ASSESSMENT OF LAND USE/COVER, ECOSYSTEM SERVICES AND RURAL LIVELIHOODS CHANGES: THE CASE OF WALGA WATERSHED, SOUTH WEST SHEWA, ETHIOPIA

MSc. Thesis

BELETU CHALA GELETE

JUNE, 2016

JIMMA, ETHIOPIA

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A Thesis Submitted to the College of Agriculture and Veterinary Medicine, School of Graduate Studies, Jimma University

In Partial Fulfilment of the Requirements for the Degree of Master of Science in Natural Resource (Watershed Management)

Beletu Chala Gelete

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DEDICATION

This thesis is dedicated to my beloved families and husband.

STATEMENT OF THE AUTHOR

I, the undersigned, declare that this Thesis is my work and is not submitted to any institution elsewhere for the award of any academic degree, diploma or certificate and all sources of materials used for this Thesis have been duly acknowledged. This Thesis has been submitted in partial fulfillment of the requirements for M.Sc., degree at Jimma University, College of Agriculture and Veterinary Medicine and deposited at the University Library to be made available to borrowers under the rules of the library.

Name: Beletu Chala Gelete

Place Jimma University, Jimma

Signature _______________

Date __________________

BIOGRAPHICAL SKETCH

The author Beletu Chala Gelete was born on 21 July 1989, in Tole district, South West Shewa zone, Ethiopia. She had attended her elementary school at “Maallimaa Sadan Bottonnee” School from 1994 to 2002, secondary and preparatory education at Yehibrat Fire Senior secondary School from 2002 to 2006. Beletu Chala Gelete studied Natural Resource Management at Madda Walabu University from 2007 to 2009. Right after her graduation she was employed by South West Shewa Zone Rural Development and Agricultural Office and worked for Kersa Mallima District as Soil and water conservation expert three years. Beletu Chala Gelete joined Jimma University College of Agriculture and Veterinary Medicine in 2013 to pursue post graduate study in Natural Resource Management specializing in Watershed management.

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ABREVIATIONS AND ACRONYMS

AOI	Area of Interest
DA	Developmental Agents
DEM	Digital Elevation Model
EMA	Ethiopian Mapping Agency
ENVI	Environment for Visualizing Images
ES	Ecosystem Services
ETM^+	Enhanced Thematic Mapper
FAO	Food and Agricultural Organization
GCPs	Ground Control Points
GDP	Gross Domestic Product
GIS	Geographical Information System
GIZ	German International Cooperation
GPS	Global Positioning System
IFS	International Fund for Research
ILWISI	Integrated Land and Water Information System
LCM	Land Change Modeler
LULC	Land Use and Land Cover
MEA	Millennium Ecosystem Assessment
ROI	Region of Interest
RS	Remote Sensing
SLM	Sustainable Land Management
SPSS	Statistical Package for Social Science
SVM	Support Vector Machine
TM	Thematic Mapper
USGS	United States Geological Survey
UTM	Universal Traverse Mercator

TABLE OF CONTENTS

Contents **Page**

LIST OF TABLES

LIST OF FIGURES

LIST OF THE APPEDIX

ABSTRACT

Understanding land use/cover and associated ecosystem services and livelihood strategies are becoming an important discussion point at local, regional and global levels. The issue is particularly so in developing countries like Ethiopia where anthropogenic driven land use/cover changes are apparent. These studies aims at detecting land use/cover change (LULC) over a period of 30 years and assess associated ecosystem services and livelihood strategies changes at Walga watershed South West Shewa, Oromia regional state. Remote sensing was employed to quantify land use/cover for past three decades (1985-2015) and household survey was employed for collecting associated changes in ecosystem services (ES) and livelihood strategies in the study area. The result shows that there was a drastic shrink in forest, grazing land, water body and shrub land between1985-2015. For instances, forest, grazing land, water body and shrub land loss were estimated to be -3329ha, -278ha, -27ha and -424ha respectively, while crop and enset (Ensete ventricosum) farmlands, settlements and degraded lands were increased at the expense of the forest, grazing, water bodies and shrub land cover types by 1631ha, 1543ha, 122ha and 763ha respectively. A dramatic change of forest conversion to crop and enset farmlands, degraded land and settlements were observed in the study area. The implication of these LULC changes which assessed by household survey revealed that there was extreme change in ES which provided by each LULC in the study area. During the first 15 years of the study period forest was ranked as major source of soil and water conservation, timber, fuel wood, fodder, recreation, climate regulation and ecotourism, crop farmland as a source of food, water body as source of recreation and ecotourism, spiritual services, grazing land as source of fodder; however in the current period the services of ecosystem losses due forest degradation, shortage of grazing land and soil erosion problem in the area, inclination to mainly rely on Enset farming as major source of food and fodder were observed. The total simultaneous change regulation and cultural services were showed strong positive correlation with land cover change in area in-contrary to provision services which shows weak correlation due to high coverage of land degradation results fertility loss in the area. Likewise, the livelihoods of local community shows similar trend as a result of LULC change. The result shows the livelihood strategies of the households had changed from sole farm dependent livelihood to mixed livelihoods strategies. In general there was a drastic change in LULC of Walga watershed for past three decades which has brought about a temporal change in ecosystem services and the livelihood strategies of the local communities.

Key Words: Land use/cover, GIS and remote sensing, livelihood strategies, Ecosystem services.

1. INTRODUCTION

1.1. Background Information

Land use refers as the total of all arrangements, activities and inputs that people undertake on a certain land (Abbas, *et al*., 2010). Whereas, land cover refers to the physical and biological cover over the surface of land, including vegetation, water, bare land (Wei, 2007). Land use/ cover (LULC) is, therefore, seen as an interface between the natural conditions of the land and the human influence that provides a framework for linking socioeconomic developments with the consequent environmental impacts (Shifera, 2011; Lambin *et al*., 2002). Changes in LULC can directly and/or indirectly impact ecosystem functioning, and goods and services they provide to people.

Humans have modified the land in various ways and intensities largely to meet rapidly growing demands for food, fresh water, timber, fiber and fuel wood (MEA, 2005). Over the past 50 years, humans have changed the ecosystems more rapidly and extensively than in any comparable period of the time in human history. Deforestation and agricultural land expansion are undertaken to improve the livelihoods. Nevertheless, land use changes have had a severe influence on the environment, ecosystem services, and social development in the long run (Atelal, 2014). LULC change has contributed significantly to the forest fragmentation, biodiversity loss and the ecosystem services. Due to this LULC change and its impacts on different ecosystems have identified as high priority issues in global, national, and regional levels (Fu *et al*., 2000).

Dynamics of LULC has become one of the major prior issues in developing countries like Ethiopia. Some studies have shown that land cover change is vicious and there has been agricultural land size expansion at the expense of forest cover (Dessie and Kleman, 200). FAO (2007) has also estimated that the annual deforestation rate for Ethiopia to be 0.8%; these change shows significant impact on ecosystem processes and function Houet (2010) resulting in soil degradation and loss of the ability of natural systems to support life (Berhe, 2004). In Ethiopia LULC change has a negative implication to household food security status and contributes directly to change in the household livelihood strategies.

In Walga watershed LULC change has led to degradation of natural resources threatening the livelihoods of surrounding community (Ketema, 2015). The charismatic landscape (presence of hot springs, a highly diversified floral and faunal life around the lake boundaries) of the watershed is under progressive changes (Ketema, 2015). According to De Groot *et al*. (2010) despite LULC changes, the magnitude and extent of LULC changes are poorly understood.

The changes of ecosystem services and livelihoods strategies as a result of LULC change in Walga watershed are not well investigated. Therefore this study tries to provide empirical information on; the change in LULC changes over the past three decades by using remote sensing and household survey. Which is the best method to show and understand how LULC change impacted ecosystem services and livelihoods and what types of changes was there in the past decades and current issues.

1.2. Objectives

1.2.1. General objective

The main objective of this study is to contribute to better understanding of land use/cover dynamics and associated impacts on ecosystem services and local livelihoods.

1.2.2. Specific objectives

- To detect land use/land cover change over time.
- To assess associated ecosystem services and
- To assess impacts of land use/cover change on livelihood strategy of community in walga watershed

Research questions

To achieve the above research objectives, the following main research question need to be answered:

- What are the magnitude of land use/cover changes over 1985-2015?
- Does associated ecosystem services changes positively or negatively correlated to land use/land cover changes in the watershed?
- What are the changes in the livelihood strategies of the local community due to changes in land use/ land cover and associated ecosystem services?

2. LITERATURE REVIEW

2.1. Land Use Change, Ecosystem Services and Livelihoods

2.1.1. Land use/cover change

Land use can be broadly defined as the level of spatial accumulation of activities such as production, transaction, administration and residence with highly dynamic relationships between them (Lambin *et al*., 2003). Land uses include settlement, cultivation, water bodies, forest, pasture (Grazing) and range land, recreation, residential among other (Chrysoulakis *et al*., 2004; Zubair, 2006).

Whereas, Land cover is defined by the attributes of the earth's land surface captured in the distribution of vegetation, water, desert and the immediate subsurface, including biota, soil, topography, surface and groundwater and it also includes those structures created solely by human activities (Lambin *et al.,* 2003; Chrysoulakis *et al*., 2004). Land use/cover change is defined to be any physical, biological or chemical change attributable to management which may include conversion of grazing to cropping, change in fertilizer use, drainage improvements, plantations and land degradation and conversion to non-agricultural uses (Quentin *et al*., 2006).

2.1.2. Concept of ecosystem services

According to MEA (2003) and FAO (2007) ecosystem services are the benefits people obtain from nature, the conditions and processes through which natural ecosystems and the species that make them up, sustain and fulfil human life. De Groot *et al*. (2010) also stated that, ecosystem functions are defined as the capacity of the natural processes and components to provide goods and services that satisfy human needs directly or indirectly. The MEA (2003) divides these ecosystem services into four categories: provisioning services, regulating services, cultural services and supporting services.

Provisioning services are the products people get from nature, such as food, which includes the vast range of food products derived from plants, animals and microbes. Today 35% of the

Earth's surface is used for growing crops or rearing livestock (MEA, 2005). Despite this, only about 30 crop species provide 95% of humanity's food (Williams and Haq, 2002) and it has been argued that the world is currently over-dependent on a few plant species. Grasslands were also important as the original source fodder for most domestic animals such as cattle, goats, sheep, and horses, as well as many crops, such as wheat, barley, rye, oats, and other grasses (Daily, 1997). Fresh water is also provision ecosystems services play important roles in the global hydrological cycle, contributing to water provision quantity, defined as total water yield. Global water use is dominated by agricultural withdrawals (70% of all use and 85% of consumptive use), including livestock production, followed by industrial and domestic applications.

Regulation functions are an ecosystem services that provide the necessary pre-conditions for all other functions. Benefits obtained from the regulation of ecosystem processes have direct and indirect benefits to humans (such as maintenance of clean air, water and soil, prevention of soil erosion and biological control services, climate regulation (local and global). Forest ecosystems regulate soil erosion, cut surface runoff and store water, reducing the effect of extreme weather events and natural hazards like mitigating floods (De Groot, 2006).

Cultural ecosystem services are defined as the nonmaterial and intangible benefits obtained from ecosystems including recreation, ecotourism, heritage and aesthetic values. Among these recreational pleasure that people derive from natural or managed ecosystems is defined as recreation service (MEA, 2005). Although it is often difficult to measure in ecosystem assessment assessments, cultural heritage values for a given socio ecological contexts have been concretely linked to specific ecosystem features (Daniel *et al*., 2012). Many cultural and amenity services are considerable as economic resources such as, tourism generates approximately 11% of global GDP and employs over 200 million people. Approximately 30% of these revenues are related to cultural and nature-based tourism. Supporting services are also other natural ecosystems provide refuge and reproduction-habitat to wild plants and animals (De Groot, 2002).

2.1.3. Livelihoods Strategies

The concept of livelihood is about an individual households or groups making a living, attempting to meet their needs, economic necessities, coping with uncertainties and responding to new opportunities (De Haan and Zoomers, 2003). Formally, a livelihood can be defined as the assets (natural, physical, human, financial and social capital), the activities and the access to these (mediated by institutions and social relations) that together determine the living gained by the individual or household (Ellis, 2000).

When the cultivation of land cannot support livelihoods, off-farm income becomes crucial. Raised livelihood expectations due to exposure to higher standards of living have further driven land use change (Soni, 2006). They diversify their livelihood to a range of off farm income generating activities (livelihood diversification) or walk away to seek other livelihood elsewhere, either temporarily or permanently (migration) (Ellis, 2000). Agricultural intensification results in a gain to livelihood from agriculture due to livestock rearing, aquaculture or forestry; through the processes of intensification (i.e., more output per unit area through capital investment or increases in labor inputs) or intensification by bringing more land under cultivation (Soni, 2006).

2.2. Application of Remote Sensing and GIS for Land Use/Cover Changes

According to Comber *et al.* (2005), there are two primary methods for capturing information on land cover, namely field survey and through analysis of remotely sensed imagery. Remote sensing data has been used widely for land cover identification and classification of various features of the land surface from satellite or airborne sensor. Application of remotely sensed data for land cover and land use mapping and its changes is a key to many diverse applications such as environment, forestry, hydrology, agriculture and geology.

Since 1972, the Landsat satellites have provided repetitive, synoptic, global coverage of high-resolution multispectral imagery. Their long history and reliability have made them a popular source for documenting changes in land cover and use over time (Warra *et al*., 2003) and their evolution is further marked by the launch of Land sat 7 by the US government in 1999. The remote nature of remote sensing technology allow us to make observations, take measurements (i.e. measuring the reflected and/or emitted electromagnetic energy from the earth), and produce images of phenomena that are beyond the limits of our own senses and capabilities. It was the launch of the first civilian remote sensing satellite in the late July 1972 that paved the way for the modern remote sensing applications in many fields including natural resources management (Lillesand *et al.*, 2014).

