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Assessment of Natural Resources and Its Implication for Ecotourism Development in Hashenge Watershed

By

Tewodros Giday Abay

A Thesis Submitted In Partial Fulfillment of the Requirements for Master of Science Degree in Geography and Environmental Studies: Specialization in GIS and Remote Sensing

Advisors

Ass.Professor. Biadgilgn Demissie

Drs. Zbelo Tesfamariam

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DECLARATION

This is to certify that the thesis entitled "***Assessment of natural resources and its implication for ecotourism development in Hashenge watershed***" is submitted in partial Fulfillment of the Requirements for Master of Science Degree in Geography and Environmental Study in Mekelle University, college of social science and language done by Tewodros Giday (ID.No. CSSL/PS 071/04) is an authentic work carried out by him under our guidance

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Table of Contents page

List of Tables

List of Figures

Acronyms and Abbreviations

WCMC	World Conservation Monitoring Centre
EFCOT	Ethiopia Forum for Community Based Tourism
LULC	Land and Land Cover Change
LUCC	Land Use Cover Change
GIS	Geographic Information System
RS	Remote Sensing
GDP	Gross Domestic product
USD	United States' Dollar
WTO	World Tourism Organization
LUPO	Land Use Policy Oromia
OWWSSP	Ofla Wereda Water Sector Strategic Plan
OWARDO	Ofla Wereda Agricultural Rehabilitation and development Office
BoANRD	Bureau of Agriculture and Natural Resources Development
CSA	Central Statistical Agency
GPS	Global Positioning System
GCP	Ground Control Point
TM	Thematic Mapper
ETM+	Enhanced Thematic Mapper plus (The Successor of TM)
USGS	United States Geological Survey
AOI	Area of Interest
DBH	Diameter at Breast Height
CVM	Contingent Valuation Method
NS	Number of Species
NRS	Number of Resident Species
NMS	Number of Migratory Species
AS	Abundant Species
MoCT	Ministry of Culture and Tourism of Ethiopia
WTO	World Tourism Organization
ha	Hectare

Abstract

Land use and land cover change has become a central component in current strategies for managing natural resources and monitoring environmental changes. To assess the natural resources and to maintain the potentials of the area, a land cover mapping was done. The aim of this study was to detect the extent and rate of land use and land cover change for the last 28 years. The landsat imageries of 1986, 2000, 2007 and 2014 were taken for land use and land cover classification. For the classification purposes, five land use and land cover classes were identified. Change Detection between the images for all the land use and land cover classes were computed. For Accuracy Assessment Classification error matrix was done. The floristic composition and structure of Hugumburda forest, is described and related to environmental factors. To analyze the forest and environmental data forty plots (10m x 10m) were used. For each species the abundance value was estimated. Height and diameter at breast height (DBH) of all woody individuals taller than 2 m and thicker than 2 cm were measured. A total of 41 species belonging to 32 families were recorded. The most extensive land cover category of the study area is farmland i.e. 46.8%. The second most extensive land cover category is forest 33.3% in 2014. The overall accuracy of classification methodology is 82.11% for the 2000 and 2007 images. Seven most abundant families were found namely: Fabaceae, Anacardiaceae, Apocynaceae, Celastraceae, Cupressaceae, Sapindaceae and Solanaceae. Regarding plant life forms, the forest is composed of 56 % shrub, 44 % tree species. Related to the bird species, a total of 66 species of birds grouped under 19 families were recorded. Family Alopochen aegyptiacus (20.07%) had the highest number of species. The lowest number of species was under the Families Phalacrocorax carbo (0.14%), Phoenicopterus minor (0.15%) and Lissotis melanogaster (0.15%) respectively. Lake Hashenge has two species of fish and grouped under two families. The analyses of the study revealed that natural resources such as abundance and diversity of bird, forest, fish, lake and beautiful landscape attractions at nearby areas are the main ecotourism potential in the study area.

Keywords: eco-tourism, land use, land cover, change detection, forest, bird, fish

Chapter One: Introduction

1.1 Background of the study

It is to be noted that Ethiopia is one of the centers of plant genetic diversity, and that its indigenous forests have been warehouse of biodiversity including microorganisms, fungi, soil fauna and flora, medicinal plants, wild animals, birds, insects, as well as human beings (Breman, 2013; Negash, 2004). According to (Feoli et al., 2002) and (Woldemichael et al., 2010), Ethiopia is endowed with rich fauna and flora because of its diverse ecological features, which make the country an important center of diversity and endemism. World Conservation Monitoring Centre (WCMC 1992) has pointed out that the flora of Ethiopia is very heterogeneous and has a rich endemic element. It is estimated to contain around 6500 to 7000 species of higher plants, of which about 12 percent are endemic.

(EFCOT 2003) also indicated alternative means of income generations and off-farm activities to minimize degradations pressure on endangered environments in rural areas of Ethiopia. Ecotourism could be as a good example of alternative income generation and off-farm activities which benefit local communities while achieve the conservation goals of natural resources. Furthermore, (Gobena, 2008) indicated assessment of ecotourism or simple nature tourism does not need more facilities and depends on locally obtained facilities or natural capital of the poor that can be managed locally.

In order to make tourism sustainable in Ethiopian case, there was an attempt to introduce ecotourism to rural areas as component of natural resources management through creating diversified livelihoods for local people (Gobena, 2008). Moreover, natural resources can provide economic potential through ecotourism beside other uses (Louppe, 2008).

Nature has always offered a variety of resources for tourism in different areas. Proper understanding of the nature, significance and importance of these resources are essential for decision makers at all levels to make appropriate plans for improving the ecotourism in the regions. These plans should consider the compatibility of tourism developments to ecological potentials of land. The aim of this study was to assess the natural resources and their implication for tourism development in Hashenge watershed based on an integrated evaluation of resources offered in the area.

The natural environment is a major factor in determining Hashenge watershed attractiveness as a travel destination. Thus, the future of the natural environment and the future of tourism industry are inextricably intertwined. In order to determine an appropriate course of action for the tourism industry in relation to the natural environment, it is important to first assess the status of the environmental issues that most directly relate to the tourism industry. Based on an analysis of the primary reasons motivating visitors to select Hashenge watershed as their destination and the activities in which they participate, the following natural resources have been identified as the environmental issues most relevant to the tourism industry: Forest, Fish, Bird species and the beautiful landscape; in the study area. **Nature based tourism provides** leisure travel undertaken largely or solely for the purpose of enjoying natural attractions and engaging in a variety of outdoor activities. Bird watching, hiking, fishing, and beachcombing are all examples of nature-based tourism.

Nature-Based Tourism is a large and growing industry sector in many destinations across the world. A wide range of recreational, activity based, educational, cultural activities and experiences, can be accessed by visitors in natural and protected areas. The development of natural and/or protected areas for tourism products and experiences requires a careful balance between providing adequate visitor experiences and services, protecting the ecological and cultural values of the area and ensuring the long-term sustainability of the site.

It is important to note that all aspects of the natural resources are interrelated and that no one natural resource is isolated from the general condition of the ecosystem as a whole. For example, a poorly maintained mountain watershed could have serious impacts on potable water quality, soil erosion and biodiversity. Although it is beyond the scope of this project to closely review the condition of every environmental category, it is essential to remember that the condition of one aspect of the environment directly affects the health of nearly all other aspects. The protection of the environment as a whole is necessary to safeguard all natural resources, including those most directly related to the tourism industry.

As explained earlier in Hashenge watershed there are many natural attractions but they are remained unvisited due to lack of a proper ecotourism plan for those areas; therefore, people are not perfectly informed about them. As a result, worthy ecologic potentials of some given areas are seriously threatened by being overused. In order to prevent natural resource damage, a comprehensive ecotourism plan in harmony with the specific ecologic condition of each area is required.

1.2 Statement of the Problem

Ecotourism is just a current issue not only in Ethiopia but also at the international arena. Ethiopia has many natural attractive areas and Hashenge watershed is one of the principal attractions of natural tourism, cultural and historical which lacks healthy Community Based Ecotourism activities. Due to this, studies show that Ethiopia is not getting significant benefits out of tourism in general let alone from ecotourism. Communities are not adequately participating in the process of planning, decision making and development of Ecotourism. It is established with increasing deforestation, lack of knowledge and awareness about the importance of ecotourism, and the miss management of grazing areas around the watershed and its adverse impact on biodiversity.

In line with the use of the natural resources for tourism development, its management is very important in terms of protecting the environment and sustaining the ecosystem and thereby the ecotourism. Even though Lake Hashenge is among the few lakes in northern Ethiopian highlands and the only lake in Tigray Regional state, its potential for ecotourism development is not yet researched. The purpose of this study is, therefore, to assess the natural resources and its implication for ecotourism development and the management aspects related to the natural resources and their role for ecotourism. This study will be important in terms of giving highlight about the potential resources for ecotourism and the future management needs for ecotourism development.

1.3 Objectives of the Study

1.3.1 General Objective

The general objective of this study is to assess natural resources and its implication for ecotourism development in Hashenge watershed.

1.3.2 Specific Objectives

The specific objectives of the study are:

I. Analyzing land use and land cover change in the study area for the last 28 years.
II. Assessing species diversities of forests, birds and fish.
III. Analyzing the implication of the natural resources for ecotourism development.
IV. Identifying the main management problems in relation to ecotourism resources in the area

1.4 Research Questions

The following basic research questions were set so as to address the afforested objectives.

I. What looks like the land use and land cover change of the study area from 1986 up to 2014?
II. What is the areal extent and rate of land use and land cover change in the study area during different time periods?
III. What are the species diversities of forests, birds, and fish in the study area?
IV. What are the natural resource potentials for ecotourism development in the study area?
V. What are the main mismanagement problems in protecting the natural resources in the study area?

1.5 Significance of the Study

The wereda has a nature based potential for tourism development but the local community has no proper understanding of Community Based Ecotourism. Even the term "Community Based Ecotourism " is a strange term for them. No wonder, Community Based Ecotourism activities are not yet practiced in Hashenge watershed. Hence, this study will be important for improving the knowledge and understanding of the host community on Community Based Ecotourism and sustainable use of resources so as to develop a sense of ownership. It will also help to have a clear understanding and reciprocity to share the benefits and burdens of ecotourism. Similarly, it is important for officials and community leaders as a guide to develop and implement Ecotourism. It can also help policy implementers to mobilize local resources and improve the economy for the well-being of local communities. Finally, it can serve as an input for the researchers who would like to conduct a further research on Ecotourism development.

1.6 Scope of the Study

The geographical scope of the study is in Ofla wereda but has been limited in four Tabias. Namely; Menkere, Adigolo, Hashenge and Hugumburda. The study mainly deals with land use and land cover classification of the study area by taking different imageries of different years (1986, 2000, 2007 and 2014) to detect the changes. But this classification also limited in five land use and land cover classes; Lake, grassland, forest, settlement and farmland. On top of that, it is limited in assessing only the natural resources (forest, the lake, fish and birds) and its implication for tourism development of Hashenge watershed.

Chapter Two: Literature Review

2.1. Land Use and Land Cover Classification

2.1.1. Land Use and Land Covers Dynamics

Land is the major natural resource that economic, social, infrastructure and other human activities are undertaken on. Thus, changes in land use have occurred at all times in the past, are presently ongoing, and are likely to continue in the future (Rudel et al., 2005); (Zechmeister and Moser, 2001). These changes have beneficial or detrimental impacts, the latter being the principal causes of global concern as they impact on human well-being and safety. For instance, deforestation and agricultural intensification are so widespread when they aggregate globally and significantly affect key aspects of Earth Systems (Lewis et al., 2007; Xiubin, 1996).

Land cover is a biophysical characteristic which refers to the cover of the surface of the earth, whereas land use is the way in which humans exploit the land cover. LULC changes are caused by natural and human drivers, such as construction of human settlements, government policies, climate change or other biophysical drivers (Riebsame et al., 1994); (Lambin et al., 2003) as cited on (Kiros, 2008). In response to the increasing demands for food production, agricultural lands are expanding at the expense of natural vegetation and grasslands (Lambin et al., 2001). These changes in land use and land cover systems have great impact, among others, on agro-biodiversity, soil degradation and sustainability of agricultural production (Lepers et al., 2005).

Throughout the world processes related to urbanization, development of transport infrastructures, industrial constructions, and other built-up areas, are severely influencing the environment, and are often modifying the landscape in an unsustainable way (De Chazal and Rounsevell, 2009). In many cases land use activities go hand in hand with substantial modifications of the physical and biological cover of the Earth's surface, resulting in direct effects on energy and matter fluxes between terrestrial ecosystems and the atmosphere.

For instance, the conversion of forest to cropland is changing climate relevant surface parameters (e.g. albedo) as well as evapotranspiration processes and carbon flows. In turn, human land use decisions are also influenced by environmental processes. Changing temperature and precipitation patterns for example are important determinants for location and intensity of agriculture. Due to these close linkages, processes of land use and related land cover change should be considered as important components in the construction of Earth System models ((Alcamo et al., 2011, Frankharn, 1994).

The landscape concept used to map and assess LUCC allows us to explain relationships between Land Use practices and Land Cover patterns, and considers Land Cover change as driven largely by Land Use Types. For different scale LUCC investigations, the landscape methodology is used on the base of remote sensing data of different spatial and temporal resolution, as well as conventional thematic maps and in field data, to explain relationships between current Land Use practices and land Cover patterns (Haase et al., 2007). Present-day landscapes are territorially defined units of land surface, characterized by a structurally organized combination of natural and economic components whose close interactions give birth to the present-day landscape territorial system. Such an approach provides a base for the perception of the world as a system of interrelated territorial samples with different environmental situations. In response to this issue, a hierarchical landscape classification scheme is proposed for scale-dependent landscape applications.

2.1.2. Why to Study Land Use and Land Cover Change?

The need for optimal use of the land resources and for balance of Land Cover capability with anthropogenic stress is one of the mega scale issues of mankind. The way people use the land has become a source of widespread concern for the future of the world. The inability of many countries to balance environmental and production needs, as well as Land Cover capability and anthropogenic stress, emphasize these mega scale issues. More than ever, therefore, the need for rational planning of land use land cover development and optimal use of the land resources is evident. That is why precise and credible data on land use and land cover change and their trends are necessary for understanding global, regional and local environmental problems (Skokanová et al., 2012).

Land use data are also needed in the analysis of environmental processes and problems that must be understood if living conditions and standards are to be improved or maintained at present levels. One of the prime prerequisites for better use of land is information on existing land use patterns and changes in land use through time (LOVELAND et al., 1991).

Information on land use land cover in the form of maps and statistical data is very vital for spatial planning, management and utilization of land for agriculture, forestry, pasture, urban, industrial, environmental studies, economic production, etc. Today, with the growing population pressure, low man land ratio and increasing land degradation, the need for optimum utilization of land assumes much greater relevance (Haines-Young, 2009).

