; specifically Walmara woreda forest is under serious threat from deforestation, illegal cutting, land degradation, urbanization, overexploitation, overgrazing, shifting cultivation, habitat loss and invasive species (EPA, 1997). As a result of these threats, the trend in the conservation status of a forest resource including some other associated natural resource is declining by an alarming rate.

Teketay (2005), argues that the montane forests are specifically highly disturbed by wind throws, natural and human-made fires, landslides, grazing, tree felling and clearing for cultivation. Although welmera wereda contain Menagesha Suba State Forest as a patch of forest, which is one of the few remaining Forests in central Ethiopia, has received long years of attention and protection, which goes back to the 1600s (Zewdie, 2007) forest threat in the woreda is considerable yet including the protected areas.

Some reports, for instance Lemenih (2009) and Haile et al., (2009), reported that Menagesha

Suba State Forest is highly subjected to exploitation by local community around the forest this includes non-timber forest products (NTFPs) for home consumption and for markets. (Teketay 2005), stated that, the Ethiopian government state and the farmer over forest land and the inability of the coercive state to enforce its own regulations led to the massive and often haphazard destructions of natural forest. On reconsideration a major weakness of past forest policy for instance FDRE, Forest proclamation No. 542/2007 and Forest development, conservation and utilization proclamation, *Federal Negarit Gazeta*, pp. 3812-3828. Addis Ababa.

1.2 Statement of Problem

In developing countries, including Ethiopia, forest cover change is challenging food security, community livelihood and sustainable development, since 94% of the population relies on wood-based and biomass fuel for household energy (Bishaw, 2001). The Montane forests are highly disturbed by wind throws, natural and human-made fires, landslides, grazing, tree felling illegal cutting and clearing for cultivation (Teketay, 2005). The state forestry sector has not been able to protect the natural forest which has been designed as priority areas and there has been a constant threat of encroachment from land-hungry neighboring framers claiming a residual right in these forests (Teketay, 2005).

The absence of regular forest assessments at national level has limited the availability of up-to dated information on the dynamics and extent of forest cover change.

The most current and relatively detailed assessments of deforestation and degradation are therefore limited to specific forest areas connected to development projects on forest management and conservation, or those forests considered for academic.

Despite the woreda's frequent forest cover change, there is no empirical and consistently updated information about the trend and current forest cover change of the wereda and the major driving forces to the forest cover and the rate of change also remain hidden too. Thus, this study is designed to contribute to bridge the information gap on the extent of forest cover change and its driving forces important for resource use policy and decision making.

1.3 Objective of the Study

1.3.1 General Objective

To examine and understand the trends and the major drivers of forest cover dynamics of Walmara woreda.

1.3.2 Specific Objectives

1. To examine and map the trends and extents of forest cover dynamics in the study area and show the current status of woreda's land cover land uses.
2. To identify the major proximate and drivers of the forest cover dynamics in the Walmara woreda.

1.4 Research Questions

1. What is the trend, extent and the current status of the forest cover dynamics of Walmara woreda.
2. What are the major proximate and underlying driving force to Walmara Wereda forest cover dynamics?

1.5 Significance of the Study

The importance of investigating forest cover dynamics as a baseline requirement for sustainable management of natural resources such as forest and other associated land use has been highlighted by many researchers involved in global change studies. It is arguable that a more focused management intervention requires information on the rates and impacts of forest cover changes as well as the distribution of these changes in space and over time.

Therefore, this study contributes to generate important information on forest cover dynamics of the Walmara Woreda which will be an input for policy makers and practitioners in designing, developing and implementing relevant sustainable land use practices. The study was carried out for academic purpose, and mainly focused on Walmara woreda in the Oromia National Regional State, Ethiopia. But, the findings of the study will contribute for detail understanding of the spatial and temporal analysis of forest cover dynamics and other major land cover land use changes and the major driving forces in Walmara woreda and the finding of the study may also give some clues concerning the forest cover dynamics and its major driving forces that occur in the past and an present across the region and the country in general. It adds an awareness that has been undergoing on the patterns and rate of forest cover dynamics.

1.6 Scope and Limitation of the Study

The study has spatial, temporal and analytical scopes. Spatially, this study was limited and undertaken in Walmara woreda, west Shewa zone of Oromia Regional State. In spite of this, the study is not free from limitation, specifically arising from satellite imagery source of data extraction problems like, it's resolution capability. Though the highest quality image resolution was not used for this study because of its expensiveness different data confirmation and validation methods were employed to reduce the limitations of this study to some extent.

2. LITERATURE REVIEW

2.1 Forest Resources of Ethiopia

Forest is curtailing renewable natural resources and has an imperative role in preserving an environment suitable for human life (Baral, 2004).

Dependency on firewood for cooking and heating house, fodder collection, grazing and traditionally practiced for livestock are some of rural people's dependency on the forest. In Ethiopia, forestry activities are closely related to the needs and survival of rural people. As the ministry of Enviroment, forest and climate change of Ethiopia/MEFCC/(2015) defined that, forest is land spanning at least 0.5ha covered by trees (including bamboo) attaining a height of at least 2m and a canopy cover of at least 20% or trees with the potential to reach these thresholds in situ in due course. This forest definition is in the light of the varied forest types and potential of carbon stocks in the country, the national capacity for measuring, reporting and verification (MRV) and the need for engaging local communities and benefit from forest carbon incentives. The reason for Ethiopia to change its national forest definition is to give a credit and capture dry and lowland-moist vegetation resources as forest part.

Hence, lowering the tree height from 5 to 2 m is to capture *Combretum-Terminalia and* dense woodlands found in Gambella and Benishangul Gumuz Regional States and the reason for increasing the canopy cover threshold from 20 to 10% is to avoid acceptance of highly degraded forest lands into the forest definition. The proposed change in the forest definition results in the inclusion of what previously was classified as Ethiopia's dense woodlands which have a widespread distribution through the country.

Based on the newly adopted national forest definition 13, 284 ha of Oromia's rural and semirural Wereda's include some forest. In this study the country wise of forest definition is considerable.

Data on the forest resources of Ethiopia reported in FAO (2010) puts Ethiopia among countries with forest cover of 10-30%. According to this report, Ethiopia's forest cover (FAO 2010 definition) is 12.2 million ha (11%), clearly underestimated compared to the IPCC definition. High forests, either coniferous or broad-leaved, where the climax vegetation of 35-40% of

Ethiopia before human settlement took place. With the inclusion of savanna woodlands, some 66% of the country was originally covered with forest or woodlands (Yirdaw, 1996). Further estimates of the distribution of forest and woodland areas made on the basis of information from LANDSAT image of 1979 revealed that 2.8% of the land surface are under forest and woodland (MOA, 1991).

However, because of deforestation, much of the highlands, typically dry mountain forest at present are covered with wooded grasslands in which secondary tree species like *Acacia abyssinica, Acacia negrii, and Acacia pilispina* occur (Friis, 1992). High forests in these Woredas have been identified and efforts are being made to conserve, protect and manage these resources on a sustain yield bases.

However, at present, accessible Dry Mountain forest of the woreda areas is exposed to the various local pressures, including illegal cutting, human settlement, grazing, and logging operations and agricultural land expansion (MOA, 1991).

Several proximate and underlying driving forces such as human population, agriculture, livestock, economic growth and other factors which have a complex and dynamic relationship with the forest resources (FAO, 1999) are responsible to accelerate the deforestation and forest degradation (Kandel, 2004) of the wereda and the region too.

2.2 Forest cover Dynamics in Ethiopia

Forest cover dynamics are defined as the change in the shape and structure of a forest, related to its underlying physical and biological forces (Pretzsch, 2009). For forest cover dynamics, two main elements are recognized: forest disturbance and forest succession. Forest disturbances are caused by changes induced primarily by fire, flood, human influence (logging), and diseases, whereas forest succession is characterized by the recovery of the vegetation after a disturbance event either through plantation or regeneration (GOFC, 2010). The physical component and the disturbances that are destructive or negative and positive, for the overall forest ecosystem will be the concern of this study.

According to FRA (2005), information on dynamics to the forest area was limited to the calculation of net area changes per year, based on information provided for the desired periods. The model used to illustrate forest change dynamics has two classes: forest land use and all other non-forested land uses, which may include the rest land uses excluding forest.

2.2.1 Deforestation

Deforestation and consequent land degradation are global menaces, and so are they in Ethiopia. According to FAO, (2007) deforestation has been defined as the decrease of the tree canopy below 10% boundary, due to the conversion of forests to other land use such as farms, ranches, mines, or urban sites other than forest. The world’s forests have continued to be converted to other land uses at a very high rate and deforestation of tropical forests is almost 1 per cent per year (FAO (2007). Ethiopia is one of the sub-Saharan African countries where forest destruction and land degradation severely affects socioeconomic development.

Based on historical evidences Gebremarkos (1998), indicated that "a few hundred years ago more than 63% of the total land mass of Ethiopia was covered by dense forests, but it is not greater than 3% now." hence, high and extended rate of deforestation and forest degradation coupled with rapid population growth, as a result brought the forest cover that was estimated to be 40% in 1900 to 16% in 1954, 8% in 1961, 4% in 1975, 3.2% in 1980 (Amogne, 2014). Alebign, (2015), indicates that at the beginning of the twentieth century around 420,000 square kilometers (35% of Ethiopia's land) was covered by trees but recent research indicates that forest cover is now less than 14.2% due to population growth. Despite the growing need for forested lands, lack of awareness among local people has led to a continuing decline of forested areas. However, recent disclosed unpublished MEFCC reports claim that, the Ethiopian forest cover has reached about 15%.

The situation got more severe in the past two to three decades when large numbers of people moved to central Ethiopia, in which welmera wereda is among in the scope of illegal settlement which leads to urbanization programs and logging is the major problem.

Consequently, the pressure on the forest resources themselves increased due to a higher demand for firewood and construction, timber including agricultural expansion and medium and small-scale investment. Large-scale destruction of forest resources is not the only change that has taken place at the national level rather the cumulative insignificant forest cover change happened at the local level. In the entire country, much of the forest increase was due to the conversion of grasslands and croplands into forest lands. A total of about 5.5 million ha of grassland and about 2.4 million ha of cropland has been changed into forest land between 2003 and 2008 (FAO, 2007).

During the same period, FAO (2007) described that, the dynamics show that a total of about 3.3 million ha of forest land was changed into grassland and another 1.9 million ha of forest land was changed into cropland.

The net change in forest area is thus the sum of all negative changes due to deforestation and natural disasters and all positive changes due to afforestation and natural expansion of forests. According to FRA (2010), it is proposed to include estimates of each of the following elements of forest changes: deforestation (due to human intervention and natural disasters), afforestation and natural expansion of forests.