Satellite image data enable direct observation of the land surface at repetitive intervals and therefore allow mapping of the extent and monitoring and assessment. Remote sensing at various scales plays a major role in spatio-temporal earth surface monitoring (Ashenafi, 2008). Application of remote sensing and GIS was found helpful in quantifying past and present resources so that appropriate planning could be made for the future.

The collection of remotely sensed data facilitates the synoptic analyses of earth-system function, patterning and change at local, regional and global scales over time. Such data also provide a vital link between intensive, localized ecological research and the regional, national, and international conservation and management of natural resources (Ernani and Gabriels, 2006). Remotely sensed data have powerful helps understanding and managing earth resources and have been proven to be a very useful data for LULC change detection (Lillesand and Kiefer, 2014). The advantage of using remote sensing in LULC is that information from the same area could be easily obtained at different times and this is important in change detection applications. Furthermore, remote sensing can provide the required data in short time with a reasonable accuracy (Billah *et al.*, 2004) and has an important contribution to make in documenting the actual change in LULC on regional and global scales from the mid-1970s (Lambin *et al.*, 2003).

According to Giri and Jenkins (2005) the particular interest on LULC mapping is to better understand and manage emerging environmental problems arising from local to global scale. Land use and land cover mapping is the primary activity which has to be conducted prior to change detection analysis. Spatial resolution (the total area covered by a pixel in an image), varies from one sensor to another (For example the Landsat Thematic). The smaller the spatial resolution, the greater the amount of detail that can be extracted from a particular image and the greater it is the less the detail.

2.3. Image Classification

Image classification is the process of automatically categorizing every pixel in a raster environment based on their individual spectral reflectance. One of the most important uses of remote sensing is the production of LULC maps through a process called “Image Classification”. Image Classification had made great progress over the past decades by producing land cover map at regional and global scale, development and use of advanced classification algorithms, such as subpixel, pre-field, and knowledge-based classification algorithms, use of multiple remote-sensing features, including spectral, spatial, multi-temporal, and Multi-sensor information and incorporation of ancillary data into classification procedures, including such data as topography, soil, road, and census data (Jwan *et al.*, 201).

There are two approaches to the classification process: supervised and unsupervised. The latter automatically groups cells into clusters based on the statistics of their digital numbers (DNs), which are representative of each pixels intensity value (Lillesand *et al.*, 2014). This process requires minimal user input; aside from selection of preferred number of classes, the unsupervised classification method is entirely automated. In a supervised classification, the user manually controls the inputs, allowing the user’s knowledge to influence the results. There are many methods of supervised classification method among them support vector machine is the best method which applied in ENVI classic software.

a. Support Vector Machine supervised classification method

Machine Learning (ML) is a discipline of computer science that develops dynamic algorithms capable of data-driven decisions, in contrast to models that follow static programming instructions. In 1959, Arthur Samuel first defined ML as a Field of study that gives computers the ability to learn without being explicitly programmed. The very first mention of ‘machine learning’ in the literature occurred in 1930 and use of the term has been growing steadily since 1980 (Anne, 2016).

Support vector machines (SVM) was developed by Vapnik in 1979 for image classification Cortes and Vapnik (1995), he introduced the soft margin hyperplane for non-separable data which made SVM more applicable. Ability and good performance of SVM in variety of research domains make it attractive. SVM is gaining popularity in the field of remote sensing. SVM gives improved results with respect to traditional classifiers like maximum likelihood.

The advantage of ML over traditional statistical techniques, especially in earth science and ecology, is the ability to model highly dimensional and non-linear data with complex interactions and missing values (Death and Fabricius (2000); Recknagel, 2001; Olden *et al*., 2008; Haupt and Pasini *et al*., 2009; Knudby, Brenning *et al*., 2010 cited in Anne, 2016).

b. Accuracy assessment

Accuracy assessment is an important step in the process of analyzing remote sensing data. Accuracy assessment is an integral part in an image classification procedure. The success of an image classification in remote sensing depends on many factors, the availability of high quality remotely sensed imagery and ancillary data, the design of a proper classification procedure, and the analyst’s skills and experiences. The most common means of reporting accuracy is inclusion of a contingency table tabulating the predicted versus known class for each in pixel in a testing dataset. The contingency table also should include overall, user’s, producer’s, and per class accuracies (Foody, 2001; Conglton and Green, 2009).

According to Minale and Rao (2012) the scientifically accepted result for kappa statistics was defined as poor when kappa coefficient is less than 0.4; good when it was between 0.4 and 0.7 and it will be taken as excellent when kappa coefficient is greater than 0.75. While accuracy targets (like 85% overall accuracy) are useful to guide analysts working on LUCC data products, the accuracy target itself should be determined based on specific project goals. LUCC products that use a large number of classes will generally have lower overall accuracy, while simpler products like forest/non-forest classifications can usually be produced with higher accuracy. Data limitations are also important, as spatial and spectral resolution will both affect accuracy (Conglton and Green, 2009). Although the basic approaches to accuracy assessment seem relatively straightforward, many problems are often encountered when evaluating an image classification. These problems range from issues associated with a failure to satisfy basic underpinning assumptions through to the limited amount of information on map quality that is actually conveyed by a basic accuracy assessment (Foody, 2001)

2.4. Change Detection Image Analysis

Land Change Modeler: The Land Change Modeler (LCM) for analyzing past land cover change, empirically modelling its relationship to explanatory variables and projecting future changes. LCM is based on the power of neural networks and provides a well-established procedure for land change prediction (Hughes, 2014). A number of LUCC models have been developed; however it is difficult to compare which one gives more accurate representation (Wu and Webster, 2000). Among the numbers of land use modelling tools and techniques, the commonly used models are the modelling techniques embedded in IDRISI; Land Change Modeler (LCM) which is widely used modelling tool (Mishra, 2014).

Land change analysis is critical in areas such as environmental and resource management, land use planning, biodiversity conservation and REDD (reducing emissions from deforestation and forest degradation). Clark Labs has produced a set of tools organized in a stepwise fashion to facilitate such analysis. The first step in the process is to analyse historical change between two land cover maps of different time periods. The user specifies two land cover maps of different dates and Land Change Modeler (LCM) rapidly assesses the changes between the two. The user can immediately review and evaluate area gains and losses, net change, persistence and specific transitions both in map and graphical form.

2.5. Land Use/Cover Change Observed in Ethiopia

Land cover has gone under continuous change for millennia. Hence human's production demands cannot be fulfilled without modification or conversion of land covers. In the past two centuries, the impact of human activities on land has grown enormously because of population increase, technological development and the requirements thereafter, altering entire landscapes and ultimately impacting the biodiversity and environment (Lambin *et al*., 2003), especially in the developing country. The intensification of economic activities promotes degradation and destruction of soil, vegetation cover, activates erosive processes, and triggers the expansion of land degradation (Seto, 2002).

Human activities, such as agriculture and settlement expansion, severely influenced the landscape and diminishing its natural ecosystem. The disturbance of the respective woodland ecosystem is closely related to the occurrence of significant land use transformation within many regions (Zewdie and Csaplovics, 2015).

2.5.1. Forest resources

Forest provide people with fuel wood, material for building purposes, spices and many other things. Conversion of woodland into cultivated land is the greatest root of migration of wild animal and destruction of tree species shocks (Mikias, 2014). The adjusted area estimate for forest loss over the period 2000-2013 corresponds to an annual loss of approximately 70,000 ha/yr and annual forest gain of approximately 30,000 ha/yr (Hailemariam *et al*., 2016).

LULC studies showed that land cover change is vicious and there has been agricultural land size expansion at the expense of natural vegetation cover lands and marginal areas without any appropriate conservation measures (Dessie and Kleman, 2007; Gashaw *et al*., 2014) and high rate of deforestation to 14,100 hectares per year (FAO, 2007), Lemenih (2004) estimated the annual deforestation rate for Ethiopia to be 0.8%, Clearing natural vegetation for agriculture, fire wood, and grazing are the immediate causes of LULC changes in Ethiopia (Kassay, 2004).

Tesfaye (2010) reports showed that, Oromia has large and self-perpetuating ecosystem composed of a large number of different flora and fauna which accounts for a large diversity of biological resources. Oromiya's remaining natural high forest is found in South-West, Southern and South Eastern part of the region. The Central and Northern parts are being almost completely deforested. The total natural forest cleared between 1984 and 2009 amounts to 3186 ha. This is 50% of the forest cover that existed in 1984. On the other hand, cultivated land increased from 6.01% in 1984 to 21.96% in 2005 and 34.07% in 2009. Vegetation cover has completely declined the proportion of degraded lands has increased (Getahun, 2013).

2.5.2. Land degradation

Increasing rates of forest conversion, unsustainable agricultural land use and severe soil degradation create the vicious circle of the poverty-environment trap, which is the situation characterizing land degradation in the highlands of Ethiopia (Sonneveld and Keyzer, 2003).

According to lemineh (2004) reports, the process of prolonged use with low inputs has aggravated soil quality decline leading to soil degradation, which may ultimately lead to land abandonment, furthermore the depletion of the natural forest ecosystems in Ethiopia, as only less than 3% of the country's land area is covered with natural forests today.

In Ethiopia, specifically in high land areas rapid population growth on the limited land area, cultivation on steep slopes to produce food, clearing of vegetation and overgrazing are the main factors which results land degradation (Hurni and Meyer, 2002). The immediate consequence of land degradation is lower crop yields, leading to higher poverty rates among agricultural households. Recent estimates using satellite imagery show that land degradation hotspots over the last three decades cover about 23 % of land area in Ethiopia (Abate, 2014).

2.5.3. Water resources

With a rise in population, there is an increase in the quantity of water required for agricultural production, domestic consumption, industrial use and recreation. Currently, about 17% of the 7 billion people experience severe water scarcity (FAO, 2011a). During the same period, rain fed crop area decreased by 0.2% (FAO, 2011b). Climate change, water pollution and land degradation are all increasing the uncertainties of freshwater resources, further putting pressure on the available freshwater resources. The situation is more alarming in arid areas in developing countries, which experience severe water shortages.

The degradation of terrestrial habitat affected the diversity and abundance of birds and mammalian due to its change to vegetation community structure and composition (Getaneh *et al*., 2015). These substantial changes in land use, notably the expansion of degraded land and decreasing in size of the lakes have adversely affected the local environment and livelihoods of the people. Many of deforestation, expansion of farming, overgrazing and over extraction of water coupled with conflicts between resources and local communities are detected as the major problem contributors to the degradations of natural resources of the central Rift Valley of Ethiopia (Adem *et al*., 2008).

2.5.4. Crop farmland

Expansion of cultivated and settlement land, insecure land tenure and the 1975 land reform program, shortage of agricultural inputs and technologies and lack of early awareness of farmers about soil erosion and soil fertility are obviously responsible for the major land use/cover changes (Molla *et al*., 2010). The increasing number of rural population from time to time, needs more agricultural land because there is increase in their demands for food production, farmers' also lack of livelihood security has forced them to use the woodlands to cope with recurrent household shocks (Biazen, 2014).

Clearance of vegetation has had an impact on the decline of agricultural productivity through soil fertility decline by the removal of vegetation cover and soil erosion which decline in vegetation cover include expansion of cropland, firewood collection for domestic consumption(Amanuel, 2014). The disturbance of the respective woodland ecosystem is closely related to the occurrence of significant land use transformation (Zewdie and Csaplovics, 2015). This change may result in an irreversible loss of biodiversity and in the depletion of ecological services provided by the natural environment.

2.5.6. Enset farmland

The tradition to grow enset in drought prone areas in Ethiopia gives food and fodder in the current climate, and will be even more important if rainy and dry periods will occur more random in the future, as predicted (Meadovs, 2011; Mohammed *et al*., 2013). Mohammed*et al*. (2013) also reported that Enset has high water content (85 to 90%), which is beneficial when used as fodder during dry periods. Enset corm contained 17 of 20 amino acids and had similar or higher concentration than potato of 12 of these. Leaves had 13% protein, among the highest available in Ethiopia, 20% crude fiber and 10% sugar; a good fodder and suitable for ensilage.

Enset is high yielding (Tsegaye and Struik, 2001), can be harvested during different times of the year and the product kocho is possible to store long times without refrigerators. Enset could be an important part of the diet for humans as well as ruminants in much larger areas than currently used. Cultivation of enset should be encouraged in areas with suitable environment and with drought problems, since it can substantially improve the food security for people (Mohammed *et al*., 2013). The ubiquity of agricultural production also means that other ecosystems are frequently adjacent to food producing land and processes and practices of agriculture may therefore have a broader impact.

2.6. Change of Ecosystem Services and Livelihood

LULC change and management decisions have major impacts on ecosystems and the goods and services they provide to people. Ecosystems have a wide range of functions within a social, economic and ecological context. The ecosystem functions are related to different land cover and land use types (De Groot *et al*., 2010). Natural resources are interdependent and degradation of one affects ecosystem services acquired from vegetation include provision, regulation, cultural and supporting services. Vegetation degradation negatively influences erosion regulation and food supply (Wallace, 2007).

Changes in land use will increase the provision value of some services but decrease others (MEA, 2005; De Groot *et al.*, 2006). A more of narrative lack ecological production functions to predict the provision of ecosystem services such as comprise of food crops, wild fruits, small quantities of fish, fresh water, raw materials and medicinal resources such as hot springs and the Lakes (Kefyalew, 2008). The relative importance of each land use type in supplying ecosystem services and the significant interactions among each change depending on the spatial scale at which measurements and analysis were done (Felipe, 2014).