Land cover change plays a vital role in regional, social and economic development and global environmental changes. It contributes significantly to Earth atmosphere interactions. Biodiversity loss is a major factor in sustainable development and human response to global change, and is important in integrated modeling and assessment of environmental issues in general. Scientists, researchers and planners have paid much attention to the issues of land cover change over the past decade (Zeng et al., 2000). Documentation of the land use and land cover change provides information for the better understanding of historical land use practices, current land use patterns and future land use trajectory. LUCC contributes significantly to earth atmosphere interactions, forest fragmentation, and biodiversity loss. It has become one of the major issues for environmental change monitoring and natural resource management. Identifying, delineating and mapping of the types of land use and land cover are important activities in support of sustainable natural resource management (Rudel et al., 2005).

Generally, determining the effects of land use and land cover change on the earth system depends on an understanding of past land use practices, current land use and land cover patterns, and projections of future land use and cover, as affected by human institutions, population size and distribution, economic development, technology, and other factors. LULC assessment is an important step in planning sustainable land management that can help to minimize agro-biodiversity losses and land degradation, especially in developing countries like Ethiopia (Tekle and Hedlund, 2000).

2.1.3. Image Analysis and Classification Using Remote Sensing and GIS

GIS and RS are land-related and therefore are very useful in the formulation, implementation and monitoring of land use land cover change analysis and modeling. GIS is a systematic process of spatial data collection and processing. It can be used to study the environment by observing and assessing the changes and forecasting the future based on the existing situation. RS, on the other hand, is the process of data acquisition through space or air borne sensors without having any contact with the target objects. It allows the acquisition of multi-spectral, multi-resolution and multi-temporal data for the land use change analysis and modeling. Both remote sensing and GIS tools have been applied in a number of land use land cover change studies to detect, monitor and simulate land changes (Shalaby and Tateishi, 2007). Because of their cost effectiveness and temporal frequency, remote sensing approaches are widely used for change detection analysis. However, computer assisted production of spatially detailed and thematically accurate LULC information from satellite image continues to be a challenge for the remote sensing research community. This is due to the heterogeneous nature of land use land cover environment, which makes discriminating land cover classes difficult. It could also be due to the absence of appropriate classification techniques. However, recent advances in GIS and remote sensing tools and methods have enabled researchers to analyze and detect the dynamic nature of land use land cover features in a more efficient way. Some recent researches have also been directed toward quantitatively describing the spatial structure of land use land cover environments and characterizing patterns of land cover land use structure through the use of remotely sensed data (Shalaby and Tateishi, 2007).

2.1.4. Image Classification

Multispectral classification is the process of sorting pixels into a finite number of individual classes, or categories of data, based on their data file values. If a pixel satisfies a certain set of criteria, the pixel is assigned to the class that corresponds to that criterion. This process is also referred to as image segmentation. Depending on the type of information you want to extract from the original data, classes may be associated with known features on the ground or may simply represent areas that look different to the computer. An example of a classified image is a land cover map, showing vegetation, bare land, pasture, settlements, etc. (Amarsaikhan and Douglas*, 2004). A land use and land cover classification system which can effectively employ orbital and high-altitude remote sensor data should meet the following criteria (Congalton, 1991):

I. The minimum level of interpretation accuracy in the identification of land use and land cover categories from remote sensor data should be at least 85 percent.
II. The accuracy of interpretation for the several categories should be about equal.
III. Repeatable or repetitive results should be obtainable from one interpreter to another and from one time of sensing to another.
IV. The classification system should be applicable over extensive areas.
V. The categorization should permit vegetation and other types of land cover to be used as surrogates for activity.
VI. The classification system should be suitable for use with remote sensor data obtained at different times of the year.
VII. Effective use of subcategories that can be obtained from ground surveys or from the use of larger scale or enhanced remote sensor data should be possible.
VIII. Aggregation of categories must be possible.
IX. Comparison with future land use data should be possible.
X. Multiple uses of land should be recognized when possible.

2.2. Tourism in Ethiopia

2.2.1. Tourism Development of Ethiopia

In past periods, merchants played a considerable role for introduction of religions to Ethiopia, which contributes a lot for evolution of tourism in Ethiopia. It was also believed that the Portuguese's missionaries and other Europeans came to Ethiopia as earlier visitors when they made explorations to the source of Blue Nile (Gobena, 2008).

2.2.2. The Role of Tourism in Economy of Ethiopia

The numbers of tourists flow can estimate regarding to the economic and social affairs, the effects of tourism in Ethiopia and the amount of money received from international visitors. The effect of tourism also to be measured through the expenditures of tourists that have impact on Gross Domestic product (GDP) or the over-all income and earnings from the tourism sectors activities such as job opportunities and services. As far as recorded data indicated that the foreign visitors arrived in Ethiopia in 1963 were 19,836 and revenues obtained from tourists in this year was 11 million Ethiopian Birr (Sisay, 2009). However, recently the numbers of tourist arrivals and the revenues can be obtained from tourists is significantly increasing. For example, in year 2005 about 227,398 tourist arrivals reached

Ethiopia and about 1,202,368,339 Ethiopian Birr generated from these tourists (MoCT 2006). Table 1 presents trends of tourists' arrivals in Ethiopia from years 2001-2005.

Table1: Trends of tourist arrivals and money received from these tourists in Ethiopia from years 2001-2005

Year	Tourists Arrivals	Receipts (in millions)		Growth rate
		Birr	USD	
2002	156,327	676.1	77.1	-
2003	179,910	778	89.94	15.1
2004	184,079	994.4	114.62	2.3
2005	227,398	1,202.36	138.59	23

Source: Ethiopian Ministry of Culture and Tourism, 2006

As can be observed from Table 1, during the years 2002/03, 2003/04 and 2004/05 arrival has registered high growth rates of 15.1%, 2.3% and 23% respectively in Ethiopia. Foreign exchanges earnings from tourism sector also increased from 77.1 million US$ in 2002 to 138.6 million US $ in 2005 increased by growth rate of 16.6% to 20.9% respectively in each year (MoCT 2006). Foreign exchanges earnings from tourism in Ethiopia from 2002 to 2005.

The contribution of tourism to Ethiopian GDP is low when compared to the other Eastern African countries. For example, in 1996 tourism contribution in Ethiopia was about its 0.5 % GDP whereas its contribution to Kenya was 5.1 % of its GDP in the same year. Table 2 presents tourism Contribution to GDP at current Market price in Million Birr for Ethiopia.

Table 2: Tourism Contribution to GDP at current Market price in Million Birr for Ethiopia from 1996-2002

Year	GDP	Receipt	% of Contribution
1996	37,937.60	182.665	0.48
1997	41,465.10	279	0.67
1998	44,840.30	225	0.5
1999	48,687.60	252	0.52
2000	52,074.20	577.8	1.11
2001	53,011.30	642	1.21
2002	51,560.60	676.1	1.31

Source: Ethiopian Tourism Commission

2.2.3. Potential of Tourism Resources in Ethiopia

Ethiopia is endowed with unique cultural heritages and attractive natural resources that attract tourists. The oblique, churches, castles, archeological sites, caves are some of cultural resources of Ethiopia. There are also high diversity of plants and animals in Ethiopia. In addition to these, there are impressive features such as high mountains, rivers, and lakes in Ethiopia. The favorable diversity of climate is the other factor what makes Ethiopia to attract tourists. Having Addis Ababa as venue of seat for Africa Organization Unity and United Nation Economic, commission for Africa is also another feature of attractions for Ethiopia (MoCT 2006).

The Hugumburda Forest and Lake Hashenge or study site in the Ofla wereda is one of the major tourism potential sites in Ethiopia. Ofla wereda endowed with multitude habitats. Lake Hashenge is the most exciting with largest concentration of birds and it is the best and, most accessible bird area in Ethiopia.

2.3. Ecotourism

2.3.1. Emergences and Development of Ecotourism

Although tourism has a significant contribution to economic development and conservation of environmental resources, it also became negative impacts on tourist's destination areas. Especially during the past decades because of the interest of business profit of the tour operators to attract more tourists, which resulted in high negative impacts of tourist's destinations, principle of nature-based tourism or ecotourism was not considered. The negative impacts were seen like degraded vegetation, wildlife casualties, pollution of water and atmosphere in tourists' destination areas. Consequently, in the 1990s, the attentions for environmental issues of tourists' destinations areas were increased and ecotourism to be pronounced (Scheyvens, 1999).

Ecotourism was given more concerns since the world Ecotourism Summit in 2002, because it is expected as a tool for ensuring sustainable conservation of destination areas, satisfying the enjoyment of tourists, benefiting the destination community and contributes to poverty reduction (Scheyvens, 1999).

Ecotourism has a wide range of meanings because of different parties or people defined it according to their own specific interests and priorities instead of all things to all people (Strasdas et al., 2007). According to (Okello et al., 2009), ecotourism refers to tourism that is nature based but that seeks to minimize harmful impact and seeks to promote conservation. (Currie et al., 2009) also defined ecotourism as a sustainable development of tourism potentials, which consider the social, the ecological and economic aspects.

Especially, according to the recent WTO market surveys conducted indicated that, the growth of ecotourism demand will favors Africa. The region is likely to attract a higher proportion of tourists, both those on ecotourism tours and those seeking out newly developing destinations, which are abundance in the region (Liu, 2003).

2.3.2. Development of Ecotourism in Case of Ethiopia

The concept of ecotourism is a new phenomenon to and it is difficult to explain its significance achievement since the approach of ecotourism is not widely disseminated in Ethiopia. The government of Ethiopia also has recognized development and promotion of ecotourism and provided consultancy services for a number of potential developers of ecotourism sites. Although, developers and policy makers do not properly take the idea of ecotourism, some investors started to involve in development of ecotourism in different regions of Ethiopia. Bishangari Eco-Lodge located at Eastern of Langano Lake in Oromia Region and Village Ethiopia located at Afar Region (Bilen) is examples of these private ecotourism developments in Ethiopia (Gobena, 2008). In past few years, LUPO aims to create alternative income generating means such as ecotourism to reduce the pressure on the natural resources of land through conducting a pre-feasibility study of proposed areas on the potentials of ecotourism (Gobena, 2008). Like in Oromia if private investors involve in development of ecotourism in Tigray especially around Hashenge watershed, they can be beneficial for themselves as well as for the people around the watershed and the region.

2.3.3. The Impacts of Tourism /Ecotourism

Generally, tourism can have both positive and negative impacts on economic, cultural and environmental resources depending on circumstances how it is managed (Häusler and Strasdas, 2003). In other words, tourism causes three major impacts in host societies: economic, cultural or social and environmental impacts. Assessing these impacts whether positive or negative is impossible in the Third World due to difficulties in measurement and a lack of local control over the industry (King and Stewart, 1996). (Okello, 2005) stated that in areas, where tourism impacts on country and society, there may well be conflicts with competing demands for other sectors of the economy, or with community interests at large. Ecotourism is thus an important concept in tourism development to solve these problems.

2.3.3.1 The Positive Impacts/Benefits of Tourism

Tourism also causes three major positive impacts at tourists' destination areas. These are positive economic impacts, cultural or social impacts and environmental impacts. The positive economic impacts of tourism includes generating foreign exchange, diversification of the livelihoods creating job opportunities for rural areas and increasing linkages; the positive cultural impacts of tourism includes: promoting modernization and cultural pride of host communities; and the positive environmental impacts of tourism include non-consumptive use of biodiversity. Minimizing environmental impacts and contribution to environmental education and conservation are also positive contribution of tourism. The other positive impacts of tourism are increasing the linkages between tourism business and local economy (Liu, 2003) and reducing seasonality in tourism in order to ensure the well-being of employments and to minimize seasonal and casual employments (Gobena, 2008).

2.3.3.2. The Negative Impacts of Tourism

Tourism causes three major negative impacts at tourists' destination areas. These are negative economic impacts, cultural or social impacts and environmental impacts. The negative economic impacts of tourism include the occurrences of leakage, seasonal jobs and import of qualified personnel, the negative cultural impacts of tourism includes: destroying traditional cultures (crime, prostitution and so on) and the negative environmental impacts of tourism includes: pollution and over-consumption of natural resources (e.g. water) and destruction of habitats (Meyer, 2007). Moreover, as demands for ecotourism are increasing strongly, the availability of suitable ecotourism sites worldwide is deteriorating, threatening their ecological sustainability. The major reasons for deterioration of ecotourism sites are:

I. Incompatible economic uses of land area for other economic activities such agriculture, industry, mining and urban development,
II. Inappropriate tourist development and infrastructures necessary to support those development willful destructions of ecotourism by tourists,
III. Numbers of tourists in excess of carrying capacities and adverse environmental externalities or spillovers which destroy ecotourism resources or assets.

2.4. Tourism/Ecotourism and Local Economic Development

The benefits of tourism are usually categorized at two levels: the first is macro and the second is national level. At the first level, tourism is expected to speed economic growth by foreign exchange earnings and an increase in the state revenue. At a second level, it results in improvement of wellbeing of local people in areas through job creation, revenue distribution and balance regional development (Okello, 2005).

Tourism if is closely linked to rural areas where agricultural activities are habituated and destination areas of tourists. Linking tourism and local agriculture are essential because local agriculture holds a significant potential for achieving pro-poor tourism objectives that will reduce tourism negative impacts and maximizing benefits for the poor. The majority of potential pro-poor tourism beneficiaries subsist from agriculture (Torres and Momsen, 2004).

Moreover, it could be claimed that the local products of tourist destination areas will complement the major facilities of tourism such as transport, excursions or tours services and accommodation (Liu, 2003). The study in China indicated that, the contribution of tourism for the local people indicated by its integration into the local economy through benefiting the people. For example, the case of Suzhou in China showed that, promoting souvenir/ artifact or wok of art or handicraft production is being as means of creating job opportunities and incomes in tourist destination areas (Gang and Kruse, 2003).

Especially; linking local agriculture to tourism allows tourist destination areas to retain a greater share of tourism benefits and reduces leakages with respect to foreign imports (Scheyvens and Momsen, 2008). Conversely, in the absence of well-developed linkages between the external sectors of tourism and the rest of the economy could resulted in a limited development of local economy in the study conducted in Cancun, Mexico during 1997-98 on sixty Cancun hotels. Accordingly, understanding the linkage between tourism

developments and local agriculture is very important since farming; fishing and animal husbandry are the principal livelihood strategies for the poor in most developing regions (Scheyvens and Momsen, 2008).

Reducing the effect of seasonality in tourism is the other very important factor since seasonality can affect the tourism industry directly and local economy or the poor people of destination areas indirectly. According to (Gobena, 2008), tourism is very seasonal as it is being subject to changes such as fears of political instability. Seasonality in tourism refers fluctuation in income from tourism, fluctuation of employments and fluctuation in volume of tourists.