Forest degradation results in soil erosion, decreased agricultural production, increased household expenditure time to buy forests and land degradation (Ginjo, 2000).

A reduction in forest area can happen through either of two processes. According to the Millennium assessment Report (2005), Deforestation, which is by far the most important, implies that forests are cleared by people and the land converted to another non forest land use, such as agriculture or infrastructure. Natural disasters may also destroy forests, and when the area is incapable of regenerating naturally and no efforts are made to replant it, it too reverts to another land. Where part of a forest is cut down but replanted (reforestation), or where the forest grows back on its own within a relatively short period of time (natural regeneration), there is no net change in forest area.

Deforestation is a complex process that is driven by a combination of proximate and underlying causes, which can vary from region to region (Rudel *et al*., 2005).

Reducing deforestation has become an issue of global importance, not only for environmental conservation, but also for climate change mitigation.

The United Nations' program on Reducing Emissions from Deforestation and Forest Degradation in developing countries (REDD) is being intensively discussed as a key framework in international conventions on climate change (Geist and Lambin, 2002). Stern (2006) suggested that if the right policies and institutional structures were in place, preventing further deforestation would be cheaper than other types of mitigation strategies for greenhouse gas emissions. However, the issues surrounding deforestation in developing countries are not easily resolved. In Ethiopia, accelerated deforestation has taken place since the beginning of the 20^{th} century (EFAP, 1993).

Alemu and Kidane (2014) agreed that although the forests were thought to have covered nearly 40% of the country’s total area at the beginning of the 20^{th} century, forest cover today is estimated at only 9%. The rate of deforestation is calculated to be between 150,000 and 200,000 ha per annum (EFAP, 1993).

According to Molla *et al*. (2010), estimates of original forest cover and deforestation rates differ greatly because information is derived mostly from indirect sources (e.g., travelers’ accounts) and less often, if at all, from quantitative studies where forest cover is measured at different time intervals. But the general consensus is that the scale of forest clearance in Ethiopia has been massive (Bewket, 2002). Furthermore Molla *et al.*, (2010), demonstrated that continuous removal of natural land cover (i.e., vegetation) has occurred in the mountain landscape in which the Walmara woreda is among and known for its some mountainous patches of forest. As a result, a large portion of the forest and woodland and significant proportions of shrubland and riverine vegetation cover were removed.

Although the threat to forest cover change by humans to obtain livelihoods and other essentials have been there for thousands' of years, the extent and intensity of forest cover change are far greater by now than it was in the past. As it has been described by FAO (2007), global land cover today altered principally by direct human use, by agriculture, livestock raising, forest harvesting and management and urban and urban construction development. There are also incident impacts of land cover on form other human activities such as forest and lake damaged by acid rainfall from fossil fuel combustion and crop near cities damaged by troposphere ozone resulting from out mobile exhaust (Meyer, 1995). The importance of investigating forest cover dynamics as a baseline requirement for sustainable management of natural resources such as forest and other associated land use has been highlighted by many researchers involved in global change studies (Read *et al*., 2002).

These scientists have argued that a more focused management intervention requires information on the rates and impacts of forest cover changes as well as the distribution of these changes in space and over time (UNEP, 2001). According to UNEP (2001), the number of people dependent on agriculture is rising, mostly by encroaching upon a forest area. Especially the area near to urban such as Walmara woreda forest is subject to numerous pressures in which agricultural expansion, and illegal wood extraction and settlement are among. One of the major challenges faced by the country is to ensure the sustainable conservation of the forest resources, including the priority areas and state forests and controlling the population increment in parallel. In recent years, satellite remote sensing techniques have been developed, which has proved to be of immense value in preparing an accurate forest cover and monitoring changes at a regular interval of time. In case of inaccessible regions, these techniques, perhaps the only method of obtaining the required data on cost and time effective basis.

Understanding the drivers of deforestation and degradation is fundamental for the development of policies and measures Content of this work may be used under the terms that aim to alter current trends in forest activities toward a more climate and biodiversity friendly outcome.

Causes of deforestation are the forces that motivate the agents to clear the forests. However, most of the existing literature typically distinguishes between two levels of specific factors: direct and indirect /underlying causes of deforestation.

There are different activities that may be considered as direct or proximate cause of forest cover change of tropical countries typically Ethiopia. At the proximate level, tropical deforestation is best explained by multiple factors rather than by single variables.

As it has been discovered by Expansion of agricultural land, Logging and fuelwood, Overgrazing, Fires, Mining, and Urbanization/industrialization, is among many. Proximate causes are human activities or immediate actions at the local level, such as agricultural expansion, that originates from intended land use and directly impacts forest cover. Proximate or direct drivers of deforestation are human activities that directly affect the loss of forests and thus constitute proximate sources of change, that result from complex interactions of underlying forces in social, political, economic, technological and cultural domains.

Obersteiner *et al*., (2009), demonstrated that underlying driving forces are fundamental social processes, such as human population dynamics or agricultural policies that underpin the proximate causes and either operate at the local level or have an indirect impact from the national or global level. Namely, Colonialism, Exploitation by industrialized countries, Overpopulation and poverty, Transmigration and Colonization schemes, Land rights, Land tenure and Inequitable land distribution and resources are among many indirect driving forces.

Likewise welmera forest cover dynamics and other LULCC in the wereda is also as a result of both proximate and underlying causative drivers.

2.2.2. Plantation (Planted Forest and Regeneration)

The pressure on the world's forests to deliver economic, social, and environmental services has reached unsustainable levels in many places. In many regions, this loss of natural forests has been offset somewhat by a rapid increase in the amount of forest land being allocated to plantations (FAO 2006).

To strike the balance between two interests, the need for forest resource for multiple uses and the protection of the forest, plantation is very important. There is a global trend towards greater reliance on plantations as a source of industrial wood.

FAO (2001) stated that, the development of a significant global plantation estate is quite recent; half of all plantations in the world are less than 15 years old. Asia has led plantation establishment globally; as of 2000, about 62 percent of all forest plantations (FAO, 2001). Plantations are even-aged forest stands deliberately established by humans on formerly nonforested lands or deforested lands (FAO, 1993).

Ethiopia has a long history of tree planting activities. According to historical records, plantation started in the early 1400s by the order of King Zera-Yakob (WBISPP, 2005). Over 15% of the world's wood production comes from plantations, which comprise less than 5% of forested lands (Carnus *et al*., 2006). Plantations forest can pay its contribution in the conversion of degraded lands to a forested ecosystem through the modification of physical and biological site conditions.

Modern tree planting using introduced tree species, mainly Australian *Eucalyptus* started in 1895 when Emperor Minilik II (1888-1892) looked into solutions for alleviating shortage of firewood and construction wood in the capital, Addis Ababa.

During the early 1900s, most of Addis Ababa was reportedly covered by forests; in 1964, eucalyptus Plantations covered about 13,500ha (FAO, 1985).

The historic rapid expansion of large scale and community plantations occurred during the Dergue regime resulted in the establishment of large scale plantations in different parts of the country which was payed its contribution for forest coverage beside its purpose.

It was pointed out by WBISPP (2005), that, today tree plantations cover approximately 500, 000 ha out of which 133,041 ha was established as community plantations between 1978 and 1989. *Eucalyptus species* (58%) and *Cupressus* (29%) are the dominant plantation species coupled with other species, including *Juniperus procera* (4%), *Pinus* species (2%) and the rest (7%) in Ethiopia.

2.2.3 Driving forces to forest cover

Reducing deforestation has become an issue of global importance, not only for environmental conservation, but also for climate change mitigation. The United Nations' program on Reducing Emissions from Deforestation and Forest Degradation in developing countries (REDD) is being intensively discussed as a key framework in international conventions on climate change.

Stern (2006) suggested that if the right policies and institutional structures were in place, preventing further deforestation would be cheaper than other types of mitigation strategies for greenhouse gas emissions. Deforestation is a complex process that is driven by a combination of proximate and underlying causes, which can vary from region to region (Geist and Lambin, 2001).

2.3 Application of Remote Sensing and GIS in forest cover change

The use of GIS and remotely sensed data in mapping different natural resources management and environmental modeling are gaining mass momentum in recent years. Majority of work in remote sensing was mainly focused on environmental studies in the last few decades. The implication of Remote Sensing and Geographic Information System to forest cover change is now getting attention and interest among GIS and remote sensing professionals.

The techniques are becoming an important part of forest cover mapping, watershed management, urban planning, hydrological modeling, drought prediction. Remote sensed data provide advantages like synoptic coverage, consistency in data, global reach and readability, precision and maximum accuracy in data provision (Rogan, *et al*., 2002). Geographical Information System and Remote sensing has been efficiently and widely used much in single thematic analysis such as land use and land cover change mapping (Rogan, *et al*.,2002), forest monitoring (FAO 2000), watershed management and forest fire management (Kachmar and Sánchez-Azofeifa, 2003), and forest strategy appraisal.

A remote sensing device, method records responses which are based on many characteristics of the land surface including the natural and artificial cover. An interpreter uses the elements of tone, texture, patterns, shape, sizes, shadow, sites, and association to drive information about the land cover. The generation of remotely sensed data/image with various types of sensor flown abroad different platforms at a varying height above the terrain and at different times of the day. The year doesn’t lead to simple classification system and it is also often believed that no single classification could be used with all types of imageries and all scales.

3. MATERIALS AND METHODS

3.1 Description of the Study Area

3.1.1 Location

This study was carried out at Walmara woreda is found in a special zone of Oromia surrounding Finfinnee. The wereda is about 40 km southwest of Addis Ababa and found between 8^0 5´ - 9^0 51´ N and 38^0 25´- 38^0 45´ E in Oromia National Regional State (figure 1).