In Ethiopia, land resources scarcity coupled with high population growth influences land use decisions that cause conflicts with neighbouring nature conservation areas. For small holder farmers, what to eat and use from the ecosystem determines the pattern of land use changes. However, this practice failed to satisfy the food self-sufficiency and impedes sustainable land management (Funk *et al*., 2014).

Tropical agricultural landscapes are generally valued for providing diverse ecosystem services, including protecting biodiversity, in addition to supporting local livelihoods (UNEP, 2011). Obtaining food and a livelihood is inseparably linked to the exploitation of the natural resources base (land, water and forest) in Ethiopia, where over 85% of the population lives in rural areas and depend on smallholder agriculture (Funk *et al*., 2011, Williams *et al*., 2012).

3. MATERIAL AND METHODS

3.1. Description of the Study Area

Location, climate and topography: This study was conducted in Walga Watershed which is found in Wonchi district of Southwest Showa zone, Oromia regional state. The study area is located at approximately 155km, Southwest of Addis Ababa, the capital city of Ethiopia. Geographically it is located between latitudes of 8^{o}48'48" to 8^{o}49'16"N and longitude of 37^{o}50'27" to 37^{o}56'58"E. Walga watershed is characterized by Dega agro-climatic zone, which lies within the altitude range of 2270 to 3360 masl. The mean annual rainfall of the watershed is about 1350mm. Main rainy season (summer) extends from July to September, and the small rains (Belg) in March and April. The erratic nature of the rainfall made farming unpredictable and generally put it at low level of productivity (SLM, 2014).

The livelihood system in the area includes agriculture, small and micro enterprises and income generating activities from ecotourism. The average land holding size for a single household is 0.5 hectares and the main crops cultivated in the Walga watershed are Barley, Wheat, Bean, Pea, Lentil, "Enset" or False banana, and Potato. As the farming land is hilly, it is difficult to use oxen plough and the common practice is hand plough. The existing land use types are forest, shrub/bush land, and farmland and residential, hillside/degraded land, homestead, grazing land and water body (Figure 1). The major livestock reared in the watershed are cattle, Horses, Donkey, Goats, Sheep, and Poultry. They also engage in beekeeping activities parallel to the above activities. Mixed crop and livestock farming system is the mode of agriculture practice in the district (SLM, 2014).

Historical and current case profile of landmass and land cover: This figure was obtained from different documented data. From the **(**Figure 1) it is clearly shown that during the past 40-years the major land mass and land cover of the study area were forests 31%, grazing land 22%, shrub lands 20%, homestead and farmland 11% and hillsides and degraded land 5%respectively.

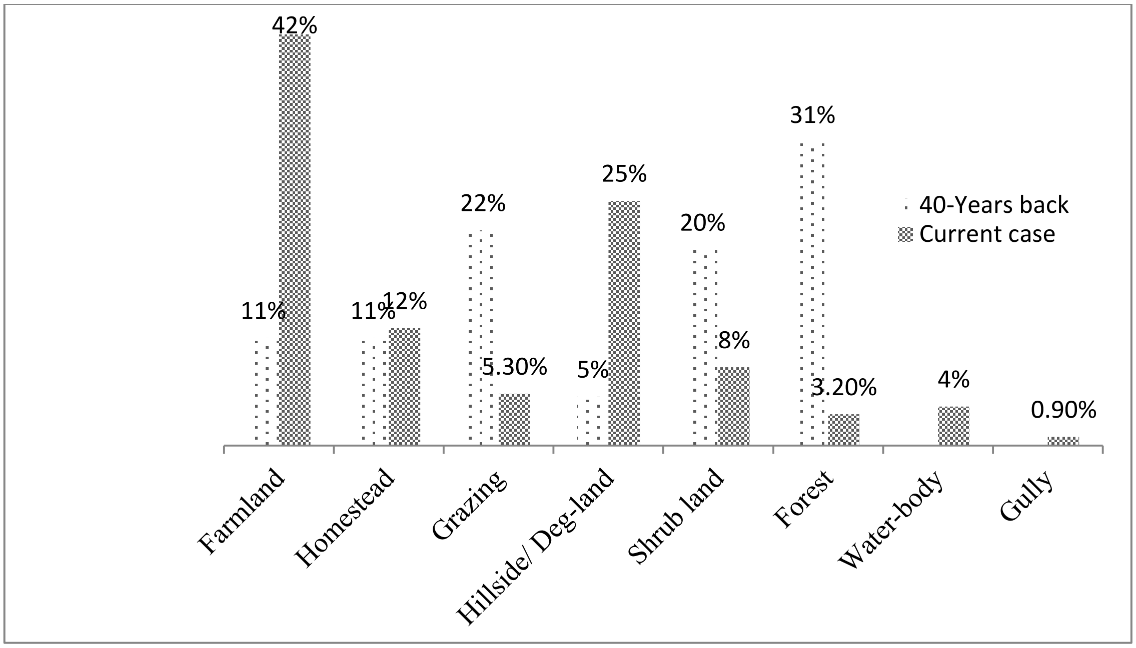

Figure 1: A bar chart showing historical profile of land covers (percentage of total landmass)

Source, Source; Giz; SLM Oromia, un-published document (2014).

While during the current case, the (Figure 1) shows, over years, there have been significant change in land use pattern. For instance farmland comprises about 42%, homestead 12%, grazing/pasture land 5.3%, hillside/degraded land 25%, forest 3.2%, and shrub/bush 8% land of the total area.

Watershed characteristics: The major watershed contains 10 community (micro) watersheds which are included in seven (7) kebeles (Figure 2) with total land mass area of 9589hectares (ha) with settlement pattern of 27 villages in total. The micro-watersheds are inhabited by a total of 3704 households (9% women headed) accommodating a total population of 20869. Land holding households constitute 72% of the total households while 28% are landless.

3.2. Remote Sensing Data Collection

In this study a methodological approaches combining remote sensing and survey technique were implemented to quantify LULC change, associated ecosystem services and livelihood strategies in the study area. Remote sensing was employed to quantify LULC change. Walga watershed was purposively selected due to the fact that there is high environmental degradation.

3.2.1. Methods

3.2.1.1. Watershed delineation

The geographical coordinates of outlets were collected through GPS. The watershed was then delineated using ILWIS software using digital elevation model (DEM) data which is available to the public and can be freely downloaded from (**http://srtm.csi.cgiar.org/**) with spatial resolution of 90m. The watershed boundary as shown in Figure 2 was derived from DEM by the following major steps: 1) fill sink, 2) assigning flow direction, 3) calculation of flow accumulation, 3) selection of outlet point, 4) extracting main and sub watershed (Figure 2). This delineated watershed was kept in shape file.

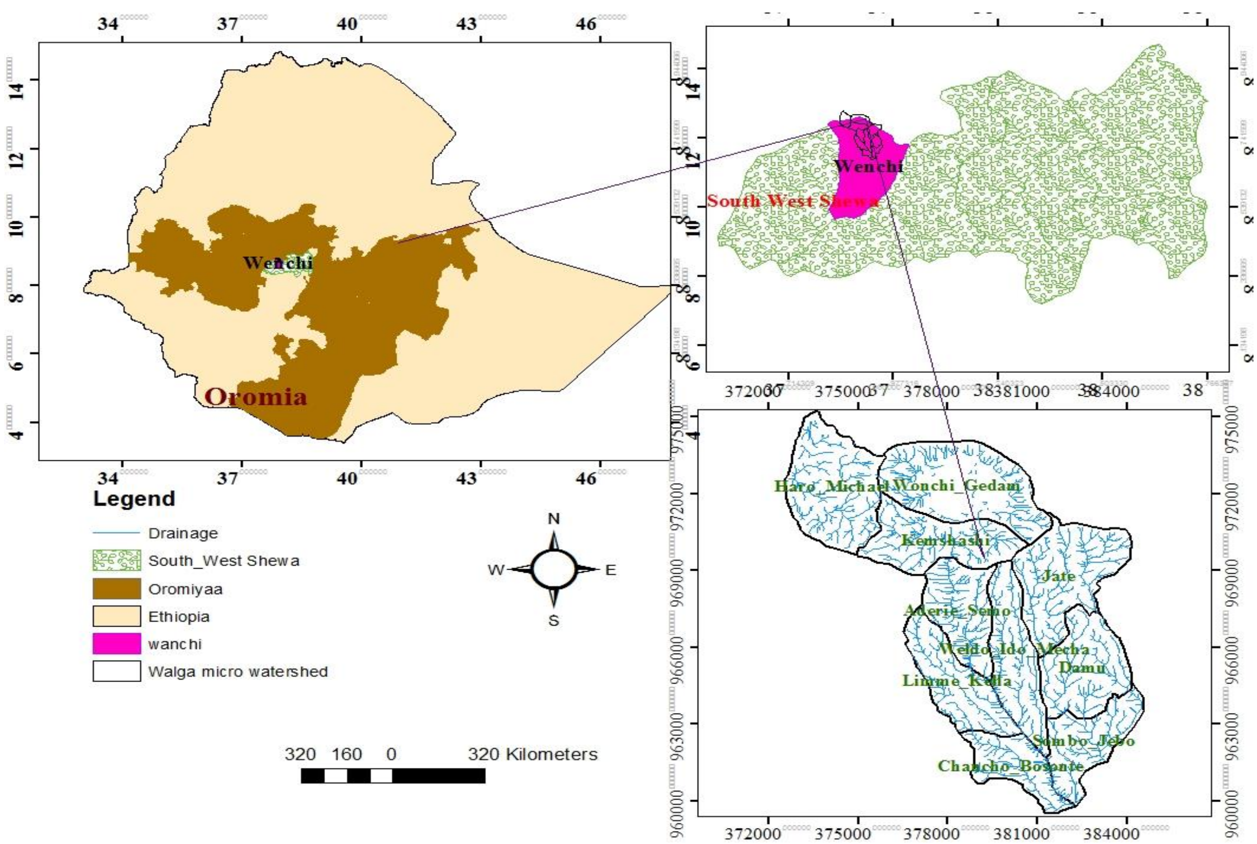

Figure 2: Location map of study area.

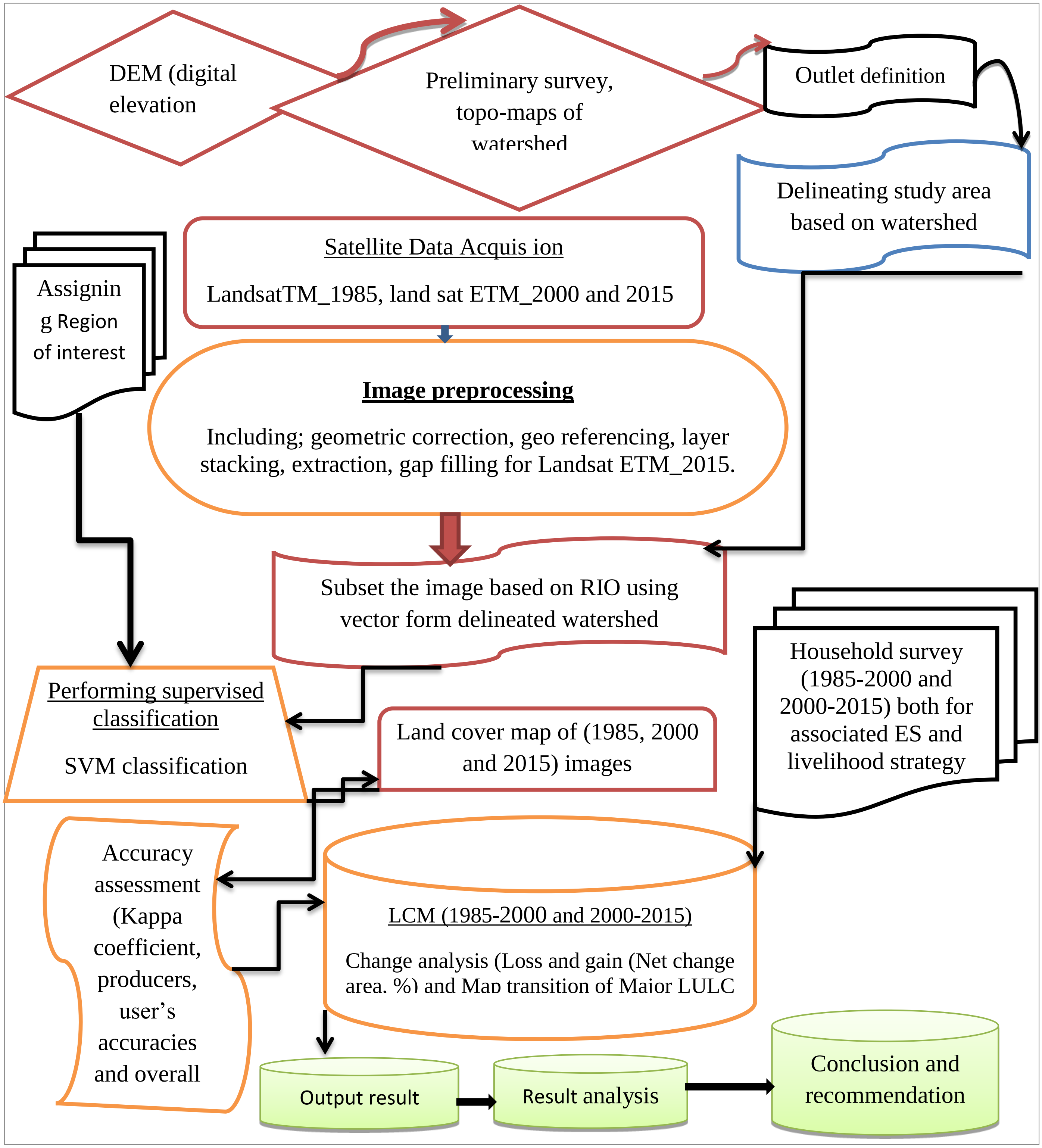

Figure 3: Flow chart which shows the methodological approach in Image analysis and socioeconomics.