Increasing length of stay of tourists by creating attractive facilities and promote local tourists to travel in the low season is the alternative to reduce seasonality in tourism. When seasonality is reduced in a significant number for a larger part of the year: the hotels, the tour operators and their employees and the local people of the destination areas are more benefited (Enright and Newton, 2004). Because the poor, in rural areas who depend directly on natural resources or biodiversity can cause severe degradation of natural resources benefited of by job opportunities of tourism may contributes to sustainable of natural resources like ecotourism or tourism (Gobena, 2008). According to (Liu, 2003) indicated that tourism was recognized as one of strategies in contribution in poverty alleviation through maximizing tourism benefits to the poor while simultaneously reducing their negative impacts.

In general, the major functions of tourism in poverty alleviations of local people are creation of job opportunities, generation of income from sales of local goods, sharing of benefits from the local business activities, collective income and infrastructure gains like roads, pipe water, electricity and so on (Liu, 2003).

2.5. The Relationship of Tourism with Environment

The relationship between tourism and environment includes the biophysical, social, cultural, economic, and political dimensions. The maintenance of a 'good quality' environment for tourists' destination is one of the major aspects of the development of tourism. The quality standard of the environmental resources that attract tourists determines the economic opportunity of tourism. It is evident that the very existence of tourism is unthinkable without a healthy of pleasant environment, with well- preserved landscape and harmony between people and nature' (Holden, 2009).

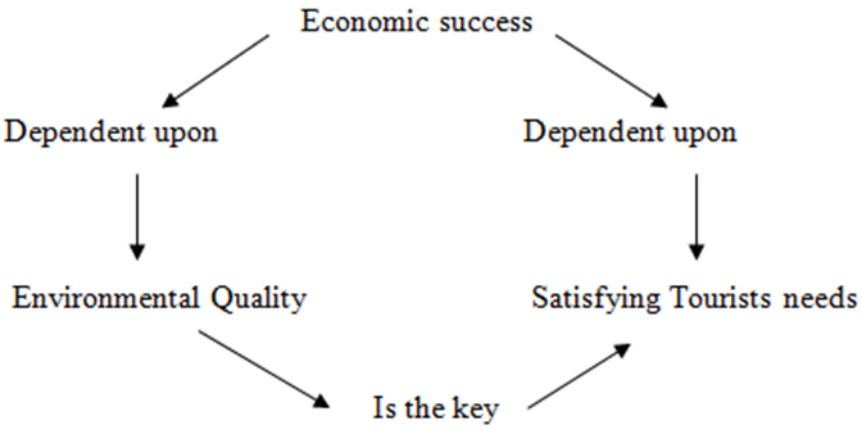

Figure 1: Relationship between the natural environment, the local economy, and tourism (Holden, 2007).

Figure 1 indicates the environmental quality contributes to attract tourists and development of tourism. On, contrary as the environmental quality deteriorates, the number of tourists gets decrease and the expected income from the tourists might be reduced. The interests of the local or destination community also will ensure the preserving of landscape and providing stewardship of the environment if tourism contributes to development of local economy (Holden, 2007).

WTO predicted that the livelihood of poor people (local people) and their environments are the major focuses that need sustainable tourism or ecotourism it recognizes the ecological, social and economic aspects of the environment (Neto, 2003). The contribution of ecotourism is not only to the protection of valuable natural resources of the environment but also benefiting the local population and national economy. For example in Uganda, ecotourism is contributing towards the conservation of mountain gorillas and other species in different areas or environments as well as improving the wellbeing of the local population who live near the park (Okello, 2005).

Chapter Three: Methodology

3.1 Description of the Study Area

3.1.1 Location and Topography

Hashenge watershed is located in Ofla Wereda, Southern Tigray Administrative Zone, Tigray Regional State, Ethiopia. It is about 633 km North of Addis Ababa and about 150 km South of Mekelle and 5 km North of Korem town. The main road from Addis Ababa to Mekelle passes through the catchment of Hashenge. Geographically, the wereda is found between $12^0$30' N to $39^0$20' E but the specified study area is found between $12^0$29' N to $12^0$40' N and $39^0$27' E to $39^0$40' E. Ofla Wereda is bordered by Endamohoni wereda from North, Alamata wereda from South, Wag-Gumra wereda (Amhara Regional State) from West and Raya-Azebo wereda from East.

The wereda comprises 25% plain land, 20% gentle slopping, 15% undulating and rugged terrain and 40% steep mountains. It has a total area of 133,500 hectares. Out of this 25275 (18.9%) hectares are cultivated land, 24340 (18.2%) hectares grazing land, 44635 (33.4%) hectares forest and bush land, 1457 (1.1%) hectares lake area and the rest 37796 (28.3%) are waste lands. Hashenge watershed includes four Tabias namely, Hashenge, Menkere, and part of Hugumburda and Adigolo. Whereas the lake is bounded only by Hashenge, Menkere and Adigolo Tabias. Hashenge watershed is characterized by undulating surface having flat lands and mountainous chain. The mountains that surround the flat grazing land, cultivated land and lake area are characterized by gentle to very steep slopes with elevation ranging from 2440 to 3600 m above sea level (Habtom 2010).

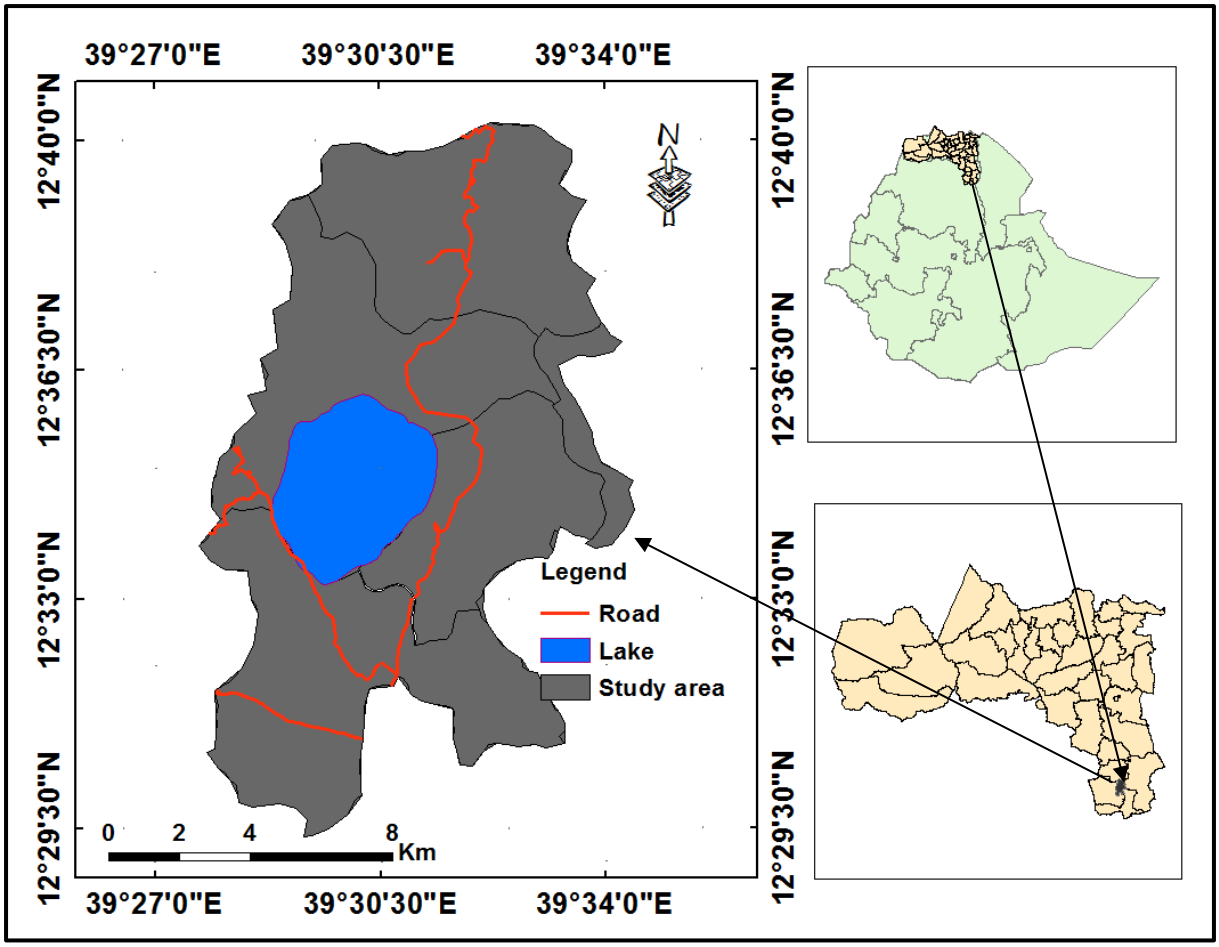

Figure 2: Map of the study area

3.1.2. Climate and Vegetation Cover

There are three agro-climatic Zones in the Wereda with greater domination of the high land or "dega' type. The dega zone comprises about 42% of the Wereda followed by "woina dega" and "kola" 29% each. Rainfall has two seasonal occurrences in a year. During the kremt season, it ranges from 450-800mm and it reaches between 180-250mm during Belg season. The highest rainfall under normal condition usually recorded during the July month. The Wereda has moderate type of temperature that usually extends between 6^{o} c to 32^{o} c. Moreover, about 33.4% area of Ofla Wereda is covered by natural vegetation and is among the few areas to have such large tree cover in the southern zone of Tigray (OWWSSP, 2004/5).

3.1.3 Geology

The study area is composed of basalt rock having different composition. These various rock types found in the area occur as ridge and can be grouped in to four intercalation groups (units). These units generally contain seven lithological units which are Ankaramite, Aphanitic basalt, basalt agglomerate, plagioclase basalt, amygdaloidal basalt, vesicular basalt and phaneritic basalt as a dyke. The above seven units can be also grouped in to two based on their composition, Ankaramite and plagioclase basalt and texture, Aphanitic basalt, basalt agglomerate, amygdaloidal basalt, vesicular basalt and phaneritic basalt (Amare 1998).

3.1.4 Farming System

The livelihood of the region depends on subsistence farming. Livestock husbandry and crop production play a major role in the subsistence farming. The dominant farming system is a highland mixed farming system. The most serious problem for the agricultural production is the shortage of land holding, ranging between 0 and 0.75 ha per household. As a result, farmers are informally owning and cultivating the land up to the lake boundary and some part of the upper sloppy areas which causes much sediment accumulation in the lake.

The planting or sowing time of different crops varies depending on the onset and continuity of the rainfall. There are two distinctly known and traditionally used cropping seasons. Short cropping season is the one, which starts at the beginning of spring season and hence will be harvested around May, allowing enough time for land preparation and sowing of the long rainy season crops. The second cropping season is the long rainy season from July to August as it is practiced in most parts of the country. The major crops cultivated in the area are wheat, barley, bean and pea. Besides, vegetable and root crops such as tomato, onion, cabbage and potato are grown on irrigated fields (OWARDO 2011).

Livestock productivity of the study area is better than other part of the region. This is because of better availability of feed in the grazing land of Hashenge plain and water from the lake. This availability of large grazing land in the plain is a conducive environment for rehabilitation of forest and closure areas in the upper catchment. Livestock in the area is used as security during drought periods, sign of prestige and source of income as commercial activities.

3.1.5. Population and Socio-Economic Features

Based on the 2007 national census conducted by the Central Statistical Agency of Ethiopia (CSA), this wereda has a total population of 126,889, an increase of 17.94% over the 1994 census, of whom 62,278 are men and 64,611 women; no urban inhabitants were reported. With an area of 1,019.76 square kilometers, Ofla has a population density of 124.43, which is greater than the Zone average of 53.91 persons per square kilometer. A total of 29,571 households were counted in this wereda, resulting in an average of 4.29 persons to a household, and 28,717 housing units.

3.2. Methods and Materials

3.2.1. Objective One: Land use and land cover change classification of the study area.

For classification of the land use types based on the surface coverage, imageries of LANDSAT TM, ETM+ and LANDSAT 8 of the years 1986, 2000, 2010 and 2014 were used. Training data were collected from field works using GPS. These training sets were used for conducting the supervised classification and accuracy assessment. The signature editor and area of interest tools from ERDAS Imagine 9.2 were used so as to pick the signatures from the satellite images that represent each land use types based on the GPS data collected for better or accurate classification.

The Google Earth images with the resolution of 23.5 x 23.5 m were taken for better visual interpretation by linking with the satellite images for accurate classification. The Google Earth images were first downloaded from the USGS then captured in a jpg format and then opened in Arc GIS 10.1, geo-reference, rectify and then spatially reference the images so as to easily link with the Landsat imagery subject for the automatic land use and land cover classification. All the digitized AOIs for all land use types by linking Google Earth and Landsat images for the three different periods was saved on independent signature editors so as to classify independently for the three study periods. Related to the classification of the land use and land covers, the supervised image classification technique was applied in ERDAS Imagine 9.2 in order to compute. Finally, recoded images for all land use types were produced for all periods.

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. To assess the classification accuracy, confusion matrix was used. Confusion matrix indicates that the nature of the classification error and the overall accuracy is 82.11%. This shows 82.11% of the land use and land cover classes are correctly classified.

Dynamics was done in order to show the quantitative change of the land uses by combining different images of different years. This is the process of transforming linearly referenced data (also known as events) that have been stored in a table into features that can be displayed and analyzed on a map. Post classification comparison change detection technique was used in this research. This change detection method was applied and generated change detection maps on the (1986 and 2000), (2000 and 2007), (2007 and 2014) and (1986 and 2014). These land cover maps were compared pixel by pixel with the final results showing both change-no-change information as well as 'from to' land cover change information.

3.2.2. Objective Two: Assessing species diversities of forests, birds and fish.

3.2.2.1. Forest Species

Data on the standing vegetation was collected in 40 (10 m × 10 m) nested plots intervals in W-E parallel transects, which were spaced 50 m apart. The seedling bank composition and density was determined in 10 m × 10 m plots. All woody plants were identified and counted, and diameter at breast height (DBH) (measured with a caliper) was measured for plants with height > 2 m and DBH > 2 cm Species identified in the field.

In order to relate with the vegetation, environmental variables were measured in the field together with the vegetation measurement. The environmental variables measured were elevation (taken from a topographic map), slope (measured with a clinometer), and extent of disturbance was subjectively rank based on grazing intensity. Elevations were measured using GPS whereas slope was measured using clinometer.

3.2.2.2. Forest Structure and Diversity

The importance of a species was determined by calculating the importance value index (IVI), which is obtained by summing up relative density, relative dominance and relative frequency of a species (Freemark and Merriam, 1986). Density of a species is the number of individuals per hectare, frequency is the percentage of plots in which a species occurs, and dominance of a species is the sum of the basal area of individual stems.