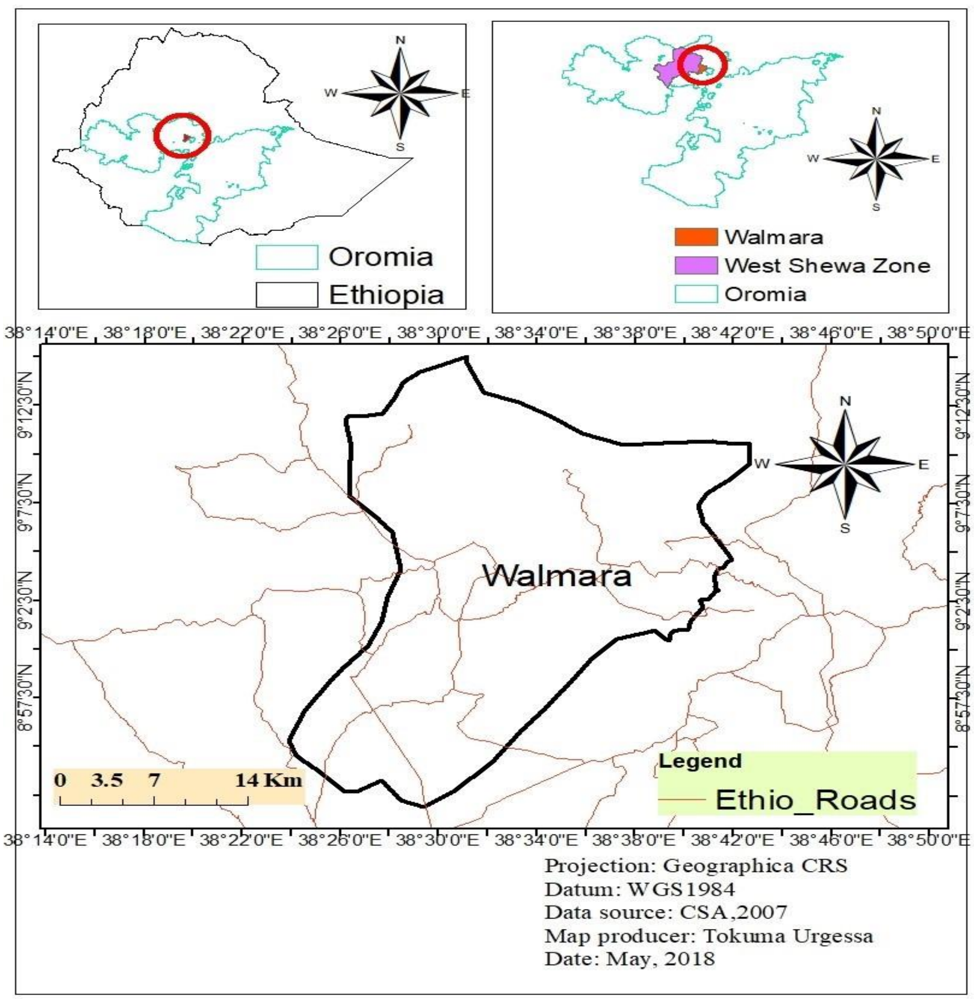


Figure 1: Study area

Walmara is located in West Shewa Zone and is boarded with Burayu woreda to the East, Ejere woreda to the West, Sululta and Ada'a Berga to the North and North east respectively and Sebeta Awas to the South east with Holeta as a capital city (Ayele, 2011). The wereda has 24 kebele administrations of which 23 are rural kebeles while menagesha kolobo is urban administrative.

3.1.2 Population

There are four major ethnic groups in welmera wereda; namely Oromo, Gurage, Walayita and Amhara with the Oromo ethnic group being an absolute dominant group in terms of population number. The Wereda's total population was 100,439 of which 50,281 (50.06 %) are male and 50,158 (49.94%) are female (CSA, 2013).

3.1.3 Vegetation and topology

There are some remnants of indigenous tree species such as *Podocarpus gracilior, Juniperus procera*, *Olea africana*, *Croton macrostachyus* and Acacia species in the woreda. The dominant plantation Eucalyptus species are *Eucalyptus globules* and *Eucalyptus camaldulensis*. The most Eucalyptus plantations are used for construction and as an energy source in the Wereda. Now days it has become one of the income sources as equal as a cash crop in the wereda. This pushes the farmers to the unplanned harvesting of the plantation forest, thereby reducing forest cover.

3.1.4. Climate

According to Holeta Bee Research Center (2002), Agro- ecologically, welmera wereda is classified into Highland and midland that covers 61% and 39% of the total area respectively, with annual average rainfall varies from 795mm to 1300mm while the mean annual rainfall of the year is 1070mm.

The wereda elevation ranges lies between 2060m a.s.l to 3380m a.s.l and lies in two Agro-ecological zones, namely, Dega (2400-3200) and weyinadega (1500-2300) which shares 61% and 39% respectively.

The rainfall of the wereda is bimodal in Dega part of the Wereda: short rains, belg, from the last weeks of January to April; and long rains, meher, from June to September. The rainfall is unimodal in Weyina Dega part of the Wereda that is long rains, Meher, from June to September. According to Holeta Bee Research Center (2002), the average relative humidity is 58 % and the annual mean temperature of the wereda is 14^{o}C with May being the hottest month while the highest mean temperature of the wereda is 23.8^{0}C, with December the coldest month with an average low temperature. However, Walmara receives a high amount of rainfall. The average highest rainfall of the study wereda is in July and August.

3.1.5 Soil

Red silty soil is the dominant soil type in the Wereda with 60%, coverage followed by Clay loam/Verti soil type which constitutes 37%, whereas the sandy textured soil is the rarest soil type with 3% of the Woreda. The combination of these soils is suitable for different agricultural crops among which *Eragrostis teff, Hordum spp., Pisum sativa, Faba bean* and *Gizotia abyssinica* are few (WWAO, 2010; unpublished).

3.2 Research Methods and Data Acquisition

3.2.1 Data collection techniques

3.2.1.1 Social Survey

Social data directly related to the forest cover dynamics and the major driving force of the change in the study area were collected using key informants (KIs) and household (HHs) survey.

Key-informant interview

Key-informant interview was conducted through semi-structured and structured checklist in December and January of 2017 and 2018 respectively. Four kebele administrations, namely Haroo bokii, Waajiituu, Ulaa-sillasee, and Talacoo were selected from Walmara woreda .The selection of the kebele administrations were purposive sampling on the basis of their surrounding forest cover potential and the visibility of the forest cover change. Six key informants from each kebele were selected using Snowball sampling techniques. Snowball sampling techniques is a technique for finding research subjects in which one subject gives the researcher the name of another subject, who in turn provides the name of a third, and so on (Bernard, 2002).

Four individuals (two from kebele officials and two from farmers) were asked randomly from each kebele's to suggest the name of six KIs from their respective kebele's. Accordingly, the most frequently mentioned KIs were ranked based on the frequency they have been suggested and a total of 24 respondents (6 from each kebele) were selected and interviewed.

Household questionnaire survey

The household survey was conducted on 10% of the selected kebele's household with purposive random sampling techniques.

A checklist that has contained structured and semi structured questions was used to guide the interviews and the HHs taken the participation of the female's in advance despite their unequal participation by males. The questionnaires were prepared and translated to the local language "Afaan Oromo".

3.2.1.2 Remote sensing data

Remote sensing data particularly, TM (Thematic Mapper) and ETM+ (Enhanced Thematic Mapper plus) and operational land imager (OLI) were used to assess the extent of forest cover change including the rest land cover and land use change in the study area.

For this study highest level-1 free sources satellite images of different Landsat satellite sensors, TM (Thematic Mapper) and ETM+ (Enhanced Thematic Mapper plus) and operational land imager (OLI) of 1985, 2000 and 2017 were download from US Geological Survey web site https://earthexplorer.usgs.gov/.

To cover the extent of the study area, mosaic of two satellite of the same year and season were used for change detection analysis. The two imagery used for mosaicking were with a different path numbers but with the same raw number, (168 &196) and "054" respectively and the study area was defined by clipping using Walmara woreda's shape file.

The dates of the images has been chosen as closely as possible to be in the same vegetation season, the dry season to minimize the cloud cover.

The period for the ground truth point collection were also chosen as closely as possible to be in the same season with the imageries used.

Ground truth points were collected using the Geographical Positioning System (GPS) for the current image and google earth also used additionally and satellite imagery were used for the assessment of the forest cover change of the woreda after the pre request operations were done on the raw imagery.

Table 1: Time series of satellite images used for this study and some of their characteristics

Producer	resolution	sensor	cloud cover of The image	date of acquisition	path/raw	year
USGS	30m*30m	TM	0.00	19850102 &19851109	168054& 169054	1985
USGS	30m*30m	ETM+	0.00	20001205& 20001126	168054& 169054	2000
USGS	30m*30m	OLI	0.00	20171212 &20171203	168054 169054	2017

Date format: YY/MM/DD

3.4 Data Analysis

3.4.1 Tools and Software Used In the Study

GPS, pen, pencil, hand notebook and digital camera are a list of materials used in the study, whereas Statistical Package for Social Science (SPSS) version of 16.0 and Quantum Geographical Information System (QGIS) 2.18 version, soft wares were used to process and analysis the spatial and temporal change and the qualitative data and from the social survey respectively.

Different published documents and maps including google earth engine and Bing maps and topo map sheet were used as a reference to get secondary information about the Woredas forest cover dynamics beside the primary data collected.

In this study the qualitative data obtained through KIs, and household survey was analyzed with SPSS version 16.0 software, and described with descriptive statistics such as frequency and percentages whereas the quantitative data that were obtained through satellite imagery classification were analyzed using (QGIS) version of the 2.18 software and finally the thematic maps showing the forest dynamics and LULCC were produced for each year.

3.4.2 Image Preprocessing

Image Preprocessing is a technique which is used to enhance raw images received from cameras and sensors placed on satellites, space probes and aircrafts or pictures taken in normal day-today life for various applications. Preprocessing according to Coppin and Bauer (1996), commonly comprises a series of sequential operations, including radiometric normalization, image layer stacking, image registration, geometric and atmospheric correction with Dark Object Subtraction (DOS1) and masking of clouds, water and irrelevant features. The normalization of satellite imagery takes into account the combined, measurable reflectance of the atmosphere, aerosol scattering and absorption, and the earth's surface (Kim and Elman, 1990). The preprocessing activities done to the raw image in this study were including merging of different bands, sub-setting, image enhancement and atmospheric correction with Dark Object Subtraction (DOS1) prior to clipping and mosaicking the images.

After all the images were corrected in the same way, all scenes from the same year were mosaicked together so that fit to the extent of study area. From the mosaicked image, the portion that was felt within the study area was clipped to limit the size of the image to the size of the study area for which preliminary classification, field verification, and the processing work were done at a later stage.

Pre-field image processing were done using a false color composite with a combination of bands 4, 3 and 2 and 5, 4 and 3 in RGB transformation for TM, ETM+ and OLI respectively.

Then, collection of region of interest sample points from each land use was carried out and histogram equalization was also done so as to check the distinguishability and distributions of the training points.

3.4.3 Image Classification

Image classification is the process of assigning land cover classes to pixels (Al-sharif and Pradhan, 2013). According to Lu and Weng (2007), there are three main image classification techniques in general which may include unsupervised, supervised and object based methods. Supervised classification according to Eastman (2003), is where "the user develops one or more spectral signatures of known land use categories, such as settlement, crop, water body, wetland and forest, with the help of Semi-Automatic Classification Plugin (SCP) for QGIS and then the software assigns each pixel in the image to a particular cover type to which its signature is most comparable. Richards, and Jia, (2006) argued that "supervised classification is the process most frequently used for quantitative analyses of remote sensing image data".