The above figure 3 tried to show data used and types, several methodological approach and steps applied throughout this study.

3.2.1.2. Satellite data collection

Cloud-free Landsat of different years but of the same dry season images were downloaded from the United States Geological Survey (USGS) data portal (**http://earthexplorer.usgs.gov**). Characteristics of the Landsat data are summarized in (Table 1). Images chosen from the same season reduce the misclassification error related to spectral analysis of different LULC types (Ruiz-Mallén and Corbera, 2013).To minimize atmospheric haze and cloud cover all of the images acquired were from dry seasons. GPS 72H GARMIN was used for ground verification and to collect outlet points which were used for delineation of Walga watershed boundary.

Table 1: Images and soft wares used for the study

S. No	Sensor Types	Date of acquis	Spatial resolution (m)	WRS (Path/Row)
1	Landsat TM	12/02/1985	30x30	169/54
2	Landsat ETM^+	12/02/2000	30x30	169/54
3	Landsat ETM^+	04/01/2015	30x30	169/54

3.2.1.3. Nomenclature of land covers classes

Nomenclatures are lists of categories, summarizing information in a highly reduced form while attempting to maintain maximum information content. A nomenclature will normally cover a particular field of interest (Ali, 2009). In developing the classification system, every effort has been made to provide as much compatibility as possible with other classification systems currently is being used by the various Federal Agencies involved in land use inventory and mapping. Special attention has been paid to the definitions of land use categories used by other agencies, to the extent that they are useful in categorizing the data obtained from remote sensor (James, 2001).

Table 2: Description of Land use/ cover classes (Adopted from Ali, 2009; Kindu *et al.*, 2013), FAO, 2007; MEA, 2005.

No	LULC classes	Description
1	Forest	Land Areas covered by trees forming closed or nearly closed canopies; Plantation forest; Dense (50-80% crown cover) and ecosystem type as Lands dominated by trees; often used for timber, fuelwood, and non-timber forest products
2	Settlements	This category typically includes developments along transportation routes and in cities and towns where separate land uses cannot be mapped individually and villages where built-up surfaces are predominate.
3	Crop farmland	Areas of land prepared for growing agricultural crops and fallow land that grow annual crops (wheat, burley, pulses and lentils).
4	Degraded land	This class also included Unsuitable eroded areas characterized by bare lands and is land of limited ability to support life and in which less than one-third of the area has Vegetation or other cover and majority part of land covered with gully.
5	Grass land.	All areas covered with natural grass, non-woody, rooted herbaceous plants and small shrubs dominated by grass.
6	Water bodies	Areas with surface water in the form of lakes, streams, rivers, and reservoirs.
7	Bush/shrub land	Areas with sparse trees mixed with hillside short bushes and Shrubs, young trees; less dense than the forest with little useful wood, managed for grazing and collecting wood for household use.
8	Enset farm land	This category contains agricultural areas which are intensively managed for the production of ornamental plants. This includes, perennial crops which is dominated with trees such as Enset (false banana) , horticultural crops, chats and vegetable seedlings

3.2.1.4. Training data collection

A field work was carried out to collect data and assist the classification of the satellite images in to different land use land cover types. A visit was made to the study area in the same season at which land sat ETM_2015 image were acquired. During this both Ground Control Points (GCPs) and the Area of Interest (AOI) of study area were selected, fixed and measured by Global Positioning System (GPS) 72H Germin to navigate to each point. This is done to get an accurate reading for the specific locations for samples positions. GPS was used Records of land cover and land use units at each of these points were documented to use them as ground truths using personal knowledge and elders who deeply knew historical back ground of the study area.

Using stratified random sampling method GCPs were collected for each of LULC types through field survey. During field survey data collection: two aspects of the mapping of land use land cover were used. One for land covers classification and the other for accuracy assessment. The sample size was based on a rule of thumb per class. Forest, degraded land, grazing land, crop farmland, water body, settlements a, enset farmland and shrub land, were the LULC types identified. During the training data collection the historical profile of the study area was also gathered from elders who knew the past history of land use in the study area.

3.2.2. Method of Data Analysis

During remote sensing data analysis different method of image processing was performed. Among them image preprocessing, image classifications, accuracy assessment and change analysis were used in this thesis.

Image pre-processing: The spectral responses of surface features are largely influenced by the date of image acquisition, pre-processing procedure and the specific area of interest (Jensen, 2007). Pre-processing of satellite sensor images is necessary in order to establish more direct linkage between the data and biophysical phenomena, removal of data acquisition errors, image noise and masking of contaminated and irrelevant spots which might lead to misinterpretation and detection of unreal change phenomena (Coppin *et al*., 2004). In this study all geo-corrected cloud free Landsat of bands of TM_1985, ETM _2000 and 2015 images were geo-referenced to the Universal Traverse Mercator (UTM), Adindan (Ethiopia) coordinate system with WGS1984 as spheroid and datum across the north zone of 37 using a reference images were used for extracting biophysical features. The calibration of Landsat imagery was performed based on the known solar geometry and on the gain and bias values provided by the Landsat metadata. Sub-setting of images was undertaken using vector file of delineated watershed.

Filling Gap in Land sat ETM Image: **-** A recent land sat 7 Enhanced Thematic Mapper (ETM) sensors had failure of the Scan Line Corrector (SLC). Scaramuzza *et al.* (2004), developed a technique which can be used to fill gaps in one scene with data from another Landsat scene. A linear transform is applied to the "filling" image to adjust it based on the standard deviation and mean values of each band, of each scene. Hence in ENVI classic view land sat_gapfill.sav plugin was not available. Land gap fill plugin was downloaded from https://docs.google.com/filed/0B3e_wo8OTO47b3c4ZHNyV0NmUkk/edit?usp_ and installed to ENVI software. After the gap fill was added to ENVI tools to produce quality image in this study gap filling techniques was applied to land sat images ETM from WRS path 169 and row 54 for the image which was acquired on 04 January 2015.

Layer Stacking: Data records and layer stacking was performed to make a single image file based on walga watershed boundary. All seven bands of ETM and five bands of TM were considered for Layers stacking. The three images (1985, 2000 and 2015) were geometrically corrected to the local coordinate's system using ENVI v5.1. The nature of these different bands had to be considered to make a decision as to which three-band combination would be most helpful for classification and visual interpretation. After stacking the satellite data was clipped to a subset of the case study area in order to focus on the relevant data.

Image classification: In this study, all images were individually classified using Support vector machine (SVM) algorithm, which is a state-of-the-art machine learning supervised classification algorithm. Although many different methods have been devised to implement supervised classification, the SVM is technology method that is widely recommended in the literature for its capability to accurately classify diverse LULC types, particularly in data-scarce areas (Shahkooee *et al*., 201).

During Image classification, region of interest were, developed by selecting easily recognizable features and located in the false and true color composite images from ENVI Classic color mapping tools. False color composite images and true color composite (RGB image) using TM bands 4 (red), 3 (green) and 2 (blue) and (RGB image) using TM bands 3 (red), 2 (green) and 1 (blue) respectively of Land sat_ TM and ETM, supervised image classification technique was applied.

In order to classify the images, defining spectral class which represents each class that used to train the classification algorithm was under taken. In case using ENVI, these classes were defined via ROI (Region of Interest). The recent satellite image (land sat TM_ 2015) was visually interpreted and classified into distinct classes, whereas for land sat image TM_1985 and ETM_2000, original mosaic image and google earth, spot image which bought from EMA, were used as a reference. Then, different numbers of ROI were generated to each of these classes based on their relative areal extents. The identified area of different classes was calculated and verified with the total area of the watershed.

Accuracy assessment: The quality of finished LULC classification products is measured using the accuracy assessment process. A classification is not complete until its accuracy is assessed (Lillesand and Kiefer, 2000). One of the most common means of expressing classification accuracy is the preparation of a classification error matrix (Lillesand and keifer, 2004). There are many methods of accuracy assessment that have been discussed in the remote sensing literature however; Confusion or error matrixes which are widely promoted (Congalton *et al*., 2009), was used for each classification by considering the total stratified sampling method, which was chosen from reference points (GPS points) for the current year.

After classification of satellite images using the training samples that are not involved in the classification process, the accuracy of classification was conducted. In accuracy assessment, overall accuracy, Kappa coefficient, the producer accuracy, user accuracy, commission error (rows of each class in the error matrix) and Committee error (columns of each class in the error matrix) were used to verify the classification. The total accuracy is the ratio of the number of correctly classified pixels in a class to the total number of correctly classified pixels in all classes. It is achieved according to the following equation, using the formula which developed by kappa coefficient, to cross check the accuracy of classified maps from all image classifications an accuracy assessment was performed by generating stratified random sampling for all classified images (Getu, 2014 and Warku, 2015), using confusion matrix application in ENVI classic software. An error matrix or confusion matrix which is a common practice employed for assessment of classification accuracy and confusion matrix is currently at the core of the accuracy assessment literature (food, 2001).The matrix compares information obtained by reference sites to that provided by classified image for a number of sample areas.

In this study, a total pixel of (344) for image 1985, (345) for 2000 and (595) for image 2015 were collected from original Landsat image of 1985, 2000 from high spatial resolution images provided through Google ® and spot Image which was bought from Ethiopian Mapping agency and 2015 from field survey. Foody (2001) reports that the accuracy of classification must be conducted after classification of satellite images using the training samples that are not involved in the classification process. Therefore this study followed the same rule, after classification of satellite images using training samples which were collected from reference data and ground truth that are not involved in the classification process that means 30% (thirty percent) of total training samples were conducted using stratified random sampling method for the accuracy of classifications while 70% were used for image classification.

Class separability test: The distribution of classes on feature space often overlaps which effect on classification of data due to this problem the concept of class separability is introduced (Natasa *et al*., 2013). There are several methods that are used to perform class separability test. In ENVI software, Jeffries-Matusita and Transformed Divergence separability measure were numerically defined. These values range from 0 to 2.0 and indicate how well the selected pairs of region of interest are statistically separate. These values range between 0 and 2.0. As a guide to interpretation, values greater than 1.9 indicates good reparability of classes (Natasa *et al*., 2013).In this research Juffries Matusita (JM) was used.

Change detection analysis: Change detection is the process of categorizing differences in the state of an object or phenomenon by observing it at different times (Abiy, 2010).There are different methods of mapping LULC change among them, post classification method is the most widely used change detection algorithm which is used for the detailed "from – to" information (Abiy, 2010, Wu and Webster, 2000). In this study, LULC map of Walga watershed obtained from image classification for the period of 1985, 2000 and 2015 were used for change analysis using IDRISI software. By using this software Land Change Modeler (LCM) package of IDRISI software was used for the pair-wise comparison of change analysis of qualitative data which is used for analyzing past land cover change. This is most widely used in time series analysis; particularly these techniques are concerned with the analysis of trends and differences across multiple images (Pontius, 2000).

Change analysis: Change analysis is a set of tools provides for the rapid assessment of change, allowing the generation of gains and losses evaluations, net change, persistence and specific transitions in map form (Getu, 2014). There for this study also used change analysis methods: Net change both in ha, Map transition and persistence and Map change. The change analysis process provides three graphs of land cover change between the land use cover maps using different variety of units. LCM can be used to know detail spatial increase and loss, net change, net change drivers, tendencies of change and landscape prediction (Mhangara, 2012). For this study the classified land cover map of walga Watershed of 1985, 2000 and 2015 were used as the input parameters. In general, for this study; ENVI v5.1, IDIRISI selva v17, ILWIS v3.3, Arc GIS v10 and SPSS v20 soft wares were used for processing satellite images, LULC analysis, change detection analysis, watershed delineation, accuracy assessment and analysis of household survey.

3.3. Socioeconomic Data Collections Methods

3.3.1. Methods

Socioeconomic information was collected on ecosystem services and livelihoods of the households in the watershed. Preliminary/historical background information that assists for socioeconomic information was collected during the ground truth data collection. Once the image classification was completed a structured questionnaire was prepared to collect the socioeconomic data on ecosystem services and livelihoods. During assessment of associated ecosystem services and livelihood, both primary (key informants (expert) consultation and household survey) and secondary data was used.

Key informant interview: The key informants were selected purposively. These purposively selected key informants were, the woreda technical watershed committee having total of 12 members from different multi-disciplines. Hence these experts (technical committee) were already established by GIZ for the purpose of watershed planning activities.Then in discussion with the key informants and consulting relevant literature, major ecosystem services were identified.

The major associated ecosystems services considered during this study were (Table 3), provision services such as (food, fodder, fuel wood, timber, water supply); cultural services (ecotourism, recreation, religion and spiritual services) and supportive services; (habitat places) and regulation services;(soil and water conservation services and climate regulation) based on (MEA, 2005 and De groot, 2010) which is provided by each most LULC classes in watershed area. These ecosystem services were identified for each combination of land use classes based on literatures and expert knowledge.

3.3.1.1. Ecosystem services

Discussion with the key informants and consulting relevant literature, major ecosystem services were identified. First major ecosystem services categories were established following Daily (1997); MEA (2003) and De Groot (2006) as shown in table 3. Then structured questionnaire was prepared, pretested and finally information on ecosystem services and livelihoods was collected through household interview.