(Lieberman et al., 1985) diversity numbers was derived from the Shannon diversity (H) and Simpson's index (D) of diversity indices which was unaffected by species richness and tend to be independent of sample size.

Equation 1: $(H) = -\sum_{i=1}^{s} pi\ ln\ pi$

In the Shannon index, **p** is the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N), **ln** is the natural log, **Σ** is the sum of the calculations, and **s** is the number of species.

Equation 2: $(D) = \sum_{i=1}^{s} (pi)2$

In the Simpson index, **p** is the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N), **Σ** is still the sum of the calculations, and **s** is the number of species.

The species area curve was determined using the number of species recorded in the nested plots. The vegetation of moist and dry forests was delineated by overlaying the plots that belong to either of the plant communities on the map of the study area in GIS. The location map, distance to the nearest stream, topographical wetness index, and a map showing the plant communities was developed using Arc GIS 10.1 software.

3.2.2.3. Bird and Fish Species

Ecological investigation of the species diversity and abundance of the birds was carried out by periodically walking within the study area, on a daily basis as well as on alternative days. Type, number of individuals, activity pattern and habitat association of birds of the area were carried out during the study period. This information was correlated with time of the day, weather condition and season of the year.

Data collection was carried out early in the morning from 7:00 to 10:00 a.m. and in the late afternoon from 3:00 to 6:00 p.m., when the activity of birds is prominent. The habitats and sites which are conducive to birds for access to food, water resources, nesting and roosting were also observed during the present study.

Birds in the study area were observed using naked eyes and binoculars for better identification as well as hand tally during counting. Digital camera photographs were also used for further confirmation of the bird species. Field data sheet were used to record the identified species. GPS was used to locate the points for the bird counting methods. Identification and categorization of birds to their respective taxonomic groups were done based on field guide books (Sinclair et al., 2003); (Buttemer et al., 2010).

Estimation of relative abundance of fish will do by the contribution of the catch in each sampling effort. Shannon diversity index (H) will use to evaluate relative abundance and diversity of fish, respectively. An index of relative importance is a measure of relative abundance or commonness of the species based on number and weight of individuals in catches as well as their frequency of occurrence (Kolding, 1993).

Shannon index of diversity (H)

The Shannon index of diversity (H) is a measure of species weighed by the relative abundance (Begon et al. 1990).

Shannon index of diversity (H) will be calculated using the formula below:

Equation 3: $$H' = -\sum_{i=1}^{s} pi\ ln\ pi$$

Where, pi - the proportion of individuals in the i^{th} species.

Data analysis

The data related to the bird species was analyzed using different diversity indices and estimate relative abundances. Species evenness, which measures the pattern of distribution of the bird populations present in the area, was evaluated using Shannon-Wiener evenness Index (E) as follows:

Equation 4: $E = H/ln(S)$

Where:

E = Shannon-Wiener Evenness Index

H' = Shannon-Wiener diversity Index

H max = ln S= natural logarithm of the total number of species (S) in each month (Tramer, 1969)

3.2.3. Objective Three: Analyze the implication of the natural resources for ecotourism development.

In order to assess the implication of the previous and existing natural resources as well as the changes observed overtime, data were collected using focus group discussion, interview, and observation. The focus group discussion was conducted with district and region experts who have keen involvement in natural resource conservation and development activities in the study area. Interviews were made with expert related to natural resources and the local people. Expert observation was also used. The data were qualitatively analyzed.

3.2.4. Objective Four: Identify the main management problems in relation to ecotourism resources of the area.

Sampling Design

Structured and semi- structured interviews were designed for sample households from local communities and other concerned stakeholders. The respondents from households of local communities were selected by systematic sampling from four Tabias or peasant associations based on approach of (Sarantakos, 1999).

Before the systematic samples carried out, the sampling fraction, the household population as target population and the estimate households as sample size were determined. The sampling fraction method which is symbolized by **k**, the samples was drawn from a sampling frame on the basis of the sampling fraction that is equal to **N/n**, where N is the number of households in the target population that is total households and n is the number of households as sample.

Equation 5: $k = N/n$

Where k= sampling fraction, N= target population and n=sample size

Data analysis

Descriptive statistics was used to analyze responses to the interviews to come up with results and discussions. Contingent valuation method was also employed (Dixon et al., 1994). This method (CVM) is a stated-preference technique, as in the individual "states" his preference (Mitchell and Carson, 2013).

Chapter Four: Results and Discussion

4.1. Land Use and Land Cover Classification

Land use and land cover percentage and the area coverage of each land category for each study year were derived from the four satellite image. Image classification of (1986, 2000, 2007 and 2014) has resulted in five land use and land cover classes: lake, grassland, forest, settlement and farmland. The intention was to separately identify the land use and land cover change of the study area. The four dates of land use and land cover classification map of the study area is presented in the figure 3, 4, 5 and 6 for the years 1986, 2000, 2007 and 2014 respectively.

4.1.1. Land Use and Land Cover in 1986

The proportion of the land use and land cover classes in 1986 of the study area is presented in this study (Table 3 and Figure 3). From the 1986 land use and land cover map interpretation; farmlands cover about 50% half of the study area. Forest accounted for about 29% whereas grassland covers about 12% of the land area of the study area. This shows that 91% of the total area of the study area was covered by farmland, forest and grassland and the remaining 9% was covered by lake and settlement.

Table 3: The proportion of the land classes of the study area in 1986

Class Name	Area coverage In hectare	Percentage
Lake	1418.04	9.182
Grassland	1848.78	11.971
Forest	4432.59	28.703
Settlement	26.91	0.174
Farmland	7716.42	49.967
Total	15442.74	100

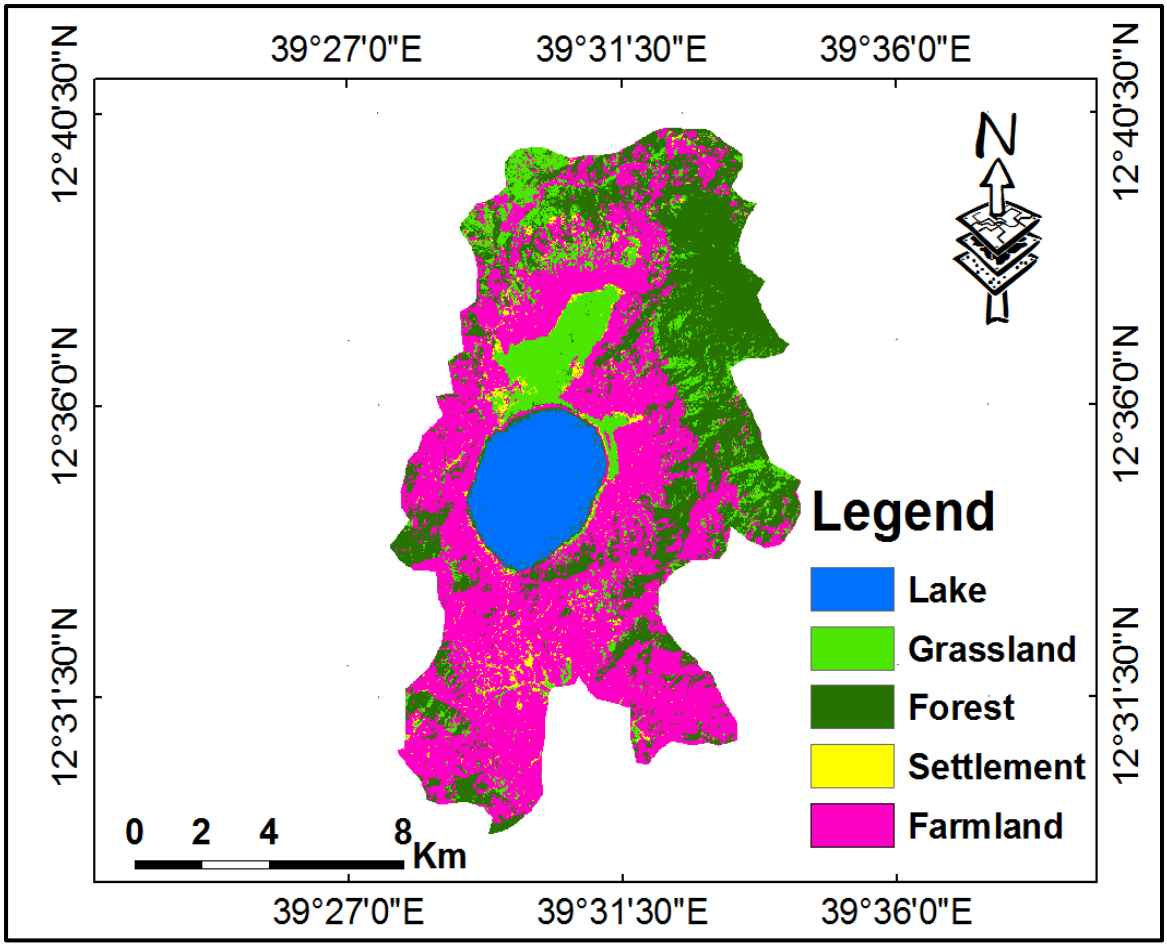

Figure 3: land use and land cover map of 1986

4.1.2. Land Use and Land Cover in 2000

From the 2000 land use and land cover map interpretation; the greatest share of land use and land cover as indicated in (table 4 and figure 4) was accounted by grassland for about 41% in the year 2000. Farmland and Forest take the share of 32% and 17% respectively. The remaining area was covered with lake and the settlement 9.07%. This shows that 91% of the total area of the study area was covered by grassland, farmland and forest and the remaining 9% was covered by lake and settlement.

Table 4: The proportion of the land classes of the study area in 2000

Class Name	Area coverage in hectare	Percentage
Lake	1380.45	8.939
Grassland	6379.92	41.313
Forest	2703.96	17.509
Settlement	11.4	0.073
Farmland	4967.01	32.164
Total	15442.74	100

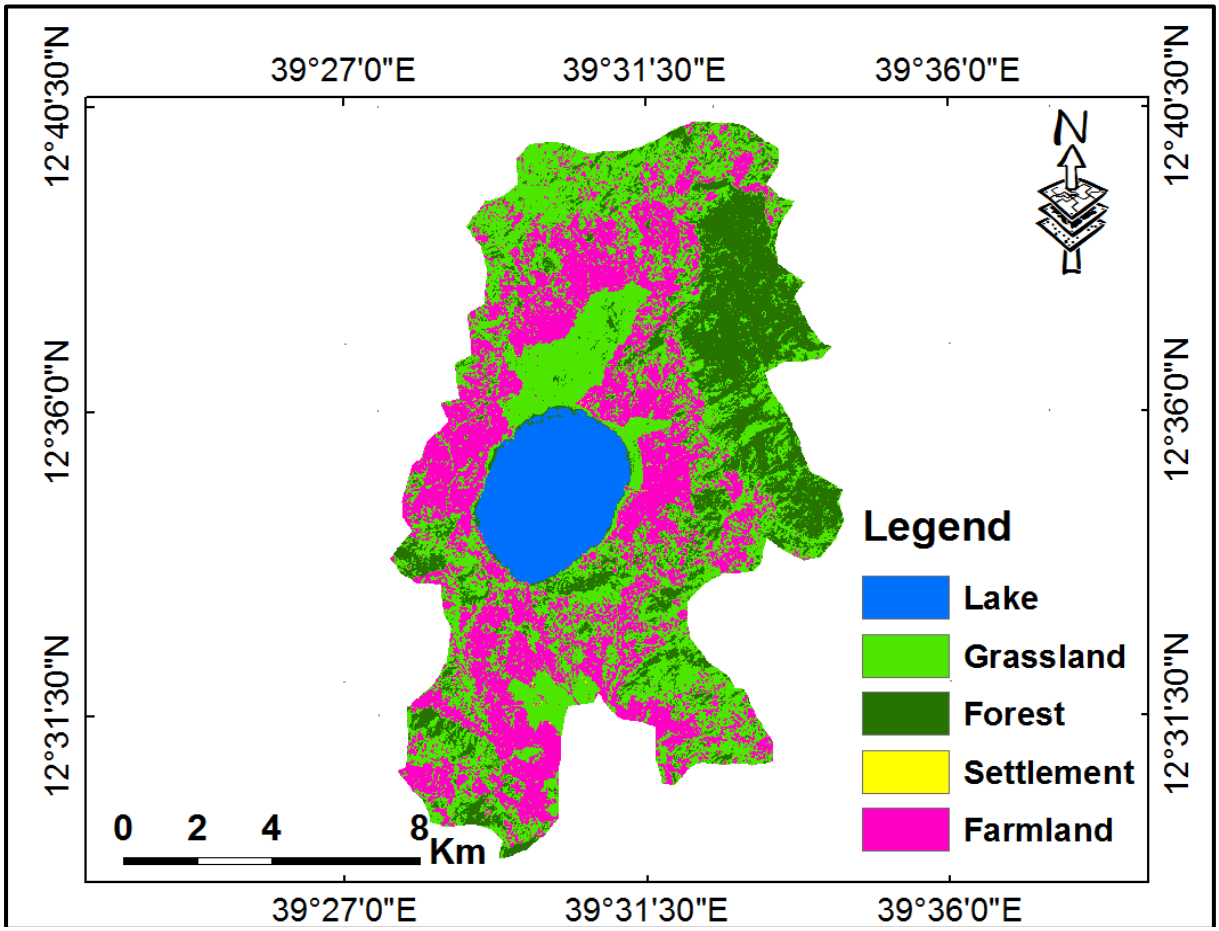

Figure 4: land use and land cover map of 2000

4.1.3. Land Use and Land Cover In 2007

The proportion of the land use and land cover classes in 2007 of the study area is presented in this study (Table 5 and Figure 5). The grassland areal coverage unit was about 51% half of the total area and farmland accounts about 31%. Land category under forest, lake and the settlement accounted 9%, 8.7% and 0.12 % respectively. This shows that 82% of the total area of the study area was covered by grassland and farmland and the remaining 8% was covered by forest, lake and settlement.