For this study, supervised classification with Maximum Likelihood Classification (MLC) algorithm was performed with sequential steps, including training area selection, Generating of signature file for the training areas which were in vector/polygon forms and Classification was done at the end.

During the satellite imagery classification both visual and digital image interpretation were used. Using visual cues, such as tone, texture, shape, pattern, and relationship to other objects, an observer can identify many features in an image (Chavez, 1996).

Methods to visually interpret satellite images are very similar to methods developed to interpret aerial photographs over long years ago. In the digital classification process, training areas for different classes are defined on the satellite imagery on spectral response pattern in different spectral bands.

Based on these training areas satellite imagery is classified into different classes (Lillesand, and Kiefer, 2007). Vector data can be produced by visual interpretation of pixel based satellite imagery and the maximum likelihood algorithm assumes that the statistics for each class in each band is normally distributed and calculate the probability that a given pixel belongs to a specific class where each pixel is categorized to a class that has the highest probability. The assumption of this technique is that the minority classes in the image have the opportunity to be included in to their respective spectral classes, thereby minimizing the problem of uncategorized pixel from entering in to another class during the classification process.

Six major land use/land cover namely cropland, grassland, forestland, wetland, waterbody and settlement areas were identified through the field observation and from the classified multitemporal satellite images.

During the classification processes all vegetation types including the plantation forests and other types of vegetation that fulfill the newly nationally adopted forest definition were considered as a forest in this study. The other categories of land uses in the wereda are considered as other land uses in this study and well-thought-out as non-forested (table 2).

Table 2: Summary of table shows the description of the forest and non-forest land uses

LULC	Description
Forest	Is land spanning at least 0.5ha cover attaining a height of at least 2m and a canopy cover of at least 20% or trees with potential to reach these thresholds in situ in due course, this forest definition is in the light of the varied forest types and potential of carbon stocks in the country, the national capacity for measuring reporting & verification (MRV) and the need for engaging local communities and benefit from forest carbon incentives.
Non-forest land uses	includes the other major types of the land uses in the wereda and classified in either of the rest classes (Cropland, Water body, Settlement areas, Wetland land and grassland/shrubland) in the wereda apart from forest land uses.

Adopted from Ethiopian Ministry of Enviroment Forestry and Climate Change (MEFCC), Feb (2015).

***Settlement*:** Includes infrastructures such as road, both small and large scale investment builtups in the Woreda including the built-up for settlements except the very scattered ones.

***Grassland*:** refers the free grazing land and the shrubland on the progressive of rehabilitation. Both were considered as the single land use because of their spectral reflectance are more or less similar.

3.4.4 Accuracy Assessment:

Accuracy is one of the vital issues that need to be considered while satellite image classification is done as it determines the quality of the map extracted from remotely sensed data and it was done to understand the representation of the classified images on the ground.

Unless and otherwise accuracy assessment is done to an image classification it limits the confidence of the result. Accuracy assessment is commonly done with reference to other images (Gessesse and Kleman, 2007; Teferi *et al.,* 2010). Accordingly, for this study accuracy assessment was done for the whole classified images. For the recent image (2017) ground truth points were collected with GPS from the field and some of them (40%) were used as a reference point for accuracy assessments, whereas reference points for the old images (1985 and 2000) were collected from the corresponding period of Google Earth images including Aerial photograph google earth engine and Bing map were also used.

Furthermore, the Key formant's and Households interviews and interpretation of the sacked imagery. A total of 300 ground control points (GCPs) and 50 GCPs for each land use were collected from field between 10:00 a.m. and 4:00 p.m. and of these ground control points, 60% (180) were used for the classification while 40% (120) were used for validation assessment to the classification done. The reference point collected by GPS used in accuracy assessment were independent of ground truth point. Various measures of accuracy assessment such as producer accuracy, user accuracy (Congalton, 2005) and overall accuracy were done to the multitemporal images used in this study.

Congalton, (2005) recommended that the standard of overall accuracy assessment was a standard approach in the identification of the LULC change and the acceptable overall accuracy is 85% to 90%. Accuracy assessment in geographic information System (GIS) has been a topic of considerable debate and research in remote sensing for many years.

Although the kappa coefficient is often reported as a measure of map additional accuracy assessments, its use has been questioned by many articles and is therefore not recommended (Pontius and Millones, 2011).

According to Pontius and Millones (2011), this is in part because the promoted standard methods such as the kappa coefficient are not always appropriate. This article concludes that these Kappa indices are useless, misleading, and/or flawed for the practical applications in remote sensing. Moreover, it has been elaborated by these scholars in their document referred above that, there is nothing unique about the use of kappa coefficient in compensating for chance agreement or in allowing the significance of differences in accuracy to be evaluated as these are features shared with other accuracy matrices.

Some have also argued, for example, that chance agreement is effectively overestimated in the calculation of the kappa coefficient resulting in an underestimation of classification accuracy (Foody, 1992; Ma & Redmond, 1995).or that, as a nonprobability based measure, the kappa coefficient is an inappropriate basis for accuracy assessment (Stehman & Czaplewski, 1998).

Hence the kappa coefficient operation was not included for accuracy assessments in this study. Finally, the classified images were compared with the reference images by means of confusion matrix tabular data. The confusion matrix is a simple cross-tabulation of the class labels allocated by the classification of the map data against the reference data (Olofsson *et al*., 2014). This means that the areas of polygons falling into a certain category of combination of map and reference data were summed up in order to create the confusion matrix. The matrix compares information obtained by reference sites those were in vector (polygon) forms to that provided by classifying image for a number of samples of the desired areas. The diagonal highlights the correct classifications where classified image map and reference data agree in their classification whereas all cells off-diagonal show omission and commission errors (table 7, 8 and 9).

The user's, producer's and the overall accuracy assessment was computed by (Congalton, 2005) formula as indicated below.

UA = Number correctly identified in a given map class / Number claimed to be in that map class

PA= Number correctly identified in ref. of a given class / Number actually in that reference class

And OA = (X/Y) *100……………………………………… equation (1)

Where, UA= user's accuracy

PA= producer's accuracy

OA= is overall accuracy,

X = is the number of correct values in the diagonals of the matrix, and

Y = is the total number of values taken as a reference point.

3.4.5 Change Detection

Change detection for geographical information systems is a process that measures how the attributes of a particular area have changed between two or more time periods (https://en.wikipedia.org/wiki/). It often involves comparison of aerial photographs or satellite imagery of the area taken at different times.

According to Du, *et.al*, (2012) change detection has been widely used to assess shifting cultivation, forest cover change/deforestation, urban growth, the impact of natural disasters.

Numerous techniques have been developed and used for change detection to monitor changes in forest cover by making use of remotely sensed data, for instance image differencing, Post-classification comparison (PCC), and principal components analysis (PCA). PCC method minimizes associated problems with multi-temporal images that are recorded under different atmospheric and environmental conditions (Lu *et al*., 2004).

As Lu *et al*. (2004), the method offers also an advantage of representation of nature, of occurring changes and it compares classifications of images from different dates and it separately classifies the data from different dates, and thus, this multi-date data does not require any adjustment for direct comparison (Warner and Campagna, 2009). A rather simple but very effective approach to identify and evaluate forest cover dynamics is the post-classification comparison and the additional advantage of PCC method is the indication of the nature of change (Yuan *et al*., 2005). Having the above described evidence in account, post-classification comparison method was used in this study. The approach was performed after the classification results was obtained from two images acquired in different time periods and subsequent comparison of pixel-by-pixel was operated.

Calculation of the Area in hectares of the resulting forest cover change for each study epoch was calculated and subsequently compared. The comparison of the forest area cover change statistics were used to assist in the identification of the total area and percentage between 19852000 and 1985-2017 periods for. After accuracy assessment of the multi-temporal classified images, area of change (Ebrahim and Mohamed, 2017) and percentage of change. Abate 2011; Temesgen *et al*., (2014a) was also computed to demonstrate the magnitude of the changes experienced between the periods using equation 3 and 4, respectively.

The total area of LULCC were calculated by = $X - Y$ ………….equation (2)

Percent of change = $(X-Y)/Y * 100$…………………………….equation (3) and

Where, X = area of LU/LC (ha) in time 2,

Y = area of LU/LC (ha) in time 1,

4. RESULT and DISCUSSION

4.1 Major land cover land uses of Walmara Woreda

There are six major land uses cover land in welmera wereda during both periods of the study time. The dominantly visible land cover land uses of the wereda are crop land, grass land, forestland, wetland, water body and settlement which each of the land uses in the wereda were marked with an area coverages of 64984ha, 2442ha, 4329ha, 1404ha, 170 and 3790ha respectively in 2017 (table 3). Settlement and crop land were experienced a dramatical area growth while grassland of the wereda shows huge area decline at 2017 (table 3). Comparatively, Forest land cover and wetland of the woreda were marked with their pint-size area downfall as compared to their base year area coverage.

Table 3: Area coverage and percentage constitutes of Walmara LULC at 1985 and 2017

Land uses	**1985**	**2017**	**Δ**	**1985%**	**2017%**	**Δ %**
Crop Land	52816	64984	12168	68.49	84.27	15.8
Grass Land	16755	2442	-14314	21.73	3.17	-18.6
Forest Land	4633	4329	-304	6.01	5.61	-0.4
Wet Land	1665	1404	-261	2.16	1.82	-0.3
Water Body	125	170	45	0.16	0.22	0.06
Settlement	1124	3790	2666	1.46	4.91	3.5

***Note*; +ve** Value indicates the area and the corresponding percentage rise; *whereas*,

-ve Value indicates the area and the corresponding percentage downfall

In this study the initial year (1985) the image is considered as a base year whereas the last year of study period II (2017) is considered as reference year.

The overall accuracy of the of the major land cover land uses classification of the study area is: 89%, 87% and 84% in 1985, 2000 and 2017 respectively (table 7a, 8a and 9a). At the base year of the study period, water body constitutes the smallest share with 125ha area coverage in comparison to the rest major land cover land uses of the woreda while crop land was distinctly noticeable with its dominance area coverage of 52816ha as compared to the other land uses at the base year of the study (table 3).