Table 3: Types and descriptions of ecosystem services provided by major LULC classes of Walga watershed

Category	Sub category	Definitions
Provision Services	Food	Small scale subsistence farming and horticultural crops. Includes; harvest of fruits, crops (both perennials and annual crops), hunting and gathering of fish.
	Animal Fodder	Grazing land and collection of grasses, leaves for Livestock feed.
	Water supply	water for drinking, bathing and washing, cooking food
	Fuel wood	Natural systems provide a great diversity of materials for construction and fuel, notably oils and wood that is derived directly from wild or cultivated plant species.
Regulation services	Soil and water regulation	Role of land cover in regulating runoff and river discharge
	Climate regulation	Regulation of regional climate, e.g. increased precipitation and decreased temperature
Cultural Services	Recreation and ecotourism	Variety in landscapes with (potential) re-creational uses, Travel to natural ecosystems for ecotourism and (recreational) and relaxation.
	Aesthetic values	Many people find beauty or aesthetic value in various aspects of ecosystems, providing opportunities for cognitive development, attractive landscape features Enjoyment of scenery (scenic roads, housing).
	Cultural heritage and identity Spiritual, religious, inspiration and sense of places	Variety in natural features with spiritual and historic value Use of nature for religious or historic purposes (heritage value of natural ecosystems and features)
Supportive Services	Habitat places	Providing habitat (suitable for living space) for wild animals species

NB: PS= Provision services, RS= regulation services, CS= Cultural services, SP= Supportive services.

After the selection of most associated ecosystem services, evaluations of developed questionnaires for both associated ecosystem services and livelihood strategies were done. After the evaluation of the developed questionnaires completed, identification of numbers household (elders) was made through these committees and developmental agents (DA) based on the number of years they lived in the area (above 45 years), those who know more about the area and culturally and traditionally respected by the society including both genders. For this study elders were used to obtain the past 30 years of the historical profile of land cover in the study area.

3.3.1.2. Sampling techniques and sample size determination

The household survey was used to capture the major associated ecosystem service and LULC interactions in the watershed area and livelihoods. For household survey data collection the number of sample household heads interviewed was determined using the formula developed by Kothari (2004) with the following equation.

$$n = \frac{Z^2 * (P)(q) * N}{e^2(N-1) - Z^2 p * q}$$

Where; n = the desired sample size

Z = 95% confidence limit (interval) under normal curve that is 1.96

P = 0.1 (population proportion to be included in the sample that is 10%)

q = None occurrence of event =1-0.1 that is (0.9)

N = total number of population = 3704

e= level of accuracy or sampling error (Where, $\alpha = 0.05$).

Based on this, out of the total household (HH) population of 3704 in walga watershed, 135 HH were interviewed. During field data collection respondents were selected by a simple random sampling procedure. To select the participants' consultation through Developmental Agents (DA) and experts of the respective study areas was used. The structured questionnaire was first preparing in English and translated in to the Regional language "Afaan Oromoo" for practical field work. Then the questionnaires were applied through interview for the selected elders of Walga watershed. Types of micro watershed, location of kebeles and the number of sample households are listed in (Table 4) below.

Table 4: Number of Sample size selected household of Walga watershed.

No	Sub Micro watershed	Total household population	Sample size	kebeles
1	H/Michael	260	11	Haro wonchi
2	W/Gedam	350	12	Haro wonchi
3	Kemshashi	201	7	Haro wonchi
4	Wo/Mechal	630	21	Azerkerensa,
5	Jate	243	9	Shegeg
6	LimeKela	738	27	Woldotelfem
7	Damu	142	5	Damudegele
8	C/Bosonte	235	9	FitewatoWoldotelfem
9	SomboJebo	351	13	Dulelekore
10	AdereSemo	554	19	AzerkerensaWoldotelfem
		3704	**135**	

Based on the information that was obtained from key informants a questionnaires which show historical back ground of investigated period (1985-2000 and 2000-2015) covering a wide range of topics relevant to the central issue of interest were developed. Detailed questionnaires have been, administered separately to the selected households based on demographic data (gender, age, labor availability, family size, educational level, life expectancy and occupation). During this data collection the information of: main sources of ecosystem services provided by different LULC cover classes, assessment of main places from local people for cultural services such as recreation and ecotourism and cultural heritage, current and past state of land use change and its impacts, main house hold energy sources, main types of livelihood strategies and socioeconomic activities such as; crop production, sources of income at house hold level, livestock holding size was identified. At the end of data collection, the collected questionnaires from household were cross checked by DA's and key informants again.

3.3.2. Method of data analysis for ecosystem Services and livelihoods strategies

The analysis focused on the relative importance of the specific ecosystem services as well as the total ecosystem services provided by the land uses at different time. The respondents asked to rate its relative importance for each of ecosystem services according to its overall importance in different years. They asked to give their relative importance by using weighted method 0(Not important at all to me), 2 (Medium to me), 3 (Important to me) and 5 (Very important to me) categories 0 means it is not important at all to me, 2 for medium, when they define medium we use it but it is not important to full fill our basic need, 3 for important this means, it almost useful rather than medium but still it doesn't full fill our basic needs, 5 for very important this means it is full fill our basic needs other than ecosystem services for both study period by having this relative scale we used the (Koschke *et al*., 2012; Kindu *et al.*, 2016) formula to calculate total relative importance of each selected ecosystem services.

In order to obtain an overall performance value for each alternative land cover class against each of the eleven ecosystem services groups, this study used relative importance of ecosystem services weighted by households, to combine individual services using the (Koschke *et al*., 2012; Kindu *et al.*, 2016) formula.

$$RI_{ij} = \sum_{k=0}^{n} s_{ij} * w_{ij}$$

Where; RI= Total percentage of relative importance of weighted ecosystem services i= rating scale given by households and experts (0=not important 2=medium to me, 3= important to me, 5=Very important to me) j = total average weighted frequency rated scale given to ecosystem services. The sum of the relative importance adds up to 1 ($0 \leq RI \leq 0$ and summation of RI=1 for I j) by multiplying average score (rated scale (frequency scored/total sample size (135) for each services, the overall performance of a land cover class was calculated for each ecosystem service groups.

Hence during the assessment of ES provided by major LULC of walga watershed a single ecosystem services can be applied to one or more LULC classes. In this study weighting the relative importance of change of ecosystem services response o LULC changes using expert and household knowledge were made. At the end matrix analysis ecosystem service with LULC classes were evaluated for the two periods (1985-200 and 2000-2015) by following the methodology which used (Burkhard *et al.*, 2009).

After the comparison of relative importance of each major ecosystem services response to LULC change was evaluated the correlation between total area coverage changes of LULC within total change of weighted relative importance of ecosystem services (cultural, provision and regulation services) were evaluated, the main livelihood strategies of community watershed also identified using descriptive statics using SPSS v20 and excel Microsoft office were used.

4. RESULT AND DISCUSSIONS

4.1. Satellite Image Classifications Result

As showed in (Figure 4) the classified land use/cover map of Walga watershed classes were water body, shrub land, grazing land, forest, enset farmland, degraded land, crop farmland and settlements which identified as the major LULC classes of the study area. The classification result of images of the three decades reveals that forest coverage (deep green) land covers varies from 1985 to 2015 both spatially and temporally which shows dramatic change over period of time. The declining trend showed that due to expansion of crop farmland and enset farmlands.

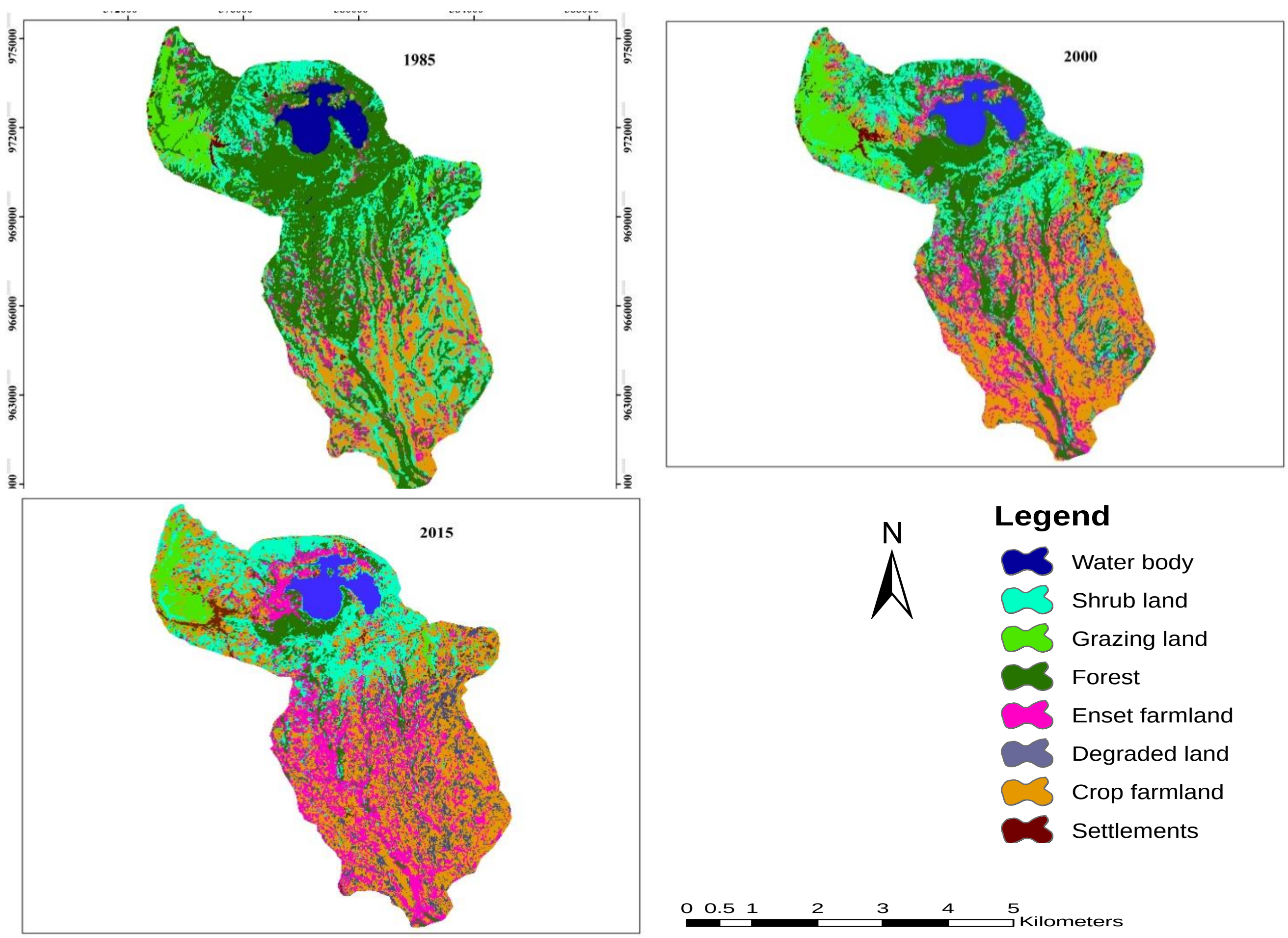

Figure 4: Land cover classes of years 1985, 2000 and 2015.

4.1.1. Accuracy assessment

During the accuracy assessment process the percentage of user accuracy, producer accuracy, over all accuracy and Kappa coefficient were computed (Table 5) which shows the accuracy assessment of classified images of 1985, 2000 and 2015.

Table 5: Accuracy of Image classification over years (%)

	Classes	Accuracy (%)					
		1985		2000		2015	
		Producer's Acc.	User acc	Producer's Acc.	User acc	Producer's Acc.	User acc
1	Water body	100	97.06	100	100	100	100
2	Shrub land	62	64.58	69.35	79.63	83.84	78.30
3	Grazing land	93.1	81.82	89.66	83.87	100	85.11
4	Forest land	94.02	83.33	90.48	82.61	91.45	92.24
5	Enset farm land	71.43	79.55	91.04	88.41	75.27	90.91
6	Degraded land	51.61	88.89	68.63	97.22	69.77	81.82
7	Crop farm land	74.07	64.52	86.84	68.75	70.37	49.35
8	Settlement	25	50	87.50	63.64	78.57	81.48
	Over all Acc.	**79.65**		**83.77**		**81.51**	
	Kappa coefficient	**74.61**		**80.93**		**78.23**	

N.B: User acc. = User accuracy, Producer Acc. = Producer accuracy

Of all the classes during classified images of 1985, 2000 and 2015 settlements, degraded lands and crop farmland exhibits low producer and user accuracy because low separability test was recorded among them for the reason of that spectral mixture with that of degraded lands. The overall classification accuracy for over period of 1985, 2000 and 2015 was 79.65%, 83.77% and 81.51% with kappa coefficient or statics 0.75 and 0.81 and 0.78 respectively. This result is in line with Minale and Rao (2012) who reported the scientifically accepted result for kappa statistics was defined as poor when kappa coefficient is less than 0.4; good when it was between 0.4 and 0.7 and it will be taken as excellent when kappa coefficient is greater than 0.75. LUCC products that use a large number of classes will generally have lower overall accuracy, while simpler products like forest/non-forest classifications can usually be produced with higher accuracy. Data limitations are also important, as spatial and spectral resolution will both affect accuracy (Congalton *et al*., 2009).

4.1.2. Land use/covers 1985, 2000 and 2015

The area and percentages under each cover type during three different periods is presented in table 6 and figure 5. The result indicates that the largest proportion of the watershed was covered by forest (42.5%) and shrub lands (22.3%). Land use categories of 2000 figure 5 and table 6 shows that crop and enset farmlands, grazing land, degraded land and settlements showed a consistence increase which accounts 2545.3ha, 1377.3ha, 972.5ha, 312.8ha and 138.2ha respectively. While forest, shrub land and water body showed similar trends which decreased from 2160.3ha, 169ha and 392.5ha respectively.

During the LULC classification result of image 2015, (Table 6) demonstrated crop and enset farmland takes the largest proportion, 3322.2ha and 2080.1ha respectively. However significant negative change was observed in the forest land decreased from 4073.7 in 1985 to 744.5ha in 2015. As shown from figures, with the expense of forest land enset farmland and crop farmland had showed a consistent increase. Degraded land and settlements have also showed a consistent increase between the study period table 6 and figure 5. On the other hand grazing land was increased from 7.3% in 1985 to 10.1% in 2000 and substantial decrease was observed in 2015 by 4.4%.