Table 5: The proportion of the land classes of the study area in 2007

Class Name	Area coverage in hectare	Percentage
Lake	1358.37	8.796
Grassland	7834.68	50.733
Forest	1445.04	9.357
Settlement	19.35	0.125
Farmland	4785.3	30.987
Total	15442.74	100

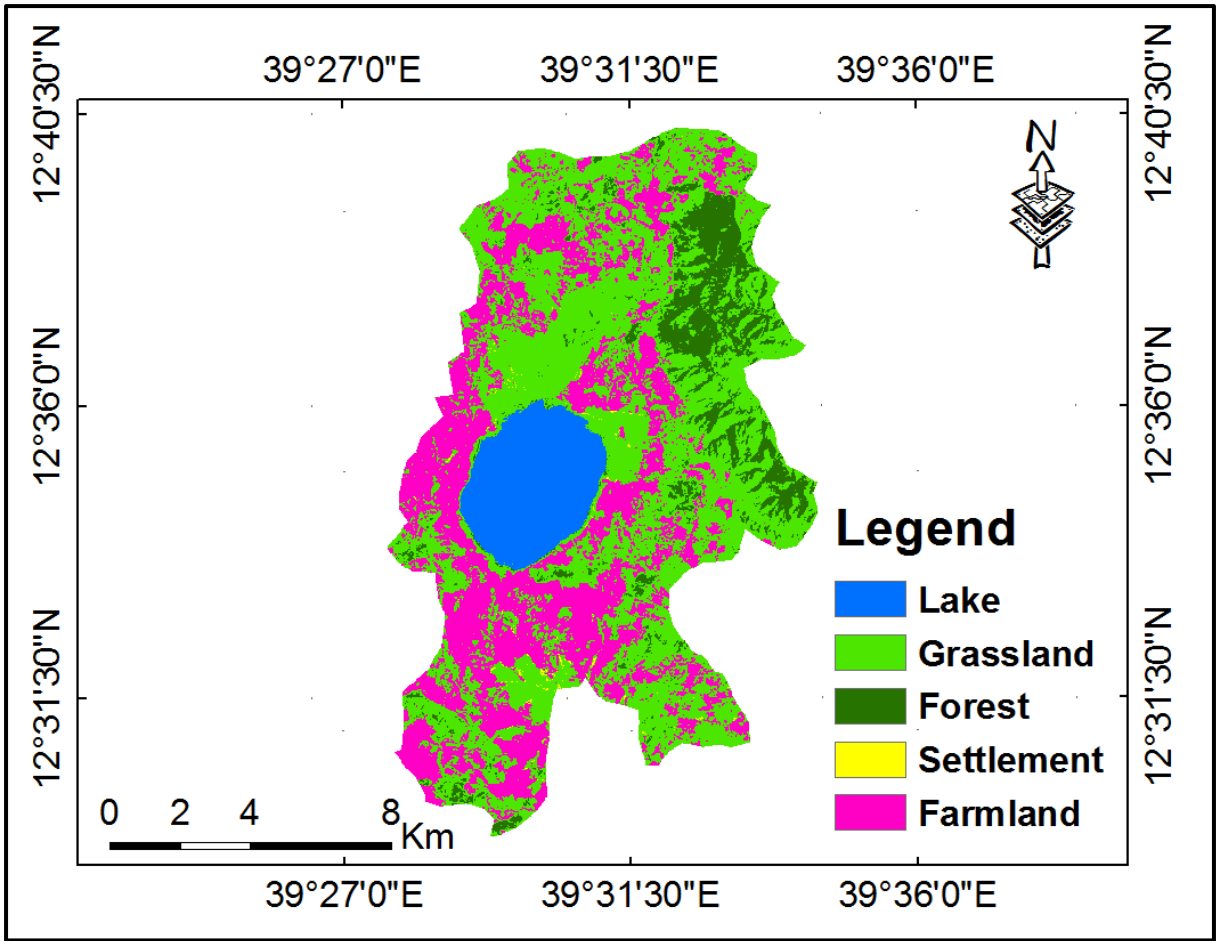

Figure 5: land use and land cover map of 2007

4.1.4. Land Use and Land Cover In 2014

In 2014 the greatest share of land use and land cover from all classes is farmland, which contributes an area of 47% of the total area. Forest and grassland accounted 33% and 11% respectively. Whereas the coverage of lake and settlement is 8.7% and 0.3% from the total area of the study area. This shows that 91% of the total area of the study area was covered by farmland, forest and grassland and the remaining 9% was covered by lake and settlement.

Table 6: The proportion of the land classes of the study area in 2014

Class Name	Area coverage In hectare	Percentage
Lake	1344.15	8.704
Grassland	1669.68	10.812
Forest	5148.99	33.342
Settlement	47.88	0.310
Farmland	7232.04	46.831
Total	15442.74	100

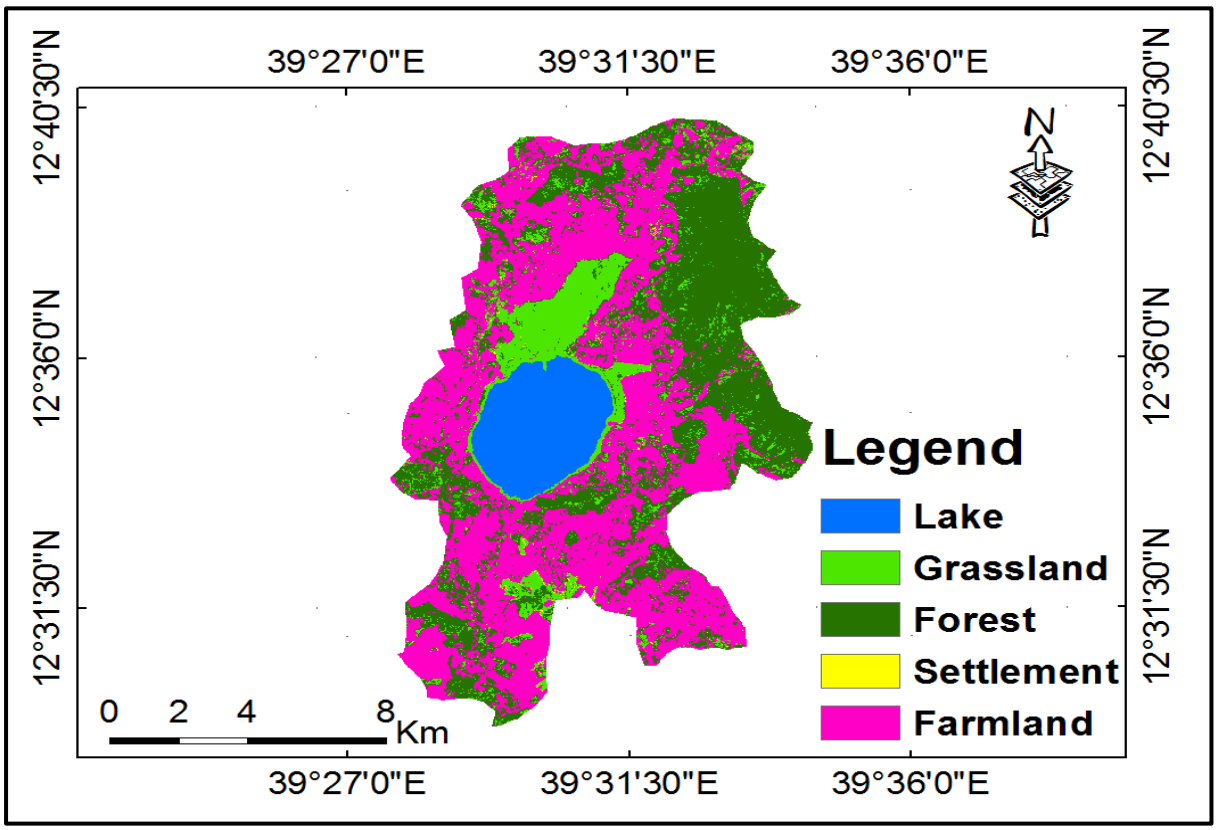

Figure 6: land use and land cover map of 2014

4.2. Land Use and Land Cover Change Detection from 1986 To 2014

An important aspect of change detection is to determine what is actually changing to what i.e. which land use class is changing to the other. This information will also serve as a vital tool in management decisions. This process involves a pixel to pixel comparison of the study year images through overlay analysis. The land use land cover change matrix depicts the direction of change and the land use type that remains as it is at the end of the day. For the land use land cover change matrix shown in (Table 7, 8, 9, 10 and 11) the rows represent the older land cover categories and the columns represent the newer categories

4.2.1 Land Use and Land Cover Change Detection from 1986 To 2000

The results of land use and land cover map as shown in (Table 7 and Figure 8) between 1986 and 2000, there was a dramatic increment of grassland to some extent followed by lake but due to the conversion of forest and farmland to grassland the areal coverage of forest, farmland and settlement shows a reduction.

Table 7: land use and land cover matrix between 1986 and 2000

Land use and land cover of 1986	**Land use and land cover type of 2000**						
	Class Name	Lake	Grassland	Forest	Settlement	Farmland	Total
	Lake	1417.7	0.18	0.12	0	0.04	1418.04
	Grassland	3.31	1348.47	263.4	0.81	232.79	1848.78
	Forest	0.41	1543.44	2665.32	0.18	223.24	4432.59
	Settlement	0.9	12.69	8.54	1.17	3.61	26.91
	Farmland	27.27	2618.35	187.29	9.18	4874.33	7716.42
	Total	1449.59	5523.13	3124.67	11.34	5334.01	15442.74
	Class change	31.89	4174.66	459.35	10.17	459.68	

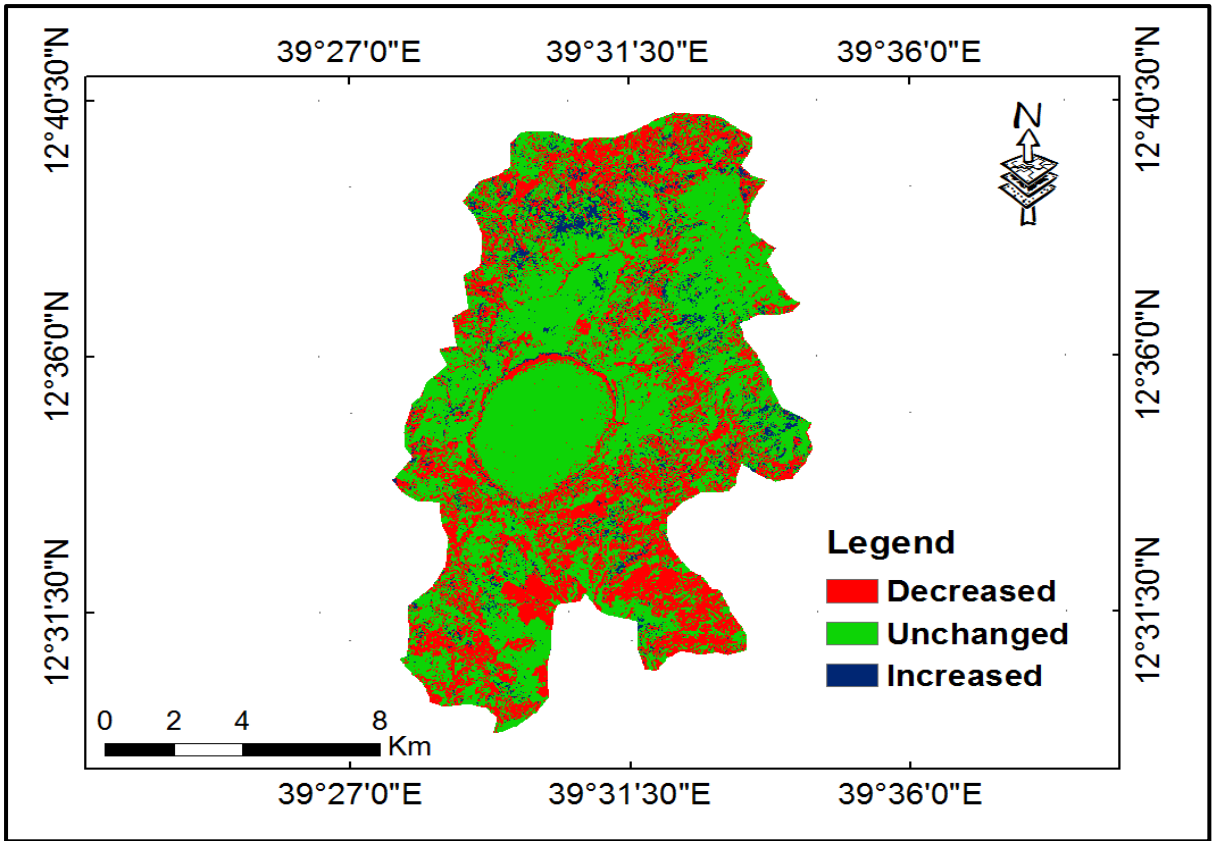

Figure 7: Land cover Change detection map of 1986 and 2000

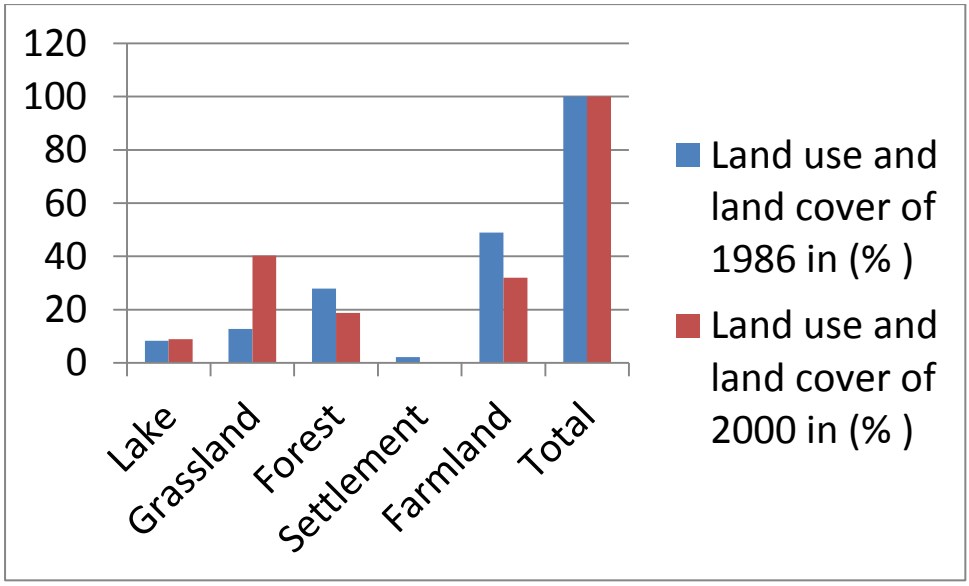

Figure 8: summary of land use and land cover extents by percentage (1986 and 2000)

4.2.2 Land Use and Land Cover Change Detection from 2000 To 2007

The results of land use and land cover map as shown in (Table 8 and Figure 10) between 2000 and 2007, there was an increment of grassland but the areal coverage of lake and forest almost unchanged. Whereas in the areal coverage of farmland shows a reduction.