4.2 Walmara Woreda Forest Cover Dynamics in Period One (1985-2000)

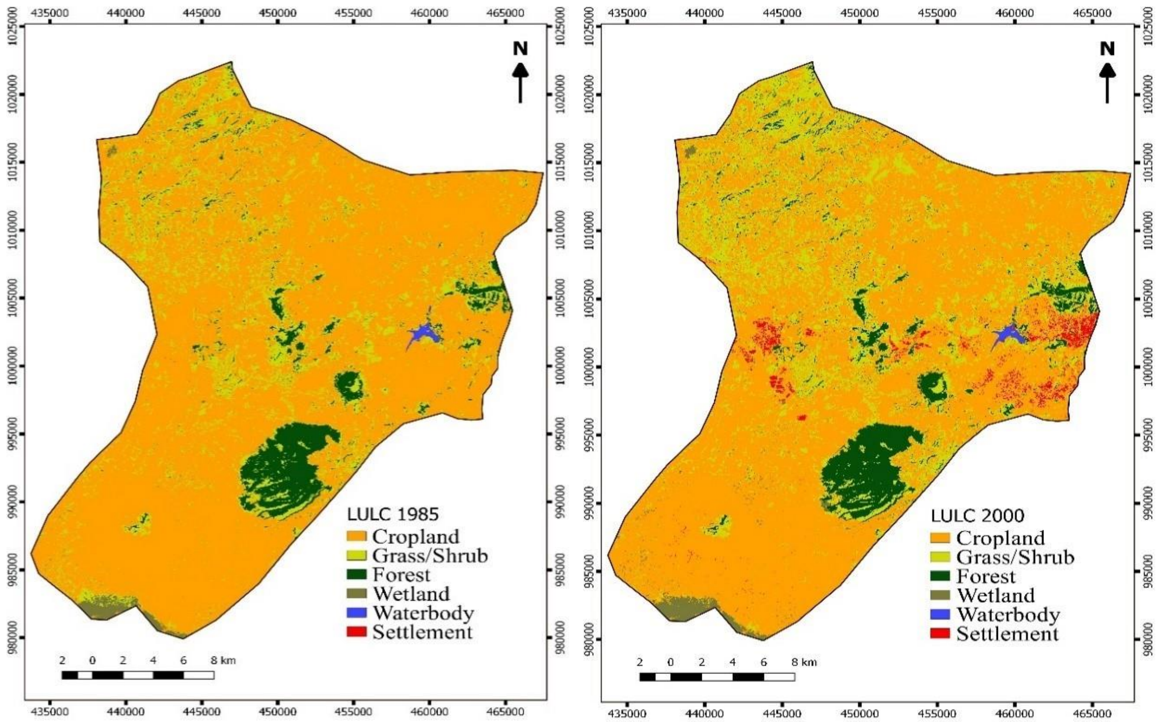
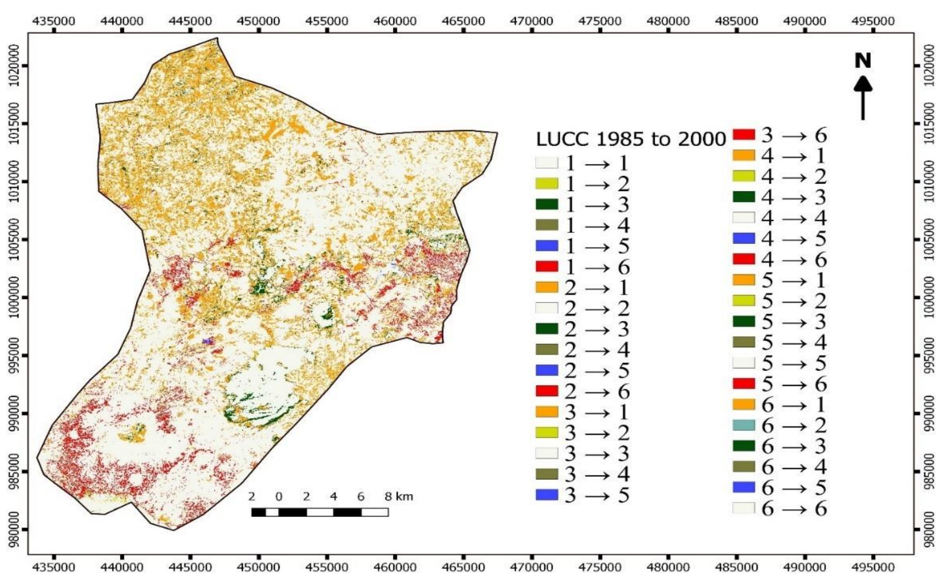


Figure 2: Classified Map of 1985 and 2000 of Walmara woreda



In period one, forest cover of the study area experienced an area coverage gain of 1719ha in comparison to its base year area coverage (table 4). At the base year, the forest cover of the woreda was 4633ha and at the end of period one, forest cover increases its area cover from 4633ha to 6352ha and congruently rises it percentage constitutes from 6 to 8 at the outgoings of non -forest land uses (table 4). This area increment was at the expenses of other land uses of the wereda, dominantly grassland and wetland in minute (table 3). The result of the spatial and temporal analysis of the forest land cover change in period one is supported by, the KIs and households interview.

About 23.8 % of the respondent's confirmed that the area coverage increment in forest cover change in this specific period is explained by the intensive reforestation and afforestation program and the establishment of the NFPAs in the wereda. During an interview conducted on 3 December 2018, G. Benti confirmed that area boost of forest land cover of the wereda during the period was due to the plantation campaign mainly *Eucalyptus* during the Derg regime as a good source of income in a relatively shorter period of time. Furthermore the government controlled and restricted harvesting of forest, and the required permits for accessing and cutting trees in forest lands by the local people as a prerequisite to harvest trees. Moreover, intensive reforestation and afforestation programs were organized by the Ministry of Agriculture and rural development and district offices that planned, coordinated, and monitored all work (G. Benti. 2018, personal communication, 3 December).

This result brings into line with the study carried out by (Bewket and Abebe, 2013) in a tropical northern central highland watershed, Ethiopia. According to Bewket and Abebe (2013), forest cover in a tropical northern central highland watershed was showed area augmentation with 1% and correspondingly rise from 16% to 17% constitutes at the end of 2001 as compared to 1981 at the costs of the other land use land covers of the study area.

Table 4: forest and non-forested land uses of Walmara woreda and their respective percentage constitutes in period I

Land uses	Area coverage (ha)		Area change (ha)	Area constitutes in %		Change in %
	1985	2000	1985-2000	1985	2000	1985-2000
Forest land cover	4633	6352	1719	6	8	37.1
Non-forested land uses	72485	70766	-1719	94	92	-2.4

In contrasted to forest land cover, the non-forested land cover of the woreda was showed area collapse with 1719ha in the same period (table 3). Its percentage constitutes downfall from 94 to 92 at the end of period one. About 70766ha area remain non-forested land uses out of 72485ha of non-forested at the base year of period one (table 4).

The result of this study is a line with the research done by (Teketay *et al*., 2010). According to Teketay *et al*., (2010), there was a formation of NFPAs in many places of the country including the study woreda during this period (period one) which was incorporated private agricultural lands and communal grazing areas through blanket notification or forceful eviction.

Hence the size of state forest and plantations in Ethiopia was increased from 42,300 ha in 1973 to about 250,000 ha in 1985 EC.

Disagreement and ignored response to the dominant policy were expressed through idiomatic expressions, jokes, and poetries (Pausewang, 2002). One of such popular poetry coined in Amharic (Ethiopian national language) during this period reads as: “Deh’ina deh’ina mere’t ba’hirza’f lebese; Yeme’yarso a’tito hizbu iya’lekese (Fekade, 2002)”.

Literally translated: according to Fekade (2002), “all the fertile lands are covered with eucalyptus while the masses/peasants are crying in need of land for farming.”

Table 5: Major driving forces of Walmara woreda forest covering first period

Common driving force	Frequency	Percent	Cumulative Percent
Illegal wood extraction	56	23.3	23.3
Agricultural expansion	81	33.8	57.1
Expansion of settlements	46	19.2	76.2
Plantation	57	23.8	100.0
Total	240	100.0	

The result obtained from the social data to make known the driving forces of Walmara forest cover change in period one witnessed that, there were four major driving forces (table 5). The four major and common driving forces to the forest cover change observed in this period were namely, namely, agricultural expansion, illegal wood extraction, settlement expansion and plantation. The respondents and the informants were acknowledged that agricultural practices was the most popular and visible driving force to Walmara woreda forest cover change with 34%.

Agricultural practices was the most discernable driving force as compared to the rest major driving forces in period one. One of the main reason for agricultural expansion in the study woreda in this period was due to the local population is mainly depend on agricultural activities to meet their livelihoods as the soil is fertile and productive.

In single file to this study, a study made by Gebrehiwet, (2004) showed that the suitability of the majority of the central highland for the extension of agricultural activities.

Furthermore, the result of this result lined up with the research by (Jima, 2010 and Girma, 2014), carried out in Goba Districts in which both researchers were disclosed that agricultural practices were the dominant driving force to the forest cover changes in Goba District. Furthermore about 23.8 % of the respondents revealed that plantation was another important practice that was positively contributed to the forest cover dynamics in period one (table 5). This result brings into line with the study carried out by (Bewket, 2002 and Yeshaneh *et al*., 2013) Gurage zone and northern Ethiopia respectively. Yeshaneh et al., (2013) reported that planting trees, especially eucalyptus, on farmlands is considered by many farmers of the northwestern highlands of Ethiopia as a good source of income in a relatively shorter period of time.

4.3 Walmara Woreda Forest Cover Dynamics in Period Two (2000 - 2017)

The spatial assessment of the forest cover change result obtained in period two showed area downfall of the forest cover of the woreda (table 6). In contrarily with the first period of the study, forest land cover of the wereda was known for its area decline experiences while the nonforested land uses showed a slight area growth (table 6).

According to the evidence tabulated on table 5, the non-forested land cover of the Woreda were increased from 70766ha in 2000 to 72789ha in 2017 in terms of area coverage while forest land cover of the wereda declined from 6352ha in 2000 to 4329ha in 2017.

During period two, about 4329ha forest cover of the Woreda was remained forest land cover while 2023ha were shifted to the non-forested land. Accordingly, the percentage constitutes of the other land uses of the study during this period was increased from 92 to 94 whereas the forest land cover was reduced from 8 to 6 out of the total land size of the woreda at the end of the second epoch of the study (table 6).

This result is contradicted with the forest cover change information obtained from Ethiopian mapping agency (EMA). According to EMA (2008), LULC classification, from 2003-2008 period, the amount of forest has increased in all regions except Afar. The increase in forest, according to the EMA maps, was particularly high in Oromiya from 2003-2008 (EMA, 2013). As per the result reported by EMA (2013), Oromia region, in which Walmara woreda is found was noticeable with a percentage rise of 17 in this period. The contradiction between the two results may be due to its boundary extent difference as Walmara woreda forest cover alone does considered in this study and the gap of years between the two studies.

On the other hand, this map result is go parallel with the satellite map classification carried out by the Federal Democratic Republic of Ethiopia, REDD+ Secretariat, Ministry of Environment and Forest in 2015.