Table 6: Area coverage and percentage statics of land use/cover units of Walga watershed from 1985-2015.

No	**LULC Classes**	**1985**		**2000**		**2015**	
		Area (ha)	%	Area (ha)	%	Area (ha)	%
1	Water body	407.6	4.3	392.5	4.1	381.6	4.0
2	Shrub land	2139.5	22.3	1690.0	17.6	1715.0	17.9
3	Grazing land	695.5	7.3	972.5	10.1	417.6	4.4
4	Forest land	4073.7	42.5	2160.3	22.5	744.5	7.8
5	Enset farm land	536.9	5.6	1377.3	14.4	2080.1	21.7
6	Degraded land	67.5	0.7	312.8	3.3	830.2	8.7
7	Crop farm land	1590.7	16.6	2545.3	26.5	3222.2	33.6
8	Settlement	75.8	0.8	138.2	1.4	197.6	2.1
	Total	**9589**	**100**	**9589**	**100**	**9589**	**100**

NB: Percentage area coverage = (Area year/total area) × 100

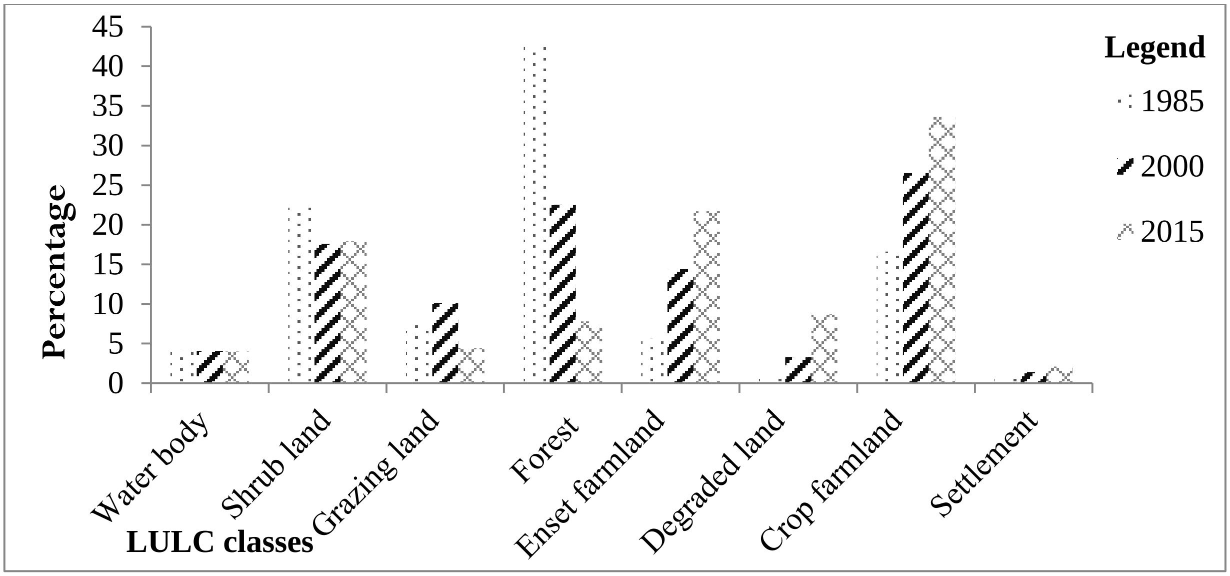

Figure 5: A bar chart showing change in percent of cover types over time.

Similar study by Mesay (2011) who conducted his study on LULC dynamics in Nonno district south West Shewa reports that, the proportion of the cultivated land amazingly increased in the Districts and of all the classes crop farmland, degraded land and settlements were continuously increasing and forest, grazing land, shrub land and water body were shows reducing.

Getahun *et al*. (2013), also reported that, the total natural forest cleared between 1984 and 2009 amounts to 3186 ha which is 50% of the forest cover that existed in 1984, with the same trend he also specified that cultivated land increased from 6.01% in 1984 to 21.96% in 2005 and 34.07% in 2009. Biazen (2015) also reports similar result during 1986, cultivated land, grazing/grass land and bare land occupied about 1440.8 ha However, acacia woodland and shrub/bush land comprised of 1394.1ha and 1721.0 ha respectively. He indicates that the cultivated land has increased by 1.8%, grazing/grass land by 6.8% and bare land by 7.3%, while acacia woodland and shrub/bush decreased by 14.7 and 1.2% respectively.

4.2. Land Use/Cover Change Analysis

The result of Land Change Modeler (LCM) was applied to net change between the two successive period of 1985-2000 and 2000-2015 in ha has been quantified using graph figure 6 (a) and (b). Figure 7 and 8 also showed a change map between 1985-2000 and 2000-2015 and this map reveals that much of change took place in catchment by showing evidence in various colors showing shift or change from cover class to cover classes as result of these change. While figure 6 (**a**, **b**) show that total net change among land cover classes.

4.2.1. Land use/cover change detection from 1985-2000 and 2000-2015

The land cover change between the study periods was quantified by using differences from the late periods to early periods. The result of change analysis using LCM tools of two decades of land cover maps of walga watershed showed significant changes in all LULC classes over the study period. Empirical evidence from figure 6(**a**), forest and shrub land and water body showed declining net change though out the year. While with the expense of forest and shrub lands; crop and enset farmlands, grazing land, degraded land and settlement were showed increasing net change during 1985-2000. These results clearly had shown us (Figure 7) forest and shrub land undergone through a major change by decreasing in area cover. This had seen that high conversion of forest to shrub land, crop and enset farm land, grazing and settlement and shrub land to crop and enset farmland, degraded land and grazing land seen in the study area during the study period.

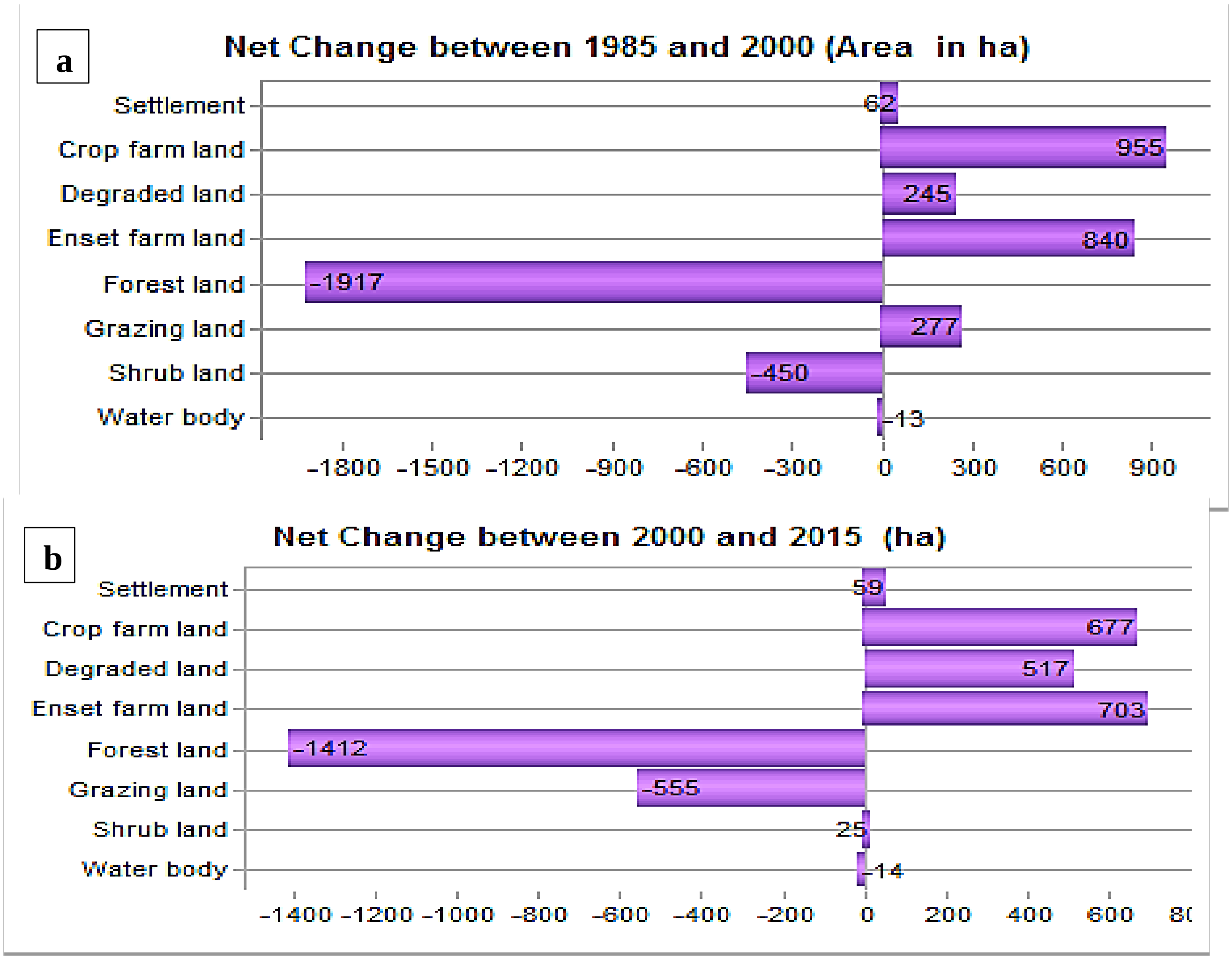

Figure 6: Net change between land use/cover change categories between 1985-2000 (a) and 2000-2015 (b).

NB: The right side (-) show that decreased while the left side (+) increasing.

From figure 6(**b**), forest, shrub and water body were showed consistent decreasing net change from -1412ha, -25ha, -14ha and -555ha respectively between year 2000 and 2015. On the other hand crop and enset farmland, degraded land and settlement have showed positive sign of total area change which implies increase in area coverage (677 and 703ha, 517ha and 59ha). This showed that over the investigated year (Figure 8) with high loss of forest land to crop farmland, enset farmland, grazing land, shrub land and degraded land which have been results high rate of land degradation over the study period.

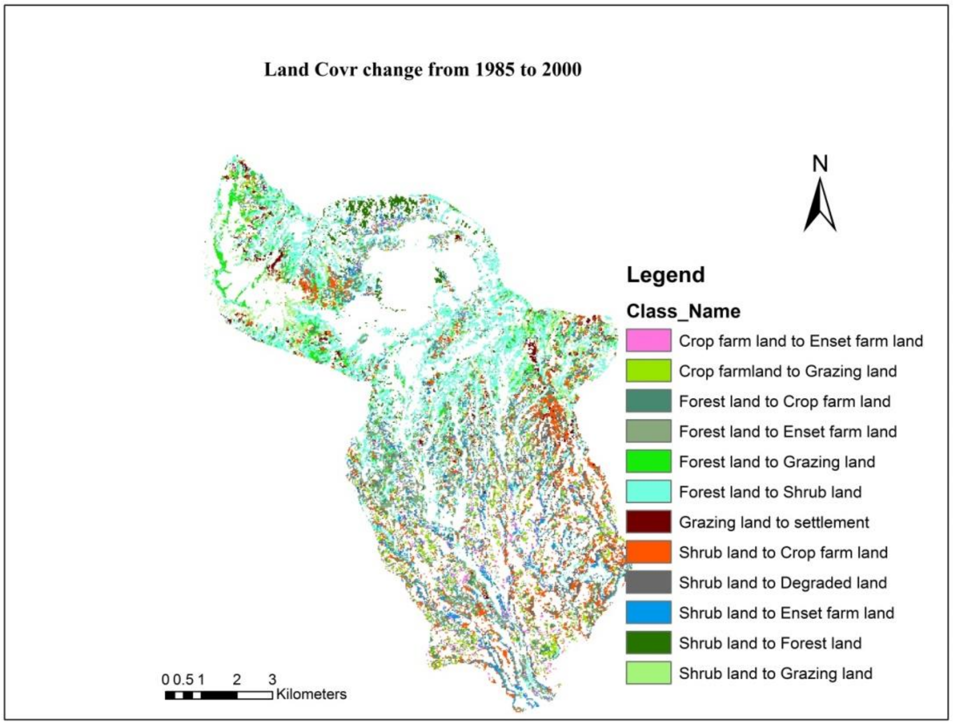

Figure 7: Map showing land use/cover change detection from 1985-2000.

This result is in line with Tesfaye *et al*., (2014) who reported that, Land use/cover change through inappropriate agricultural practices and high human and livestock population pressure have led to severe land degradation such as biodiversity loss, deforestation, and soil erosion in the Ethiopian highlands. Hylander *et al*. (2014) also put similar scenario conversion, of forests into agriculture is common as a consequence of land scarcity.