Table 8: land use and land cover matrix between 2000 and 2007

Land use and land cover of 2000	Land use and land cover type of 2007						
	Class Name	Lake	Grassland	Forest	Settlement	Farmland	Total
	Lake	1356.56	0.36	0.96	0.09	0.4	1358.37
	Grassland	86.7	3949.71	1566.99	5.49	2225.79	7834.68
	Forest	3.11	319.95	1051.85	0	70.13	1445.04
	Settlement	1.8	1.34	0.82	0.18	15.21	19.35
	Farmland	25.4	1878.5	268.04	4.3	2609.06	4785.3
	Total	1473.57	6149.86	2888.66	10.06	4920.59	15442.74
	Class change	117.01	2200.15	1836.81	9.88	2326.47	

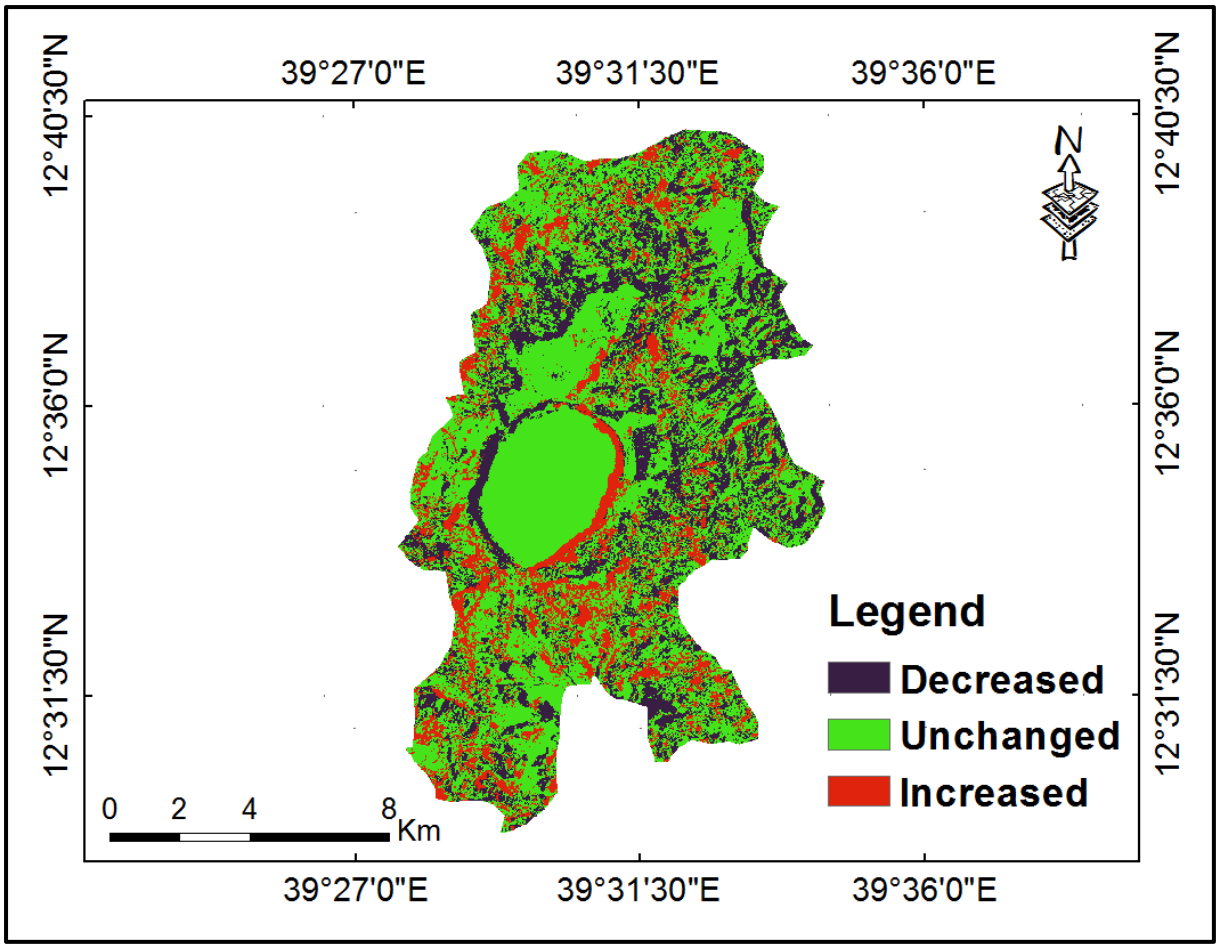

Figure 9: Land cover Change detection map of 2000 and 2007

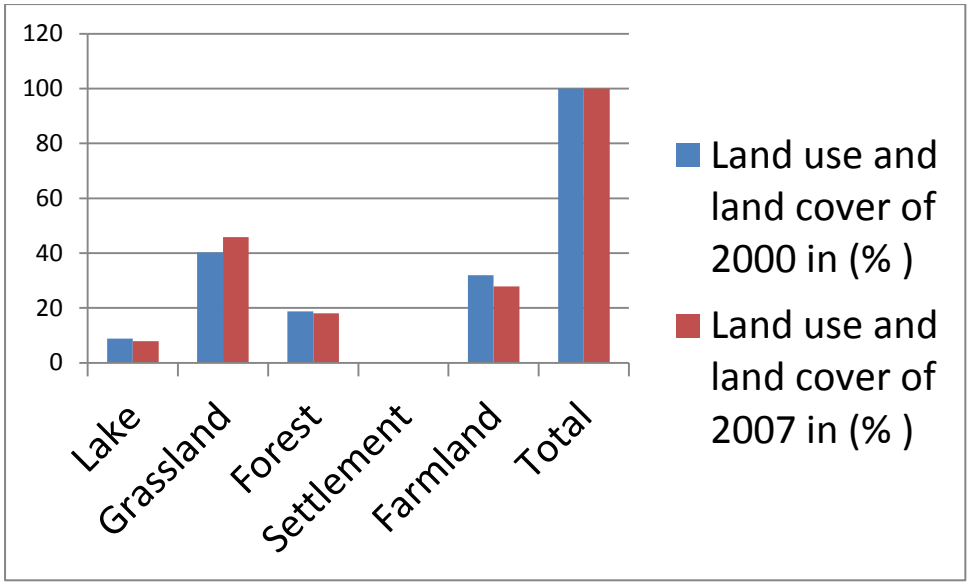

Figure 10: summary of land use and land cover extents by percentage (2000 and 2007)

4.2.3 Land Use and Land Cover Change Detection from 2007 To 2014

As shown in (Table 9 and figure 12) between 2007 and 2014, there was a dramatic increment of forest and farmland and unchanged to lake but due to the conversion of grassland to forest and farmland a dramatic reduction shown in the grassland. Whereas in the areal coverage of settlement shows a slight increment.

Table 9: land use and land cover matrix between 2007 and 2014

Land use and land cover of 2007	**Land use and land cover type of 2014**						
	Class Name	Lake	Grassland	Forest	Settlement	Farmland	Total
	Lake	1356.16	0.69	0.36	0.36	0.8	1358.37
	Grassland	82.98	1241.16	2937.87	32.63	3540.04	7834.68
	Forest	5.7	83.97	1214.05	0.27	141.05	1445.04
	Settlement	1.53	11.34	5.94	0.47	0.07	19.35
	Farmland	18.63	257.67	981.27	14.76	3512.97	4785.3
	Total	1465	1594.83	5139.49	48.49	7194.93	15442.74
	Class change	127.08	2264.94	1866.87	10.44	2326.47	

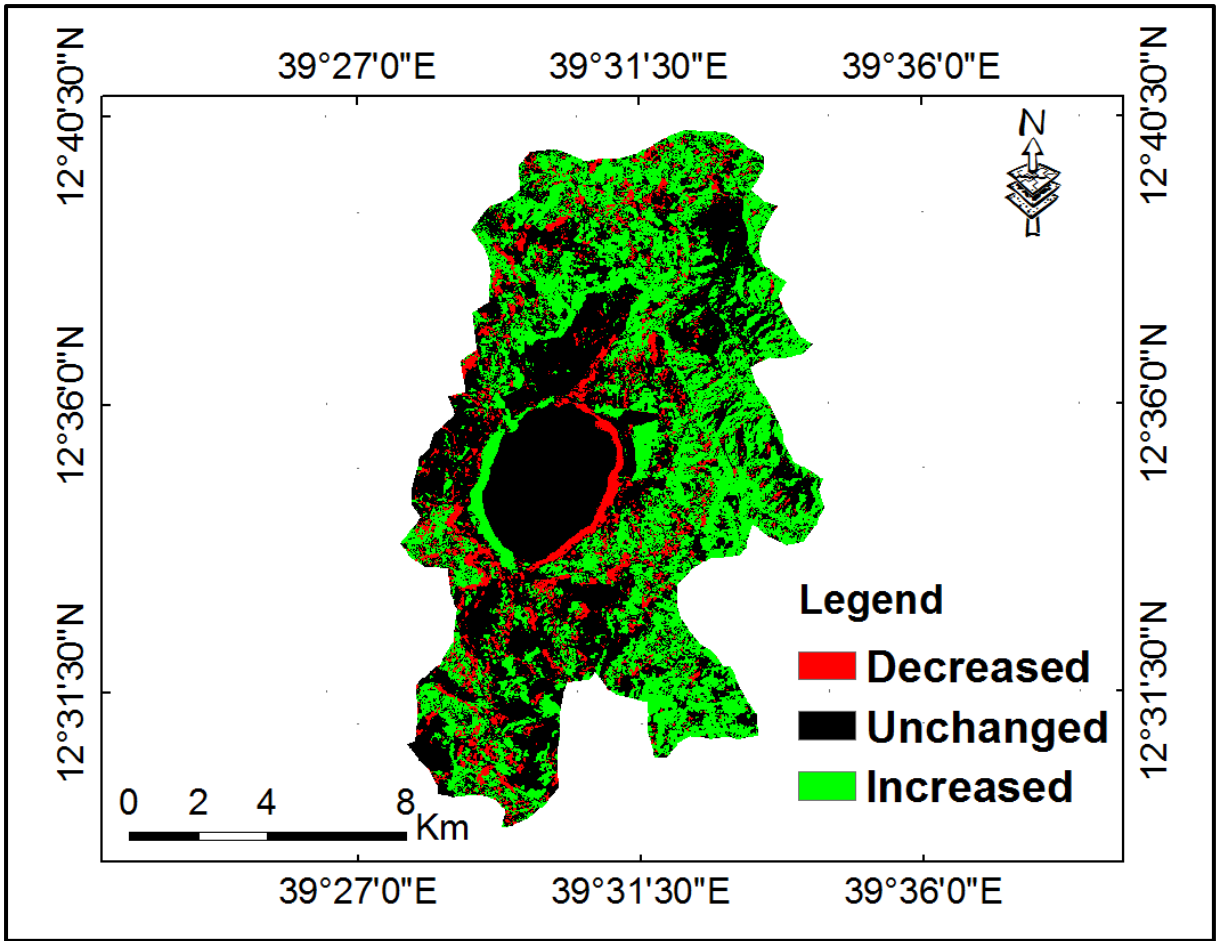

Figure 11: Land cover Change detection map of 2007 and 2014

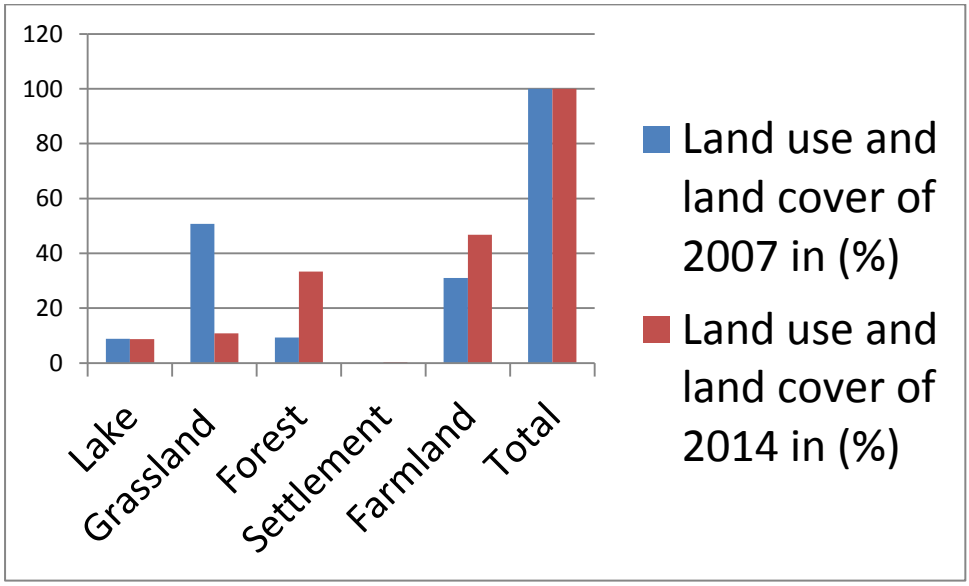

Figure 12: summary of land use and land cover extents by percentage (2007 and 2014)

4.2.4 Land Use and Land Cover Change Detection from 1986 To 2014

The results of land use and land cover map as shown in (Table 10 and Figure 14) between 1986 and 2014, there was an increment of forest but the areal coverage of lake and grassland almost unchanged. Whereas in the areal coverage of farmland shows a reduction due to conversion of farmland to forest. This is just the general impression of land cover dynamics based on comparison of individual land cover maps.