The map based result obtained from FDRE, REDD+ Secretariat, MEFCC (2015) was witnessed that, there has been some loss of forest cover in all regions between 2000 and 2015 including Oromia region in which Walmara is found.

The result found from the MEFCC (2015) also elaborated that, conversion of Forest to grassland was estimated for over 50 percent of the total CO_2 emissions from forests for the period 2000-2015 while contribution of forest degradation processes was found to be about 14 percent of the total forest emissions.

Table 6: Walmara woreda Forest and Non-forest land Area coverage at 2000 and 2017

Land uses	Area coverage (ha)		Area change (ha)	Area constitutes in (%) at		Change in %
	2000	2017	2000-2017	2000	2017	2000-2017
Forest land cover	6352	4329	-2023	8	6	-31.8
Non-forested land uses	70766	72789	2023	92	94	2.9

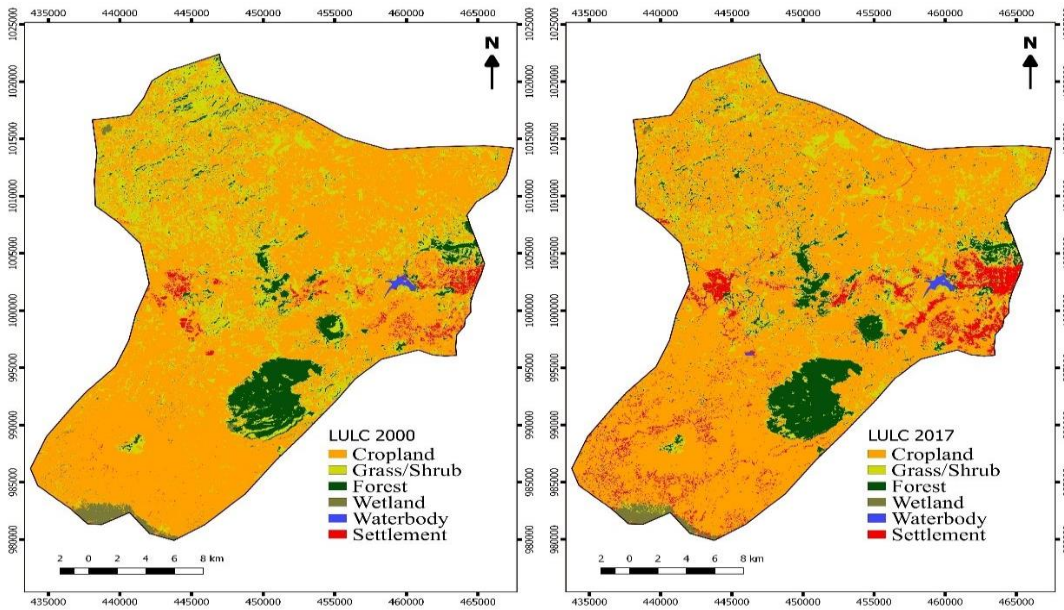


Figure 3: Classified map of 2000 and 2017

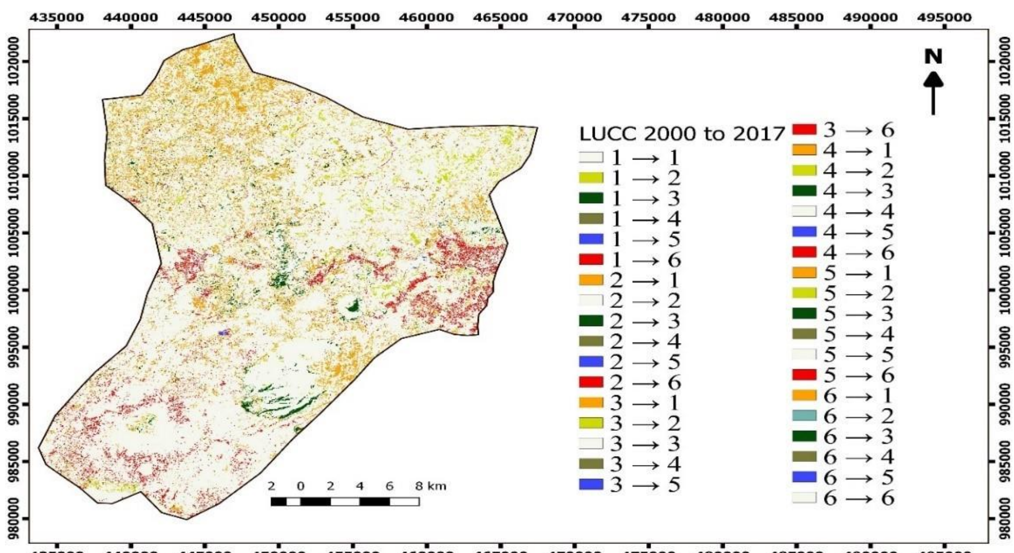


Figure 4: Change map of Walmara woreda in period two

The forest area collapsed recorded from the classification satellite image at the end of period two (2017) also was supported by the result obtained from the KIs and HHs interviews (figure 9). The KIs confirmed that, there was a moderately massive destruction of forest because of the political instability particularly during early time of the period two.

The early time of this period was unstable because political case and as a result there was no serious follow up on the deforestation activities undergoing in the wereda (K. Guta, 2018 personal communication, 5 December). During an interview conducted on 5 December 2018, K. Guta, elaborated that the farmers in the wereda have been encroached the forest surroundings their farm land and have been expanded their farm land at the outgoings of the nearby forest land patches which in turn cause area shrinkage to forest cover.

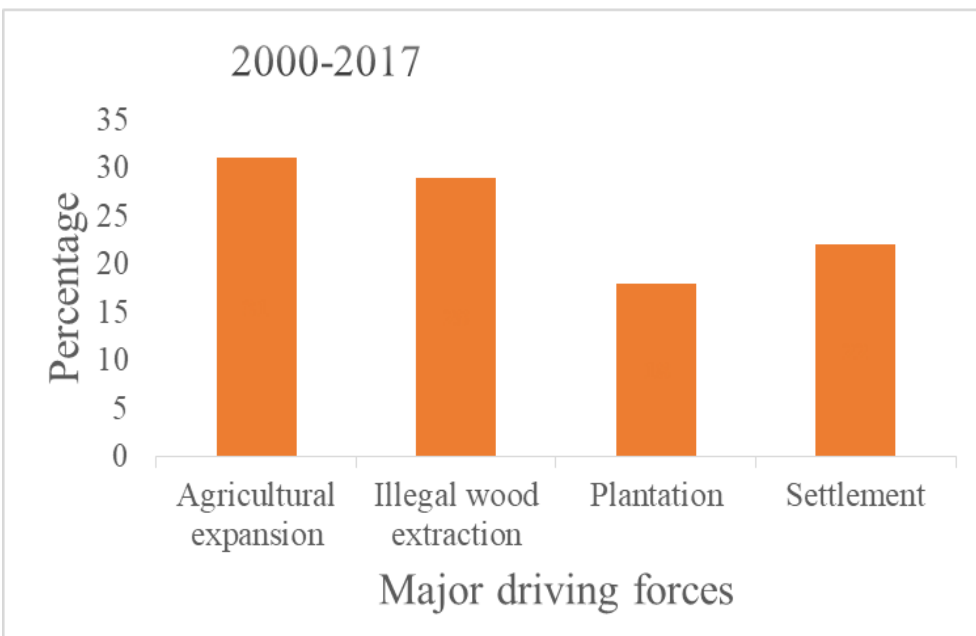


Figure 5: The proximate driving forces from 2000-2017

Source: computed result from HHs data (2018).

Similar causes of driving forces of Walmara woreda forest cover change were identified both in period one and period two despite of their magnitude differences in both periods (table 6). As it has been illustrated in figure 9, agricultural expansion and illegal wood extraction with 31 and 29 percentage respectively were mentioned as a proximate and common driving force to forest cover of the study in this period. Settlement and plantation also contribute with 22 % and 18 % respectively for the forest cover changes of the woreda according to the result of the KIs and HHs interview in this period (figure 9).

Likewise the result from the period I of the study, the computed Household survey and key informants data showed an expansion of illegal wood extraction following agricultural practices with 29 % (figure. 9).

Agricultural land expansion was the dominant proximate driving force to forest cover changes of the of the study area in period II (figure 9).this is due to the majority of the population depend on agricultural practices for their livelihood.

Agricultural practice is the common driving force to the wereda's' forest cover change with negative impact both in the first and second time of the study period regardless of its unequal magnitude.

The result of the forest land cover and non-forest land uses change between 1985 and 2017showed that, Walmara woreda forested and non-forested land experienced area coverage dynamics at the outgoings of one another (table 5). Accordingly, the forested land cover of the wereda was marked with a net area collapse of 304ha while the non-forested land uses exhibited area boost with 304ha in contrarily to the forested land coverage of the woreda (table 7).

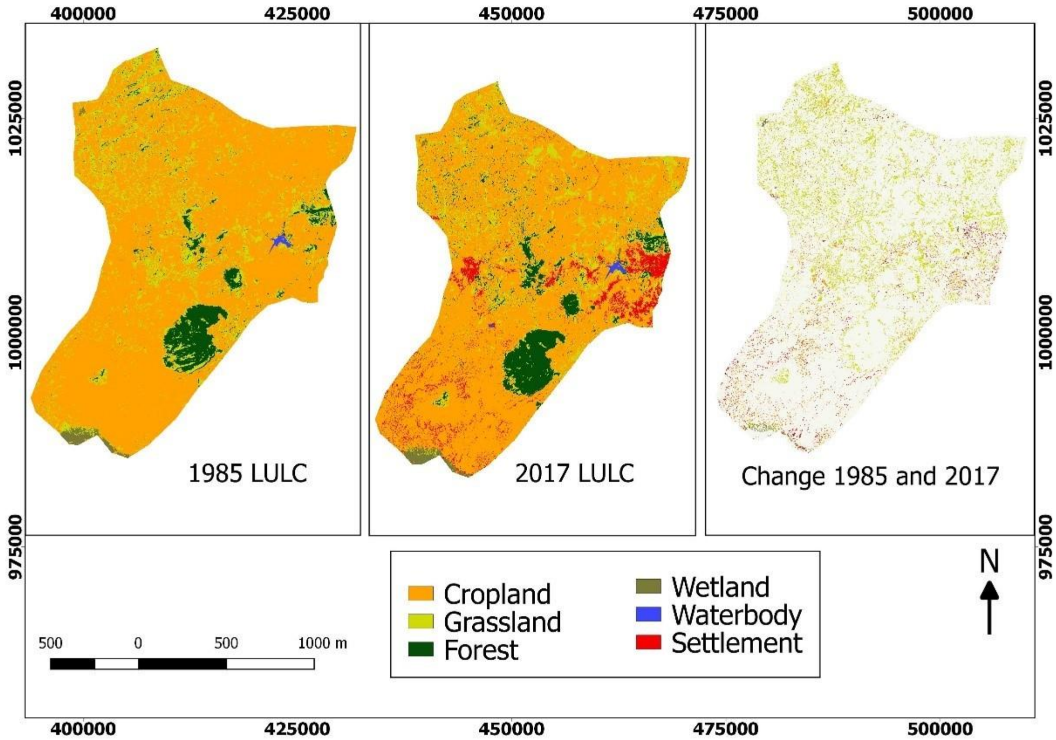


Figure 6: Classified map of 1985 and 2017 period with the change map between them

The forest covers dynamic trend of the Walmara woreda in the past 32 years showed that a slight decline in reference to its base year coverage. The forest cover of the woreda has experienced an area expansion and a reduction of about 1719ha and 2023 ha in period one and period two respectively as compared to its base year area coverage 4633ha (table 6) accordingly the percentage constitutes of Walmara woreda forest cover was knowledgeable with about 6 %, 8% and 6% in 1985, 2000 and 2017 respectively (table 3 and 6). This area coverage result is supported by the result from the social survey and aligned with the unpublished wereda's quarterly report of 2010 that showed about 8% of forest cover in the wereda. Comparing the maps period of 1985-2000 and 2001-2017 leads to the observation that there has been an overall reduction of forested areas in Walmara woreda.