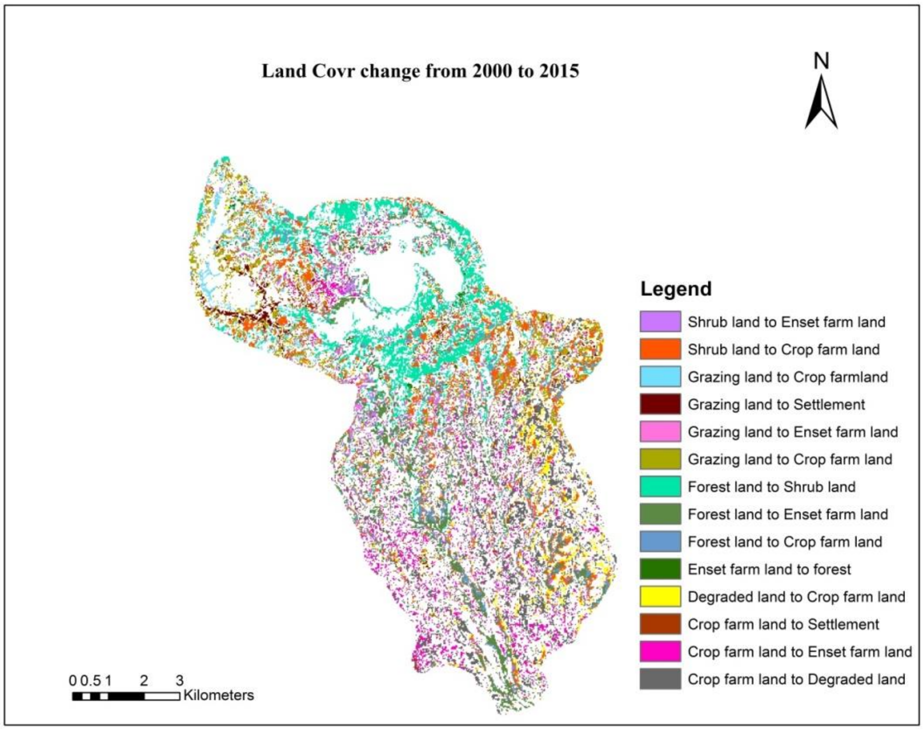

Figure 8: Map of land use/cover change detection from 2000-2015.

4.2.2. Land use/cover change detection from 1985-2015.

The result of figure 9 and 10 shows that the total net gain, losses and persistence of land cover classes during investigated year or during the past thirty years. Results showed that the total net losses (negative) of forest, shrub, grazing land and water body within investigated period or between 1985 and 2015 was -3329ha, -424ha, -278ha and -27ha respectively. While total net gain (increasing over period) of crop and enset farmland, degraded land and settlements within 30 years were; 1631ha, 1543 and 763ha and 122ha respectively. Similar facts reported by Zewdie and Csaplovics (2015) over the last forty years the woodlands have steadily declined in size and have been replaced by croplands, the disturbance of the respective woodland ecosystem is closely related to the occurrence of significant land use transformation within the region. In case of Walga watershed the expansion of crop and enset farmland and degradation of ecosystem are greater than the other land use types in different periods. This result showed that there is a conversion of LULC classes (Figure 11) from this map it is clearly seen that there is high conversion (loss) of forest to degraded land, enset farm land, grazing land, crop farmland and shrub lands. Mulgeta (2011) has reported similar findings at Nonno district Oromia regional state; grassland, dropped from 55.6 percent in 1984 to 34.7 in 2007.

Wanchi Crater Lake (water body) also showed that consistent decrease over the study period. It decreased with net loss of 27ha with in investigated 30 years. Similar facts reported by Hengsdijk and Adem *et al.* (2008), substantial changes in land use, notably the expansion of degraded land and decreases in the size and level of lakes in the central Rift Valley of Ethiopia, have adversely affected the local environment and livelihoods of the people.

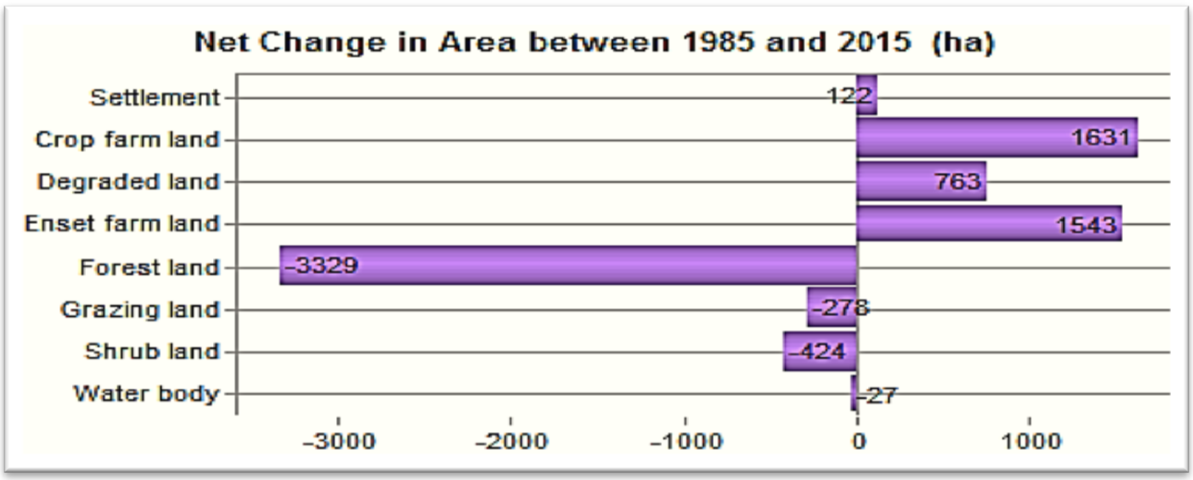

Figure 9: Net Change between land use/cover change categories between 1985-2015 Walga Watersheds.

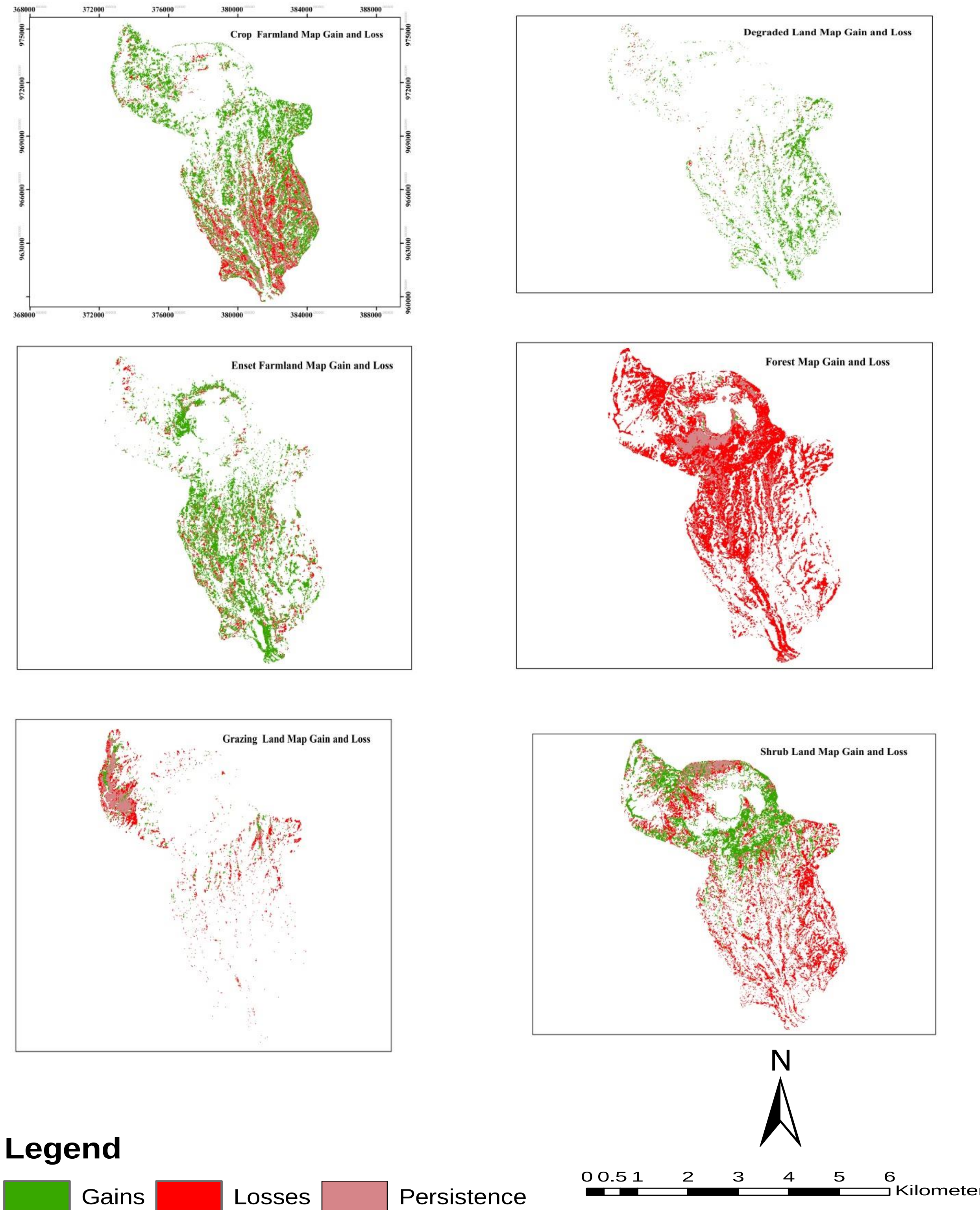

Figure 10: Map showing areas of gains (increase in size), losses (reduction in size) and persistence (area with no change in size) between 1985-2015.

The most direct negative consequence of the increasing area of land degradation is the decreasing productive capacity of agricultural land, which causes food scarcity (Gashaw *et al*., 2014). With similar scenario Berhe (2004) also reports that clearing natural vegetation for agriculture, fire wood, and grazing are the immediate causes of LULC changes in Ethiopia. According to recent findings in different place also showed that such changes are common in other areas with similar settings. Biazen (2014, 2015) reported that, Conversion of forests into agriculture is common, as a consequence of land scarcity.

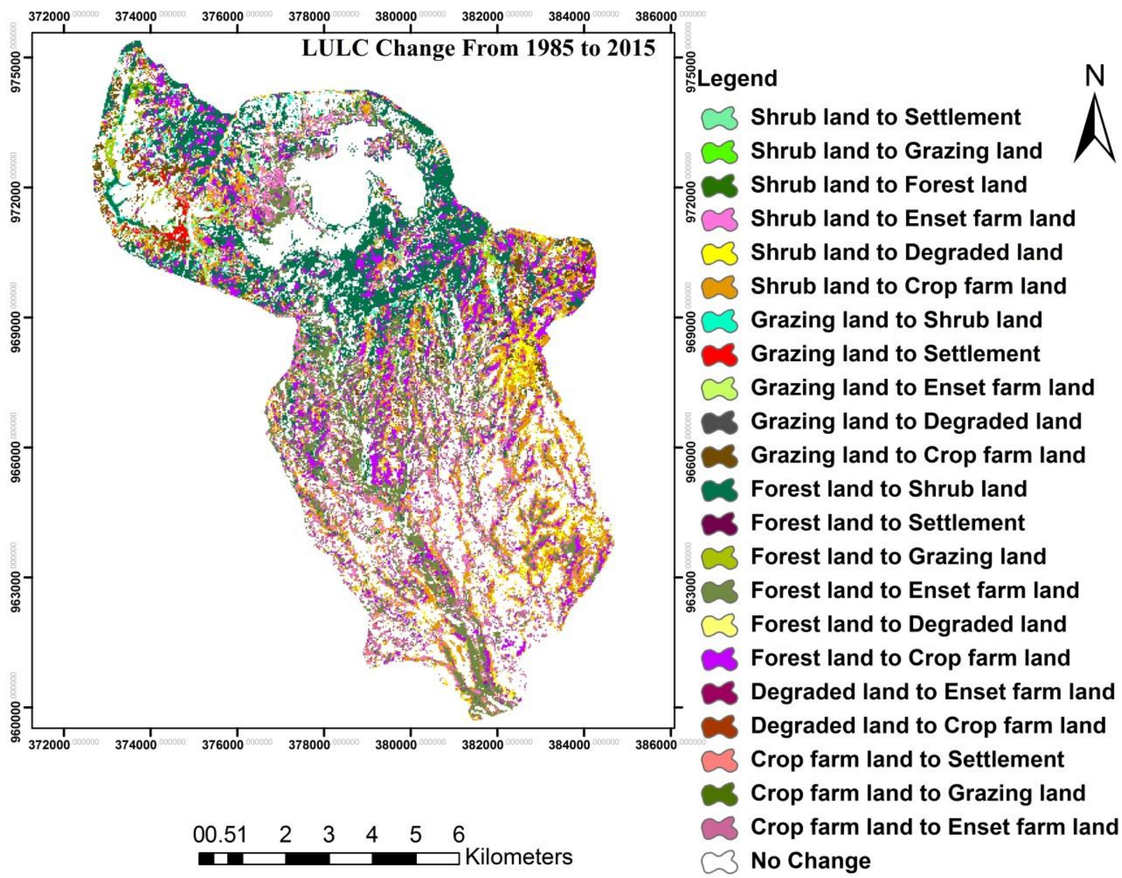

Figure 11: land use/cover change map of Walga watershed (1985-2015).

4.3. Ecosystem Services

Table 7 shows matrix change of ecosystem service associated with each LULC classes within two periods. The result shows that provision services (food, fuel wood, timber, fodder and water supply), regulation services (local climate regulation and soil and water conservation services), cultural services (recreation and ecotourism, spiritual services) and supportive services (habitat provision) were the most ecosystem services provided by forest, crop and enset farmland, water body, grazing land and shrub lands in the study period.

4.3.1. Provision services

According to the assessment made through knowledge of elders the major land use used as a source of food were: crop and enset farmland, forest and water bodies. From the point view of ecosystem food provision services; enset farm land and crop farm land (includes cereal crop and pulses) are the most source of food for rural community of walga watershed. According to household response (Table 7), during study period of the first 15 years crop farm land was the most important source of food having high total relative importance followed by enset farmland. While during the current period, enset farm land has been ranked with the highest relative important service than crop farm land. Enset farmland is the main source of food in present day contrary to crop farmland. This is the reason that crop cultivation expanded to steep and very steep slopes as well as in marginal land, lack of conservation measures, increased run-off and the fragile nature of the soil in the study area which results loss of production of cereal crop as well as pulses.