Table 10: land use and land cover matrix between 1986 and 2014

Land use and land cover of 1986	Land use and land cover type of 2014						
	Class Name	Lake	Grassland	Forest	Settlement	Farmland	Total
	Lake	1269.54	10.8	0	0	0	1280.34
	Grassland	0.63	796.05	653.49	11.16	506.25	1967.58
	Forest	59.67	343.26	3097.08	2.61	785.34	4287.96
	Settlement	0.09	123.3	52.83	6.48	149.04	331.74
	Farmland	14.22	394.38	1335.24	27.63	5803.65	7575.12
	Total	1344.15	1667.79	5138.64	47.88	7244.28	15442.74
	Class change	74.61	871.74	2041.56	41.4	1440.63	

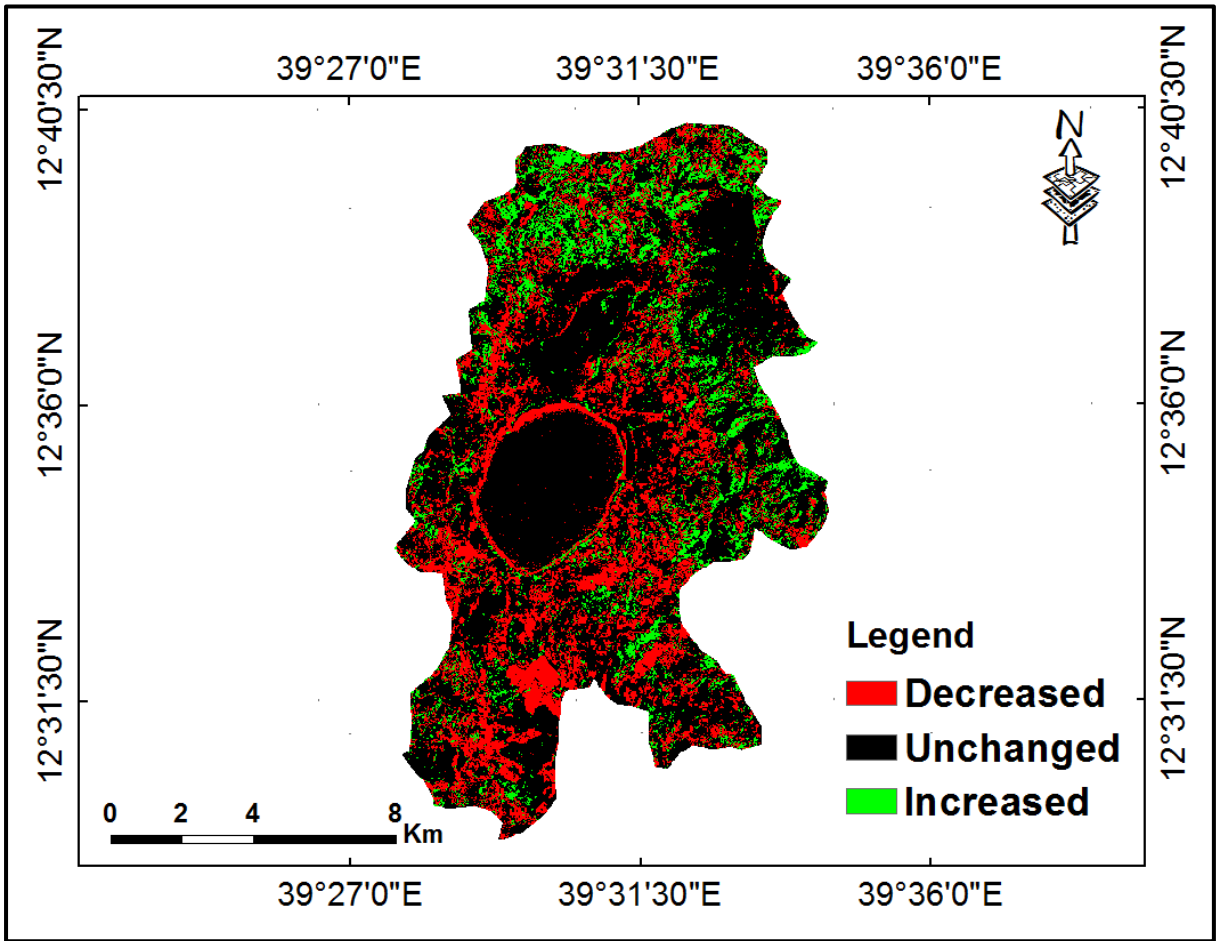

Figure 13: Land cover Change detection map of 1986 and 2014

Table 11: summary statistics of land use and land cover units: 1986, 2000, 2007 and 2014

Class Name	Year							
	1986		2000		2007		2014	
	Area/ha	%	Area/ha	%	Area/ha	%	Area/ha	%
Lake	1418.04	9.182	1380.45	8.939	1358.37	8.796	1344.15	8.704
Grassland	1848.78	11.97	6379.92	41.31	7834.68	50.733	1669.68	10.812
Forest	4432.59	28.7	2703.96	17.51	1445.04	9.357	5148.99	33.342
Settlement	26.91	0.174	11.4	0.073	19.35	0.125	47.88	0.31
Farmland	7716.42	49.97	4967.01	32.16	4785.3	30.987	7232.04	46.831
Total	15442.74	100	15442.74	100	15442.74	100	15442.74	100

The result of land use and land cover map as shown in (Table 11 and Figure 14) between 1986, 2000, 2007 and 2014, grassland increased in 2000 and 2007 with a rate of 1132.78 ha/year (29.4%) and 363.69 ha/year (9.423%) respectively. The increment of grassland in these periods was due to the conversion of 4496.85 ha and 1863.39 ha of farmland and forest to grassland as it is explained in the change matrix of (Table 7 and 8). This shows that there was a dramatic expansion of grassland within the specified time period. The expansion of grassland between 2000 and 2007 in the study area in general, could be directly related to winter season frost in the morning especially in December and January favorable to grassland.

On the contrary, forest and farmland had decreased from 2000 to 2007 with 432.15 ha/year (11.19%) and 314.73 ha/year (8.16%) and 687.35 ha/year (17.81%) and 45.42 ha/year (1.18%) rate of change. But it increases from 2007 to 2014 with a rate of 925.98 ha/year (23.99%) and 611.68 ha/year (15.85%). This is because of the replantation of forests and due to seasonal change to plough or tilling of farmland. Whereas the lake and settlement was almost continuously unchanged in all specified periods.

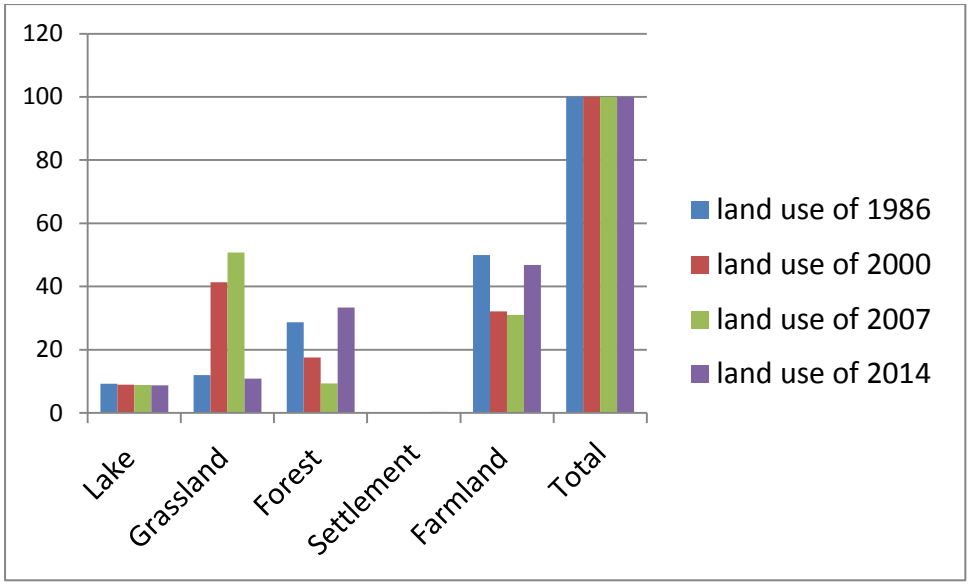

Figure 14: summary of land use and land cover extents by percentage (from 1986 to 2014)

4.3 Forest Species Composition

A total of 41 species belonging to 32 families were recorded as shown in (Appendix 2). The seven most abundant families were Fabaceae (4 species), Anacardiaceae (2), Apocynaceae (2), Celastraceae (2), Cupressaceae (2), Sapindaceae (2), Solanaceae (2). Regarding plant life forms, the forest is composed of 56 % shrub, 44 % tree species. Cynanchum abyssinicum Decn., Clerodendron myricoides (Hochst.) Vatke, F. sur Forssk., Phytolacca dodecandra L.Herit., Pittosporum viridiflorum Sims, Rumex nervosus Steud.ex A.Rich., Grewia ferruginea Hochst.exA.Rich. and Celtis africana Burm.f. are exotic species, while the remaining species are native. Juniperus procera Hochst.ex.Endl., Cadia purpurea (Picc.) Ait. and Cupressus lusitanica Miller are the three dominant species that contributed 46 % of the total species abundance as clearly shown in (Appendix 1).

Figure 15: The most dominant species forest (Juniperus procera Hochst.ex.Endl)

4.4 Bird Species Composition

A total of 66 species of birds grouped under 19 families were recorded as shown in (Table 12). Family Alopochen aegyptiacus (20.07%) had the highest number of species. Family Anatidae contributed 13 species, of this 2 are species residents and 11 species common followed by family Scolopacidae 10 species, and of this all of species are resident. Out of the species recorded in the area 2 species (3.07%) was endemic, 19 (29.23%) resident, and 46 (70.76%) migrant. The two endemic bird species in the study area are the Bostrychia carunculata (Family name Threskiornithidae) and Rougetius rougetii (Family name Rallidae) (Table 8). Six family, Anhingidae, Glareolidae, Motacillidae, Otididae, Phoenicopteridae, and Scopidae were representing only by one species. Alopochen aegyptiacus and Gallinago gallinago are the two dominant species that contributed 32 % of the total species abundance as clearly shown in (Appendix 3).

Figure 16: The most dominant species of bird (Alopochen aegyptiacus)

Picture 16.1: The most dominant species of bird (Alopochen aegyptiacus)

Table 12: Total number of species contribution, Resident, Migratory and Abundant species in the family of birds.

Family	NS	NRS	NMS	AS
Anatidae	13	2	11	Alopochen aegyptiacus
Anhingidae	1	0	1	Anhinga rufa
Ardeidae	7	1	6	Bubulcus ibis
Burhinidae	3	3	0	Burhinus vermicu-latus
Charadriidae	3	2	1	Charadrius tricollaris
Ciconiidae	5	1	4	Ciconia nigra
Glareolidae	1	0	1	Glareola pratincola
Motacillidae	1	0	1	Motacilla flava
Otididae	1	1	0	Lissotis melanogaster
Pelecanidae	2	0	2	Pelecanus onocrotalus
Phalacrocoracidae	2	0	2	Microcarbo africanus
Phoenicopteridae	1	1	0	Phoenicopterus minor
Podicipedidae	3	0	3	Podiceps nigricollis
Rallidae	3	3	0	Fulica cristata
Recurvirostridae	3	1	2	Himantopus himantopus
Scolopacidae	10	0	10	Gallinago gallinago
Scopidae	1	0	1	Scopus umbretta
Sternidae	2	0	2	Sternula albifrons
Threskiornithidae	4	3	1	Threskiornis aethiopicus
Total	66	18	48	

Source: Department of Biology, Mekelle University, March 2014

4.5 Fish Species Composition

Lake Hashenge has two commercially important species of fish and grouped under two families. Common carp was highly represented in the lake. Fish production is one of source of income to the local people. There are two fish cooperatives who have their own motor boat and each cooperative harvest an average of 85 up to 110 both " Koreso and Duba" types of fishes per day.

Table 13: Fish species and Family of the study area

No	Fish Species	Scientific (family) Name	Local Name
1	Common carp (Chinese carp)	*Cyprinidae*	Duba
2	Nile Tillapia	*Oreochromis niloticus*	Koreso

Figure 17: The dominant species of fish Chinese carp

Figure 18: The species of fish (Nile Tillapia)

4.6 Tourism Potentials of the Watershed

The survey of natural resources indicated that natural attractions or resources are the main ecotourism potentials in the study area. These resources include forest, bird, fish and scenery of landscape, attractive culture, and indigenous knowledge at nearby areas (Table 14). Therefore, it is possible to say that the study area is where ecotourism business can operate.

Table 14 presents different types of ecotourism potentials in different sites of the study area. For example, Lake Hashenge and the surrounding area of the watershed have a good topographic view with attractive landscape. The presence of cattle grazing with a large number of cattle population, large size of birds flying around the lake and swimming in the lake, and the presence of the Hugumburda forest (as a home of a variety of flora and fauna) nearby the watershed are untouched and unutilized tourist attraction sites.

Table 14: locations and major tourist attractions in the study area

No	Location sites in the study area	Tourist attractions
1	Lake Hashenge	Bird watching, fish, watching cattle in the vast grazing land, the ever green grass land and watching the attractive landscape
2	Hugumburda protected forest area	Watching the ever green forest diversity, collective melody sound of different wild life, birds and gorgeous landscape in and around the area

In general, there are ecotourism potentials in and around Lake Hashenge, which can attract tourists and may contribute to conservation of natural resources if they are developed. (Holden, 2009) also acknowledged that the ecotourism resource in protected areas could generate more revenues, which could benefit the local people and contributed to conservation of protected areas.

Figure 19: The dense forest and the attractive landscape in Hugumburda partly

Figure 20: Birds of the lake partly

4.7 Discussion

The land use and land covers for the respective years show a significant transformation, As shown in (Table 3) of 1986 farmland and forest covered 50% and 29% of the total area, respectively. Grassland shared 12%, Lake 9% and settlements constituted less than 1% of the area. But in 2000, after four years, farmland and forest declined to 32% and 17% respectively. While grassland increased to 41%. In 2007, as shown in (Table 5) grassland and farmland covered 50% and 31% of the total area respectively. But in 2014, as shown in (Table 6) after seven years grassland declined to 11%, whereas forest and farmland increased to 33% and farmland to 46%. In general form 1986 to 2014, after three decades, the forest increased and farmland decreased by 4%. But grassland, lake and settlement the change was less than 1%.

As shown in (Appendix 1) the most abundant family type of forest was identified from the classification strategies and this is Fabaceae. This family type is dominated by Cadia purpurea (Picc.) Ait. The stands sampled in this type are located at the middle of the forest, which is less grazed by cattle and its human impact is found to be low. Regenerating species of Juniperus procera and Cupressus lusitanica Miller are common here.

Juniperus procera and Cupressus lusitanica Miller has experienced human interference in the form of selective cutting. Cattle interferences were also observed in some of its stands. Opuntia ficus-indica (L.) Mill, Cynanchum abyssinicum Decn, Rumex nervosus Steud.ex A.Rich, Pittosporum viridiflorum Sims, Grewia ferruginea Hochst.exA.Rich, Celtis africana Burm.f, and F. sur Forssk are the endangered species. The stands sampled in this community are located in an area having shallow soils with medium human interference in the form of firewood collection and selective cutting. This might be due to being near to the farmer's settlement area. Although most area of this stands was highly affected before about 20 years being used as farming land, by now it is in good regeneration status.

Birds in the study area were observed either throughout the year or during specific times of the year only. Some birds were observed exclusively during the wet season while others only during the dry season. There were also bird species with high number of individuals at specific times of a year. These all were due to the availability of resources and favorability of the weather conditions. Food resources are the most important attractant feature for the birds.

The abundance of birds in the study area showed that there is statistically significant variation between months as well as between seasons. This was also determined by the presence and absence of resources on which birds depend at different times of the year.

Uncommon bird species were very abundant in the area because of the favorability of the area to satisfy their requirements during both seasons. These birds were obtain food and water resources available within and around the study area. These include their food from the lake, grass land and farmlands around the study area. The natural habitats were also major attractant features for the birds to be present in the study area. Some of the bird species were observed in restricted months of a year only. This was mainly due to the availability of resources that can attract the birds at different times of a year. Some of the birds in the study area were observed in large numbers during particular time of a year.