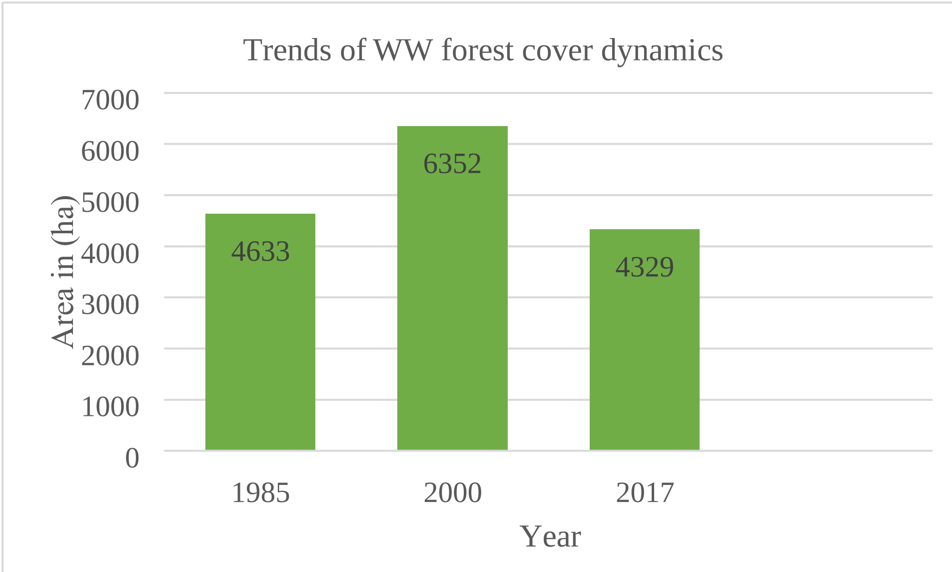


Figure 7: WW Forest cover dynamics during both periods of the study.

During both study periods, the forest cover of the wereda showed a pint-size net area decline and marked with area coverage of 4329ha at 2017 (table 6).

Depend on the data collected from the extensive HHs and KIs interview confirmed that, the wereda forest cover change was a result of multiple interconnected and inseparable reasons. Beside the common and direct driving force addressed through the socio-economic part, there was many more driving forces mentioned as indirect cause for the collapse of forested land cover change during the study periods. Appropriate policy and its unlawful enforcement and land emigration are among the frequently mentioned reasons regardless of their unequal magnitudes. The results from the socioeconomic revealed that the urbanization in the study wereda alarmingly increased, especially in the second period at the expenses of the agricultural land and grasslands proximate to the town of the woreda.

The reason why the cropland of the wereda remain a dominant land uses throughout the study period was, also its self-restorative phenomena from being diminished due to the pressure from the settlement, at the expenses of forest cover in the wereda.

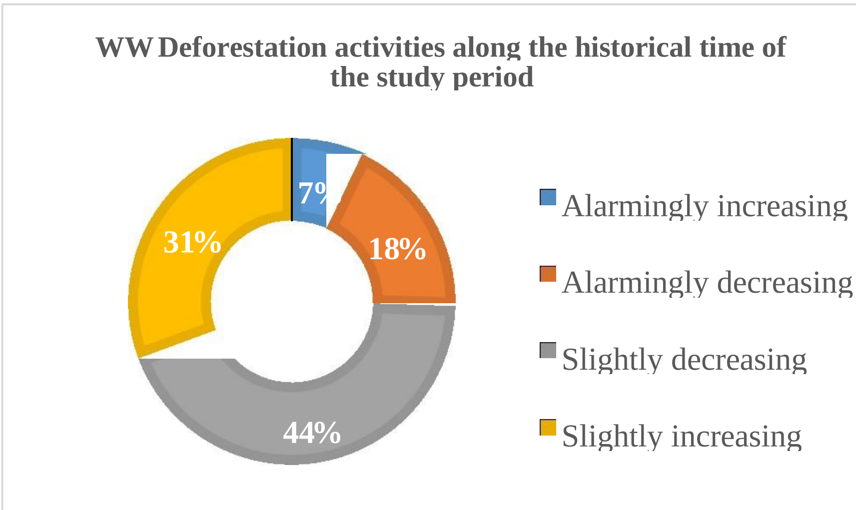


Figure 8: WW deforestation rate trends from 1985 – 2017; Source: computed from HHs data

Generally, the majority of the interviewed HHs (48.3%) was revealed that, the area coverage of the wereda's' forest were marked with slight changes through the whole period of the study.

A Forest cover of the wereda was marked with 1719ha and 2023 ha gain and loss in period I and period II respectively (table 3 and 6). Almost 4329 ha of Forest land of the wereda remains forest land at the end of the study periods, whereas the net area loss was 304ha in both periods with -0.2% change annually. The deforestation percentage in both periods were very low as compared to country level report done by WBISPP in different years. The deforestation percentage obtained by (WBISPP, 2004) indicated that, 1.05%, 1.79%, 1.62%, 1.41% and 1.47% between 1990-1995, 1995-2000, 2000-2005, 2005-2010 and 2010-2014 respectively.

The dissimilarity result between both investigation is due to many reasons for instances, the awareness made by different organizations, including non-governmental and governmental and establishment of area enclosure and protected forest priority areas and the annually plantation program done by governmental institutions, mainly wereda level (OFWE, 2017, unpublished).

Despite the slight decrement of deforestation in the woreda, still agricultural land expansion and illegal wood extraction were remain an observable challenges to the wereda's forest cover in period two including the expansion of settlements which is recent years phenomena in the woreda (figure 6).

In addition to the major and common direct proximate force to Walmara woreda forest cover dynamics, there were many more indirect causes remain hidden. The underlying causes of deforestation are not fully understood, and the influence of various factors has been extensively debated.

These include population growth and poverty (Zak *et al*., 2008), economic development, insecure land tenure and weak law enforcement (Gaveau et *al*., 2009), are among others most frequently coated. During an interview made on 13 December 2018, G. Benti and Sh. Himbale; an expert of natural resource management and forestry in the woreda respectively noticed that the proximate causes of the wereda mentioned above were triggered by uncountable underlying forces.

Underlying Drivers

The noticeable forest cover area collapse in the study woreda was not because of the above discussed proximate driving forces alone rather the sum up of both proximate and underlying causes. Socio-economic status, policy enforcement and institution weakness, demographic factors and technological factors were the understandable underlying causes in the study area.

Therefore, the economic status, policy enforcement and institution weakness coupled with demographic factors which include population growth rate, density, distribution, migration, and urbanization are important underlying drivers of deforestation of the wereda.

Demographic Factors

Population growth evidence shows that, the rapid population growth, in combination with other factors, contributes to increasing deforestation (Pan, *et.al*, 2007). According to projected data of CSA (2013), the woreda population has been constantly increasing with a growth annual rate of 2.9 %. This annual growth rate is the highest growth rate and in turn lead the woreda population to encroach and overexploitation of the forest. Countries with high rates of population growth are those where the annual population growth rate is above the median growth rate (1.33%) of all countries between 2000 and 2005 (UNPD, 2009).

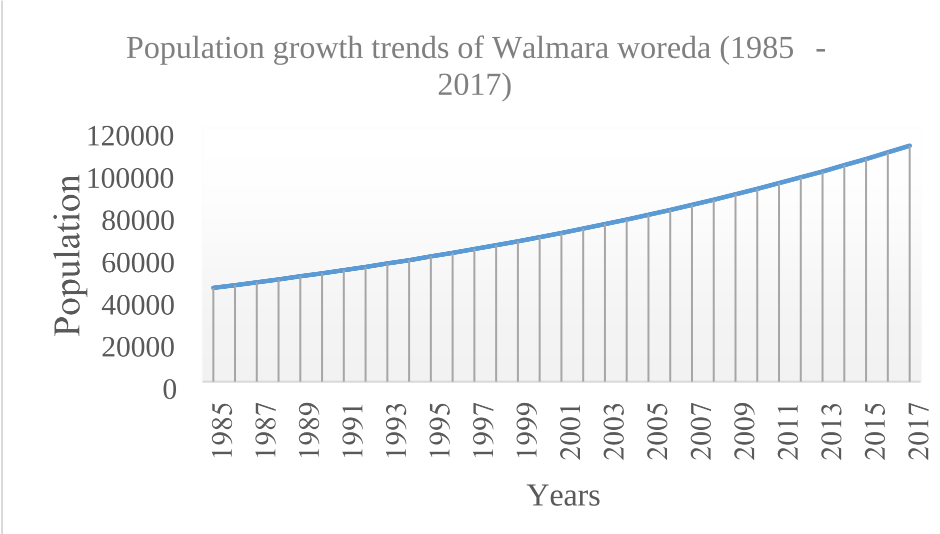


Figure 9: Population growth trends of Walmara woreda during the study period

*Source: (*CSA, 2013).