The lake is dominated by Nile Tilapia and one Garra species. The change in the species number following turbidity and water level fluctuation of shallow lakes is documented by various authors (e.g. Lakes: (Kalk, 1979); (Mengestou, 1991); (Hart, 1986); Ziway this study). Absence of species mainly cladocerans during periods of high turbidity (Hart, 1986; (Marshall, 2007); this study) is the result of direct negative effects of turbidity on cladocerans (e.g. feeding interference) or, indirectly, through low food quality caused by light limited growing phytoplankton.

The results of the analysis of the structured and semi- structured interview of sample respondents (sample from the local community, members of the two fish catchers association, and experts of agriculture and tourism in wereda and Regional levels), reveal that the areas around the lake are still unprotected, undefined and deteriorating. The deterioration is due to mainly agricultural expansion and other anthropogenic factors. The absence of dams in the tributaries of the lake to block the eroded materials from the surrounding highland areas has also been identified as a major cause. Moreover, the existence of different chemicals in the surrounding agricultural land which potentially pollute the lake, the absence of guards, less attention of authorities to the lake are also some of the problems pointed out during the interview.

Chapter Five: Conclusion and Recommendation

5.1. Conclusion

The present study area is composed of five major land use and land cover types; lake, grassland, forest, settlement and farmland. The quantitative evidences of land cover dynamics presented were delivered by repeated satellite images coupled by GIS analyses. From the analyzed results, the magnitude of land use and land cover in general was observed between the year 1986, 2000, 2007 and 2014, and generating land use and land cover map using GIS techniques of the study area. For Accuracy Assessment Classification error matrix was done. Change Detection between the images for all the land use and land cover classes were computed. The most extensive land cover category of the study area is farmland i.e. 46.8%. The second most extensive land cover category is forest 33.3% in 2014.

The survey showed that the forest is dominated by small sized tree and shrub species in secondary stage of development, indicating that the forest was heavily exploited and affected in the previous periods, but good regeneration is in process at the present time. The natural lake is the only breeding site to water bird species and fish in the study area. The lake and the surrounding are suitable for breeding and living to many birds and fish. The areas around the lake is the another alternative promising site to increase bird diversity. But the sites are still unprotected, undefined and deteriorating in area by agricultural expansion and other anthropogenic factors especially there were no dams in the tributaries of the lake. No one guards in the lake; this shows that less attention is given to the benefits of the lake.

The survey also showed that the natural resources of the watershed are the main ecotourism potentials include diverse species of birds, forest, the lake and beautiful landscape attractions. In general, the study attempted to reveal some ecotourism potentials or alternative options, which benefited the local communities, as well as the region while sustainable management of natural resources of the study area achieved.

5.2. Recommendation

Protection of the study area's natural resources is essential for the future of the tourism industry, as well as quality of life for residents and the environment as a whole. As discussed in the main body, the lake, the forest, birds and fish even if the landscape are the most relevant components of the overall environment to the visitor industry. In order to do it a suitable destination of tourists, it should linked with the construction of general infrastructure such as roads and airports, and of tourism facilities, including resorts, hotels, restaurants, shops and golf courses (because the study area has vast suitable grassland for playing golf).

To improve the natural diversity and structure of the forest, to minimize the influence of the surrounding communities and utilize the forest resources sustainably for present and future generation, the basic needs and traditional rights of the communities over the uses of forest resources should be recognized. The much-needed positive attitudes towards forest protection and development can only be obtained from the rural communities through the development of a genuine benefit sharing mechanism. Thus, community participation is quite important.

As the study area's population continues to grow, the need to provide housing, and fire wood to this population will continue to exert pressure on natural areas. The greatest pressures on the lake are erosion (the tributaries are from the surrounding high lands and there is no dam to block the eroded materials and this can be affect the fluctuation of the lake and depth), pollution (chemicals from the farm lands around the lake), and loss of marine life. The loss of natural resources would prevent Hashenge watershed from being center of tourism industry, from taking better advantage of our unique natural resources. Expansion of tourism market with regard to natural resources could help fund better management and protection practices and make residents more aware of the resources, the human impact on these resources, and what we can do to help protect them. A well-managed natural environment also produces a healthier population. Another illustration of how natural resources are essential for human resources, tourism and overall economic development. Because of the attractiveness, wonderful sites and natural resources are identified as valuable and the need to keep the attraction alive can lead to creation of center of tourism in the study area.

Establishing buffer zone is compulsory in order to create a sharp and indisputable division line between forest land and agricultural land and between the lake and agricultural land. The lake without excessive investment by its nature it could be a recreational place.

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Appendix 1

List of forest species (family name) with the result of Shannon Index (H) and Simpson Index (D)

No	Family Name	Local Name	Ns	pi	pi^2	ln pi	Pi ln pi
1	Anacardiaceae	Tetaelo	3	0.003	0.053	-5.873	-0.017
2	Anacardiaceae	Atam	4	0.004	0.061	-5.585	-0.021
3	Apocynaceae	Meroz	11	0.010	0.102	-4.574	-0.047
4	Apocynaceae	Egam	112	0.105	0.324	-2.253	-0.237
5	Asclepiadaceae	Hareg	1	0.001	0.031	-6.972	-0.007
6	Asteraceae	Tsaeda-kotsilo	6	0.006	0.075	-5.180	-0.029
7	Cactaceae	Beles	4	0.004	0.061	-5.585	-0.021
8	Celastraceae	Dawija	8	0.008	0.087	-4.892	-0.037
9	Celastraceae	Ats-ats	69	0.065	0.254	-2.738	-0.177
10	Cupressaceae	Tsihdi-ferenji	122	0.114	0.338	-2.168	-0.248
11	Cupressaceae	Tsihdi-adi	219	0.205	0.453	-1.583	-0.325
12	Ebenaceae	Kuliow	11	0.010	0.102	-4.574	-0.047
13	Euphorbiaceae	Hirtmtmo	4	0.004	0.061	-5.585	-0.021
14	Fabaceae	Chia	24	0.023	0.150	-3.794	-0.085
15	Fabaceae	Shilaen	152	0.143	0.378	-1.948	-0.278
16	Fabaceae	Hitsawits	58	0.054	0.233	-2.911	-0.158
17	Fabaceae	Konteftefe	9	0.008	0.092	-4.774	-0.040
18	Flacourtiaceae	Tuemtenay	21	0.020	0.140	-3.927	-0.077
19	Lamiaceae	Shiwhe	1	0.001	0.031	-6.972	-0.007
20	Loganiaceae	Tequare	26	0.024	0.156	-3.714	-0.091
21	Meliaceae	Kot	2	0.002	0.043	-6.279	-0.012
22	Melianthaceae	Mirkus-zibe	22	0.021	0.144	-3.881	-0.080
23	Moraceae	Shanfa	1	0.001	0.031	-6.972	-0.007
24	Oleaceae	Awlie	22	0.021	0.144	-3.881	-0.080
25	Oliniaceae	Ale-ale	3	0.003	0.053	-5.873	-0.017
26	Phytolaccaceae	Shimti	1	0.001	0.031	-6.972	-0.007
27	Pittosporaceae	Mayliho	1	0.001	0.031	-6.972	-0.007
28	Polygonaceae	Hohot	1	0.001	0.031	-6.972	-0.007
29	Podocarpaceae	Zigba	68	0.064	0.253	-2.752	-0.176
30	Rhamnaceae	Kenchelchele	5	0.005	0.068	-5.362	-0.025
31	Rhizophoracea	Keyhom	3	0.003	0.053	-5.873	-0.017
32	Rubiaceae	Tsehag	8	0.008	0.087	-4.892	-0.037
33	Rutaceae	Salih	8	0.008	0.087	-4.892	-0.037
34	Santalaceae	Kerets	6	0.006	0.075	-5.180	-0.029
35	Sapindaceae	Meara	5	0.005	0.068	-5.362	-0.025
36	Sapindaceae	Tahsos	12	0.011	0.106	-4.487	-0.051
37	Solanaceae	Berbereawald	1	0.001	0.031	-6.972	-0.007

38	Solanaceae	Engule	12	0.011	0.106	-4.487	-0.051
39	Tiliaceae	Meleglega	1	0.001	0.031	-6.972	-0.007
40	Ulmaceae	Moto-koma	1	0.001	0.031	-6.972	-0.007
41	Urticaceae	May-awalie	18	0.017	0.130	-4.081	-0.069
Total			1066	1.000	4.813	-201.684	-2.719

S (number of species) = 41
N (total number of individuals) = 1066
Σ (sum) of pi^2 $(n/N)^2$= 4.813
Σ (sum) of pi ln pi= 2.719

Appendix 2

Forest Species identified in Hugumburda

No	Species Name	Family Name	Local Name	Habit
1	Rhus glutinosa A.Rich.	Anacardiaceae	Tetaelo	Tree/Shrub
2	R. natalensis Krauss9	Anacardiaceae	Atam	Tree
3	Acokanthera schimperi (A.DC.) Benth.	Apocynaceae	Meroz	Tree/Shrub
4	Carissa edulis (Forssk.) Vahl	Apocynaceae	Egam	Shrub
5	Cynanchum abyssinicum Decn.	Asclepiadaceae	Hareg	Climber
6	Conyza hypoleuca A.Rich.	Asteraceae	Tsaeda-kotsilo	Shrub
7	Opuntia ficus-indica (L.) Mill	Cactaceae	Beles	Shrub
8	Maytenus arbutifolia (A.Rich.) Wilczek	Celastraceae	Dawija	Tree/Shrub
9	M. undata (Thunb.) Blakelock	Celastraceae	Ats-ats	Tree/Shrub
10	Cupressus lusitanica Miller	Cupressaceae	Tsihdi-ferenji	Tree
11	Juniperus procera Hochst.ex.Endl.	Cupressaceae	Tsihdi-adi	Tree
12	Euclea racemosa subsp. schimperi (A.DC.) Dandly	Ebenaceae	Kuliow	Shrub
13	Clutia abyssinica Jaub. & Spach.	Euphorbiaceae	Hirtmtmo	Shrub
14	Acacia abyssinica Hochst.ex Benth.	Fabaceae	Chia	Tree
15	Cadia purpurea (Picc.) Ait.	Fabaceae	Shilaen	Shrub
16	Calpurnia aurea (Ait) Benth.	Fabaceae	Hitsawits	Tree/Shrub
17	Pterollobium stellatum (Forssk.) Brenan	Fabaceae	Konteftefe	Shrub
18	D. verrucosa (Hochst.) Warb.	Flacourtiaceae	Tuemtenay	Shrub
19	Clerodendron myricoides (Hochst.) Vatke	Lamiaceae	Shiwhe	Shrub
20	Nuxia congesta R.Br.ex.Fresen	Loganiaceae	Tequare	Tree
21	Ekebergia capensis Sparrm.	Meliaceae	Kot	Tree
22	Bersama abyssinica Fresen.	Melianthaceae	Mirkus-zibe	Tree/Shrub
23	F. sur Forssk.	Moraceae	Shanfa	Tree
24	Olea europaea subsp cuspidate (Wall. ex DC.) Cifferri	Oleaceae	Awlie	Tree
25	Olinia rochetania A.Juss.	Oliniaceae	Ale-ale	Tree
26	Phytolacca dodecandra LHerit.	Phytolaccaceae	Shimti	Shrub
27	Pittosporum viridiflorum Sims	Pittosporaceae	Mayliho	Tree/Shrub
28	Rumex nervosus Steud.ex A.Rich.	Polygonaceae	Hohot	Shrub
29	Podocarpus (Afrocarpus) falcatus (Thun) Mirb.	Podocarpaceae	Zigba	Tree
30	Sageretia thea (Osbeck) M.C.Johnston	Rhamnaceae	Kenchelchele	Shrub
31	Cassipourea malosana (Baker) Alston	Rhizophoracea	Keyhom	Tree
32	Psydrax schimperiana (A.Rich.) Bridson	Rubiaceae	Tsehag	Shrub
33	Teclea simplicifolia (Engl.) Verdoorn	Rutaceae	Salih	Tree/Shrub
34	Osyris quadripartite Decn.	Santalaceae	Kerets	Tree
35	Allophylus macrobotrys Gilg	Sapindaceae	Meara	Tree/Shrub
36	Dodonaoea angustifolia L.f.	Sapindaceae	Tahsos	Shrub
37	S. schimperianum Hochst. ex A.Rich.	Solanaceae	Berbereawald	Shrub
38	Solanum incanum L.	Solanaceae	Engule	Shrub

39	Grewia ferruginea Hochst.exA.Rich.	Tiliaceae	Meleglega	Tree/Shrub
40	Celtis africana Burm.f.	Ulmaceae	Moto-koma	Tree
41	Debregeasia bicolar (Roxb.) Wedd.	Urticaceae	May-awalie	Shrub

Appendix 3

List of bird species (family name) with the result of Shannon Index (H) and Simpson Index (D)

Family	Species	NS	pi	pi2	ln pi	pi ln pi
Anatidae	Alopochen aegyptiacus	13	0.197	0.444	-1.625	-0.320
Anhingidae	Anhinga rufa	1	0.015	0.123	-4.190	-0.063
Ardeidae	Bubulcus ibis	7	0.106	0.326	-2.244	-0.238
Burhinidae	Burhinus vermicu-latus	3	0.045	0.213	-3.091	-0.141
Charadriidae	Charadrius tricollaris	3	0.045	0.213	-3.091	-0.141
Ciconiidae	Ciconia nigra	5	0.076	0.275	-2.580	-0.195
Glareolidae	Glareola pratincola	1	0.015	0.123	-4.190	-0.063
Motacillidae	Motacilla flava	1	0.015	0.123	-4.190	-0.063
Otididae	Lissotis melanogaster	1	0.015	0.123	-4.190	-0.063
Pelecanidae	Pelecanus onocrotalus	2	0.030	0.174	-3.497	-0.106
Phalacrocoracidae	Microcarbo africanus	2	0.030	0.174	-3.497	-0.106
Phoenicopteridae	Phoenicopterus minor	1	0.015	0.123	-4.190	-0.063
Podicipedidae	Podiceps nigricollis	3	0.045	0.213	-3.091	-0.141
Rallidae	Fulica cristata	3	0.045	0.213	-3.091	-0.141
Recurvirostridae	Himantopus himantopus	3	0.045	0.213	-3.091	-0.141
Scolopacidae	Gallinago gallinago	10	0.152	0.389	-1.887	-0.286
Scopidae	Scopus umbretta	1	0.015	0.123	-4.190	-0.063
Sternidae	Sternula albifrons	2	0.030	0.174	-3.497	-0.106
Threskiornithidae	Threskiornis aethiopicus	4	0.061	0.246	-2.803	-0.170
Total		66	1.000	4.007	-62.222	-2.611

S (number of species) = 19
N (total number of individuals) = 66
Σ (sum) of pi^2 $(n/N)^2$= 4.007
Σ (sum) of pi ln pi= 2.611