The larger the household size the higher the demand for land for cultivation to meet the food needs as well as the demand for forest products. The population of the woreda showed a growth from 44427 in 1984 to 68470 at 2000 and to 111788 at 2017 (CSA, 2013). Corresponding to this population number rise in both periods, the farmers in the study wereda have been converting different forest patches of the wereda nearby to their farmland to other non-forest land uses components, predominantly agricultural land and grazing land to sustain their life and feed their livestock (figure 9). Additionally the informants were pointed out that, farmers in the wereda have been encroaching the forests nearby to their agricultural land due to some of their land was overtaken by investments without fair equitable payments which in turn marked the agricultural practice as a dominant cause to the wereda's forest cover change regardless of time (table 4).

Socioeconomic Factors

Socioeconomic factors were found to be among the underlying factors enhancing deforestation in the study area. Local social and economic factors such as poverty, poor education and lack of employment were found to impose on efforts to conserve forest resources of the wereda. It was observed that the majority of the villagers were farmers who depended on selling their agricultural products. Some key informants mentioned that they also lacked reliable income generating activities, which would supplement their monthly income. One of the key informants said that, poverty increased the rate of deforestation and forest degradation in the study area due to increased demand for construction and fuel wood consumption at households.

Policy and Institutional Factors

The natural resources, including policies in Ethiopia remain under ideologically battlefield for a long period of time. There was no clear cut forest policy during the Derg regime besides its attachment with nationalization of land policy and therefore, people were ready anytime to take illegal advantage before somebody else did so (Desalegn, 2001).

This policy inconsistency was among indirect cause in the woreda during the study periods. Some key-informants were mentioned that, the forest policy during the Derg regime (mostly period I) has undermined their role in conserving the forest and limited them from accessing the resources. The result from the household survey revealed that, following the removal of Derg regime the people in the woreda were over exploitation the forest patch surrounding their farm lands and so that Forest resource abused as a result of unprecedented power vacuum in 1991.

This result is confirmed with the study carried out by Melaku (2003).

According to Melaku (2003), soon after the fall of the military regime in 1991, the policy shift that was made by the transitional government of Ethiopia encourages the private sector and significantly contributes to the free uncontrolled exploitation of forests.

Melaku (2003), explained that when the State's coercive structure was relaxed in 1990/91; the peasant communities took their "revenge" on the adjacent State property, including forests. This turned the forest into a near open-access resource, into non-property.

5. CONCLUSION and RECOMMENDATION

5.1 Conclusions

The study found that the Walmara woreda forest cover was under dynamics during the study periods, because of different proximate causes which were triggered with the intertwined and inseparable associated underlying causes. The causes which were contributing to the woreda forest cover dynamics were attributed to agricultural land expansion, the rising demand for free grazing land, high population growth rate, lack of income, the expansion of settlement including the different scale investment, and lack of job in negative dimension and plantation in positive. Consequently, the forest land cover of Walmara woreda has been screeched down in an area coverage due to both proximate and underlying causes. The forest cover of the study area was downfall with a net area coverage of 304ha in period I and II (1985 to 2000 and 2001 to 2017). The dynamicity of the wereda's forest cover of both period I and II were the results of proximate causes; such as cropland expansion activities undertaken by the local farmers and the settlers from different part of the country including the illegal wood extraction being lasted there for many years. Although the proximate causes raised in period I and II were similar, their respective magnitudes was not as different. The wereda people use wood as the only energy source in their households, as they don't have alternative access they are forced to extract their surrounding forest patches. The non-forested land uses of Walmara woreda experienced an area withdrawal of 1719ha and area boost with 2023ha in period I and period II, respectively as compared to the base year area coverage in 1985.

Non-forest land use of the wereda increases with an area net of 304ha in period I and II and the expansion of the non-forest cover was carried at the expense of the surrounding forest cover in the study woreda.

Cropland and settlement area had experienced area increment in period I while grassland was known of its area cover fluctuations in both periods; it has experienced area shrinkage in the first and area growth in the second period as compared to its' base year area coverage. The analyzed result from the satellite image is confirmed with the KIs respondents, this is because of the significant amount of grassland in the wereda was converted to croplands in the early time of period II. The early time of the period was known for its political instability period for the current government of Ethiopia, where there was an illegal encroachment to the nearby grassland so that increase their crop land. Furthermore, population growth and reduction of land productivity in the wereda and their desire to replace with virgin grassland at the withdrawing of forested land cover also another factor that was visible in the wereda as a driver of such changes in period II.

Generally, in line with different studies conducted in the central highland parts of the country, forest cover of Walmara woreda also experienced a net area decrement during both periods. For instance, a study in Holeta water shed and Yerer/Erer/ Mountain by (Ayele, 2011) and (Kahsay, 2004) respectively, reported the conversions of forest cover to another non-forest land uses during both periods in spite of its unequal magnitude. Similarly, a study in Upper Gilgel Abbay catchment of Blue Nile basin between 1973 and 2001 periods (Rientjes *et al.,* 2011) also reported the conversions of forested land to another non-forested land uses. Further result is lined up with the analysis of plantation forest cover of the central highlands of Ethiopia in terms of area coverage studied by (Desalegn. *et al.,* 2014).

5.2 Recommendations

It is recommended that experts of forestry, biology, natural resource management, livestock, environment, conservation, biodiversity and eco-system and ecology are required to develop a plan for sustainable use of the wereda forest resource so that ensure it functions for the next generations.

- Implementing effective Strategies to reduce deforestation

Ways to reduce deforestation must go hand in hand with improving the welfare of the surrounding communities through introducing them with new and environmentally friendly technologies and policies. Introducing the societies with other options such as a national biogas program, rural electrification, renewable energy, dissemination of fuel efficient improved stoves and encouraging population growth controlling through family planning so that lessens the pressure from the forest.

- Increase the perceived and actual value of forests

Increasing perception and actual value of the forest via several and alternative ways. Governments should impose realistic prices on stumpage and forest rent and so that improving the sustainable productivity of the forest would be improved. National and international beneficiaries of the environmental services of forests have to pay for such services (Chomitz *et al*., 2007).

- Increase area of forest plantation

Related to plantations/reforestations, devolution of forest management through participatory forest management (PFM) should be encouraged.

Planting trees outside forest areas will reduce pressure on forests for timber, fodder and fuelwood demands and also moreover, the deforested areas need to be reforested.

Increasing the area of forest plantations by using vacant or unused lands and waste and marginal lands, especially as road side, along railway tracts, on contours, avenues, boundaries and on land not suited for agricultural production should have a net positive benefit.

- Strengthening the implementation of policies and laws against deforestation. The implementation of policy and law against deforestation is weak in Ethiopia and hence its power is undermined by the societies. (FAO, 2010) considered that, half of the current tropical deforestation could be stopped if the governments impose the concerning institutions in the countries to do so.
- Encouraging the participation of forest management and the rights of local communities In order for forest management to succeed at the forest frontier, all parties with an interest in the fate of the forest should be communally involved in planning, management and profit sharing from the forest instead engaging them in one day meeting.

The government should recognize the role of forest ownership and their management rights instead restricting and undermining them, which in turn encouraged illegal logging and accelerated the destruction of remaining forests.

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APPENDICES

Appendix I

Questionaries' for socio economic survey guide line.

Respondent Name____

Sex____

Age ____

Address /Kebele/____

Date of Contact____

1. For how long you have been living here?
2. What are the major LULC of your wereda?
3. What is your main lively hood activity?

   A. Livestock raring B. Farming C. Both/Mixed

4. Are you allowed to access the forest in your surroundings?

   A. Yes B. No, if yes,

5. For which types of the forest products do you and your family members are allowed to access?

   A. For wood extraction and buildings B. For charcoal C. For grazing

6. How often do you go to the forest?

A. Everyday B. Once a week C. Once a month D. Twice a month

7. Have you experienced forest cover change of your surroundings from 1985 to 2017?

   A. Yes B. No, if yes,

8. Which is the most common driving force for the forest cover changes from 1985 to 2000?

   A. Illegal wood extraction

   B. Agricultural expansion

   C. Expansion of urbanization

   D. Plantation forest

9. Which is the most common driving force for the forest cover changes from 2000 to 2017?

   A. Illegal wood extraction

   B. Agricultural expansion

   C. Expansion of urbanization

   D. Plantation forest

10. What are the trends and experiences of the forest coverages in your surroundings in general from 1985 to 2017?

    A. Alarmingly increasing B. Slightly increasing

    C. Alarmingly increasing D. Slightly increasing

    E. Remain unchanged/stagnant.

APPENDIX II

Table 7: Error matrix table for 1985 LULC

Land uses	Crop land	Grass land	Forest	Wetland	Water body	Settlement	total
Crop land	73	16	0	4	12	2	129
Grass land	2	75	1	5	0	0	83
Forest	1	7	95	4	0	0	107
Wetland	2	2	3	87	0	1	95
Water body	0	0	0	0	88	0	88
Settlement	0	0	1	0	0	97	97
Total	100.0	100.0	100.0	100.0	100.0	100.0	600.0

Table 7 (a): Accuracy assessments for 1985 classified satellite map

Accuracy	Crop land	Grass land	Forest land	Wetland	Water body	Settlement
User's	73%	89.1%	87.3%	60.7%	86.6%	92.5%
Producer's	94.4%	75.1%	95%	86.7%	87.6%	96.4%
Over all	**89%**					

Table 8: Error matrix table for 2000 LULC

Land uses	Crop land	Grass land	Forest	Wetland	Water body	Settlement	total
Crop land	93	4	3	12	11	14	137
Grass land	3	93	13	1	0	0	111
Forest	0	2	79	0	0	0	81
Wetland	4	1	5	86	0	0	96
Water body	0	0	0	0	83	0	84
Settlement	0	0	0	0	6	86	91
total	100.0	100.0	100.0	100.0	100.0	100.0	600.0

Table 8 (a): Accuracy assessments for 2000 classified satellite map

Accuracy	Crop land	Grass land	Forest land	Wetland	Water body	Settlement
User’s	68%	79.7%	80.0%	87.4%	97.3%	96.9%
Producer’s	92.7%	93.3%	78.9%	86.1%	83.2%	85.5%
Over all	**87%**					

Table 9: Error matrix table for 2017 LULC

land uses	Crop land	Grass land	Forest	Wetland	Water body	Settlement	row total
Crop land	97	24	0	21	7	9	157
Grass land	1	68	2	16	0	1	88
Forest	1	4	96	0	1	0	102
Wetland	2	2	2	63	0	1	70
Water body	0	1	0	0	92	0	93
Settlement	0	1	0	0	0	89	90
column total	100.0	100	100	100	100	100	0

Table 9 (a): LC/LU Accuracy assessments for 2017

Accuracy	Crop land	Grass land	Forest land	Wetland	Water body	Settlement
User's	62%	78.6%	94.8%	63.4%	86.3%	95.7%
Producer's	96.8%	68.3%	96.3%	62.6%	92%	89.3%
Over all	**84%**					