According to the respondent's reply during the past fifteen years they collect some fruit from forest and also hunt wild animals such as Duiker "kuruphe" and Francolin "Gogorrii" use as a source of food while at the present, unsustainable management of the natural resource is manifested by clearing and cultivation of hillsides and steep slopes and expansion of settlements which resulted in distinction of wild life and loss their service. During the past fifteen years in wanchi crater fishing practice was undertaken but during the current period due to conflict among the owner the resources declined through time.

These results also in agreement with studies by De Groot *et al.* (2010) who reported that food is produced principally in intensively managed agro-ecosystems, but apart from areas devoted to wildlife conservation or recreation, and those used for other production systems, most landscapes are involved in food production. Urban and suburban areas have allotment and other forms of gardens that are used for food production, particularly in developing countries. Trend of traditional natural resource management is reducing with the increased demand for agricultural production.

During the past, both forest and shrub land had very important services as energy sources and both of them scored 0.99.While during current period with expense of forest, shrub land supply high relative importance scoring very important (Table 7). Enset farm land also considered as source of fuel wood with expense of forest and shrub land. According to the information gathered from elders, during the past years the most indigenous trees like *Hygienic Abysinica*, *Podocarps* and *Juniperous*, were the major dominated tree indigenous species in the walga watershed. However in the current period, amazingly due to shortage of the trees species they use enset (dried leaf part) as a source of fuel and *eucalyptus* tree species.

From knowledge of elders grazing, crop farming, forest and shrub lands have been showed consistent decreased in relative importance in fodder provision services from 0.79 to 0.42, 0.91to 0.5, 0.5 to 0.08 and 0.72 to 0.49 during the study period of 1985-2000 and 2000-2015 respectively. In contrary at an expense of forest, shrub and grazing land, enset farmland is increasing in relative importance of providing fodder provision services 0.03 during 1985-2000 to 1 in 2000-2015 (Figure 12). Mohammed *et al*. (2013), reported that enset has high water content (85 to 90%), which is beneficial when used as fodder during dry periods.

In general during field observation and community also underlined that, only in Haro Michael community watershed left very little communal grazing land (Figure12) and this leads the watershad to shortage of fodder and grass for the existing livestock which results overgrazing, poor vegetation cover and land degradation.

Total calculated percentage for each of relative importance of each of ecosystem services respect to LULC classes was found in (Table 7) for more details appendix (1).

Table 7: Ecosystem service matrix of walga watershed provided major by LULC classes.

Ecosystem Services	Relative importance of each LULC types ecosystem service											
	Before 15 years ago						**After 15 to current day**					
	Forest land	*Shrub land*	*Water body*	*Enset farmland*	*Grazing land*	*Crop farmland*	*Forest land*	*Shrub land*	*Water body*	*Enset farmland*	*Grazing land*	*Crop farmland*
Provision Services	**2.44**	**1.71**	**1.19**	**0.86**	**0.79**	**1.89**	**0.8**	**1.43**	**0.43**	**2.34**	**0.42**	**0.98**
Food	0.44			0.83		0.99	0.01		0	1		0.48
Fuelwood	0.99	0.99	0.19	0			0.61	0.94	0.34			
Timber	0.5						0.1					
Fodder	0.5	0.72		0.03	0.79	0.91	0.08	0.49		1	0.42	0.5
Water supply			1						0.43			
Regulation Services	**1.77**	**1.45**	**1.03**	**1.47**	**0.6**		**0.48**	**0.13**	**0.69**	**1.6**	**0.25**	
Climate regulation	0.98	0.55	0.51	1			0.33	0	0.11	1		
SAW	0.79	0.89	0.51	0.47	0.6		0.15	0.13	0.58	0.6	0.26	
Cultural Service	**2.33**		**1.9**	**1.02**			**0.32**		**0.31**	**1.66**		
Spiritual service	0.68		0.9				0.083		0.08			
Aesthetic inf.	0.94			0.51			0.26			0.96		
Recreation (ecotourism)	0.71		1	0.51			0.05		0.23	0.7		
Supportive Services	**0.76**	**0.5**	**0.29**				**0.03**	0	**0.02**			
Habitat provision	0.76	0.5	0.29				0.03	0	0.02			

According to the respondents water had high relative importance of provision services, regulation, Cultural and supportive services in the past decades however, it losses the service through time. According to the information's obtained from community households, the potential of the springs is in decreasing as compared to the earlier decades. They also reported that there are small number of springs with low potential for drinking for both households and livestock. As a result of the destruction the natural vegetation and poor management of land, even some of the springs are drying before the rainy season in April and May.

4.3.2. Regulation services

The main ecosystem regulation service which was identified during this study was climate regulation services and Soil and water and conservation services. According to the result of household survey forest, enset, shrub land and water bodies are the main land use which provides climate and soil and water conservation services. From table 7, climate regulation services provided by forest, shrub and water body indicated that decreased through time from 0.98 to 0.33, 0.55 to 0 and 0.51 to 0.11 over investigated period (1985-2000 and 2000-2015). While in case of enset farmland no change was observed. All interviewed respondents agreed on very important services for both decades which weighted (1) which indicates very important.

Figure 12: Main source of fodder provision ecosystem services in Walga watershed.

Forest, shrub land, water body, enset farm land and grazing lands are the major ecosystem services that serve as soil and water conservation services. Due to the fact that high soil erosion problem in the study area, respondents' agreed that this erosion problem in the catchment area there is high problem of water supply for domestic consumption however in absence of forest, shrub and grazing land soil conservation services water body especially wanchi crater lake and small springs serve as high sediment load rather than for conserving water.

The rate and scale of ecosystem degradation is significantly weakening the ability of the natural world to deliver key services such as climate regulation and erosion regulation, provision of timber and fuel wood and protection from natural disasters (De Groot *et al*., 2006).The result is in line with the study conducted by Singanan *et al*. (2008), on water quality of Wanchi crater; the lake area becomes a large sink for heavy metals, the concentration factor is the main cause of sediment toxicity while this factor through bioaccumulation by plants (Typha latifoliain this case) is apparently more pronounced. Land erosion and natural weathering of bedrocks of the lake are probably the main factors responsible for the accumulation of heavy metals in the lake ecosystem.

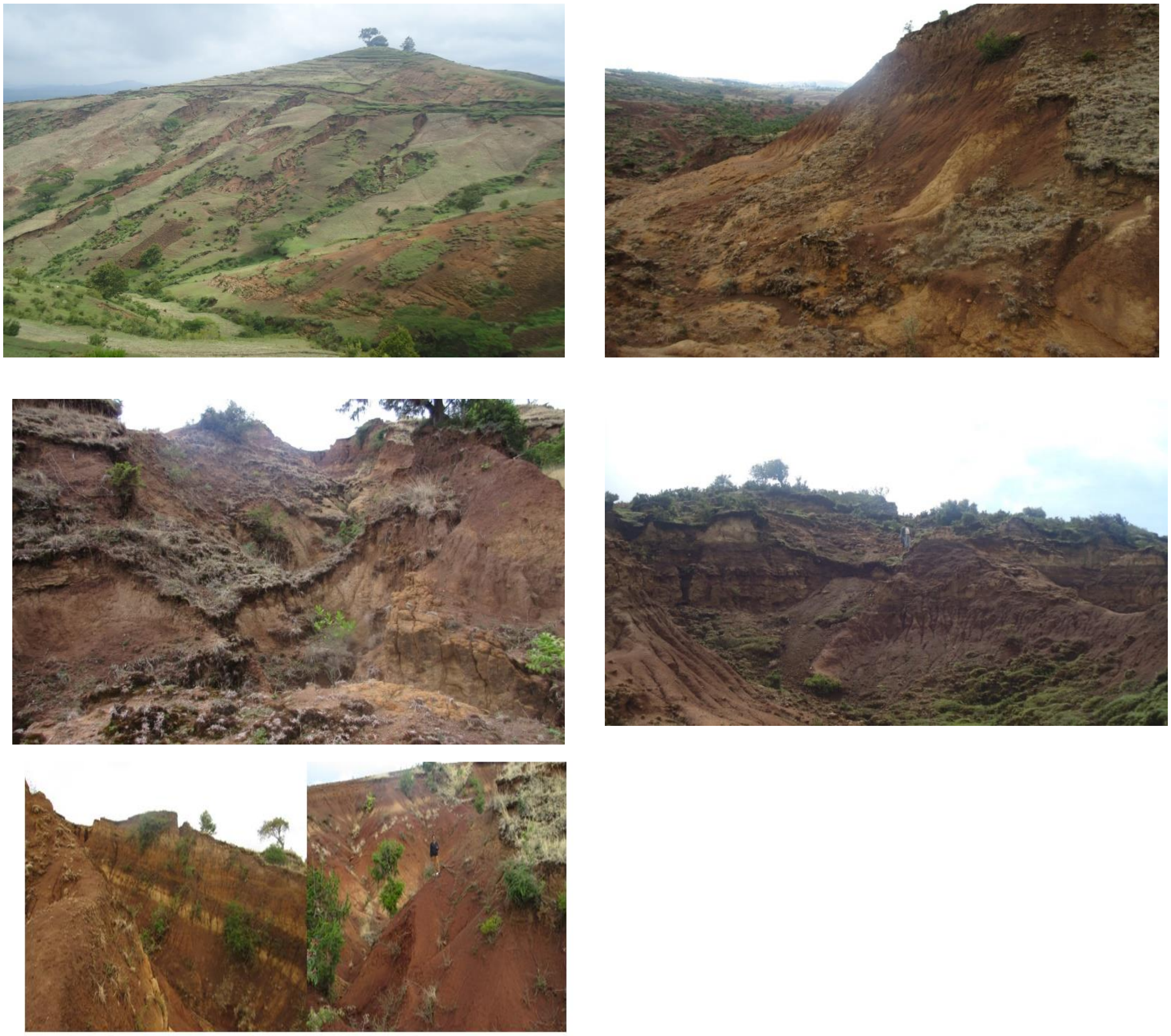

Figure 13: Gully erosion occurred due to forest and shrub land ecosystem service loss.

4.3.3. Cultural ecosystem services

The major cultural services that identified by respondents and expert knowledge which provided by land use classes of walga watershed were, spiritual services, aesthetic information and recreation and ecotourism services.

Aesthetic information: According to the assessment made by respondents' forest and enset farm land were the main sources of aesthetic services. Forest land has high relative importance 0.94 than enset 0.51 during 1985-2000, while in 2000-2015 forest loss services to

0.26 and enset farm land increased to 0.96. Aesthetic ecosystem services that used for different ornamental services during the past decades but for the current period due to the conversion of forest land to agricultural and degraded land, forest loss the aesthetic services. While enset farm land is one the managed ornamental plants around home due to this reason the relative services given by enset were increased though time.

Spiritual, recreation and ecotourism services: Walga watershed in specifically wanchi Crater Lake which has a greatest potential for community based ecotourism with its diversified nature and culture. Due to this reason community walga watershed and foreign countries used this beautiful landscape for recreation, spiritual services. As clearly showed in table 7 all land use land cover classes loss their services except enset farm land which was increased through time. The lake is gifted with natural color, hot spring, waterfalls, beautiful and attractive land scape surrounded by mountainous hill side areas and very steep slope, natural forest called “Qibaatee” forest on the western side due to this reason ecotourism and recreation services gain high relative importance from forest and water body (wanchi crater lake) during the past fifteen. Wenchi Crater Lake is a good potential for tourist activities such as: hiking, boating/canoeing, horse riding, forest exploring, Spa bathing, medical tourism, trekking, adventure and other leisure activities (Ketama, 2015).

However in present day both wanchi lake and forest land have lost their services provided by them due to high an alarming conversion rate of forest to degraded land, crop farmland, settlements, hillside degraded shrub land and loss of water quality hence high degradation results high soil erosion which leads sediment load in the lake. According to the information I gained from experts, Developmental Agents and elders they fear about the durability of this lake due to the accumulation of sediment in the lake during rainy season and conflict between among the sharing of the resources. Deforestation, expansion of cultivation land, overgrazing and over extraction of water coupled with conflicts between park and local communities are detected as the major problem contributors to the degradations of natural resources of the lake Abiyata (Adem *et al*., 2008). Systematic marginalization and little provision of incentives unfair distribution of benefits gained from ecotourism further intensify destruction of natural resources and social relations among the conflicting groups (Adem *et al*., 2008; Ketama, 2015).

4.3.4. Supportive services

The community has also underlined that expansion of land degradation due to complete removal of forest in the catchment area leads extinction of wild life. Conversion of woodland into cultivated land is the greatest root of migration of wild animal and destruction of tree species shocks (Biazen, 2014).

4.3.5. Wanchi community based ecotourism services

Wanchi lake have greatest potential for community based ecotourism however conflict of interest over resource usage and ownership of the lake, unfair benefit sharing, incapability of ecotourism business to benefit the local community equitably, inability of ecotourism to substitute traditional agriculture, illegal land marketing and tension among local community are encumbrances that can impede the sustainability of ecotourism of Wenchi. As a result of such challenges, the sustainability of community based ecotourism development of Wenchi Crater Lake is uncertain despite its potential (Ketama, 2015).

This figure is obtained from wanchi community based ecotourism Office and the starting year is depending on availability of documented secondary data. Based on this data from the beginning of 1998 to 2007 there was low income from tourism activities. Hence during the establishment of community based ecotourism they began to charge the community for fee who used hot spring found in “Qibaatee” forest as they used for medicinal services to cure from disease and Spa bathing as recreation services. Due to fact that they asked them for fee for the use of the hot springs to cure them from their diseases, and salty water to water their domestic animals, an unknown person burnt the house they built for temporary boarding of local guests according to informants. Such strong confrontation between the conflicting parties may lead to the destruction of resources around the lake (Ketama, 2015).

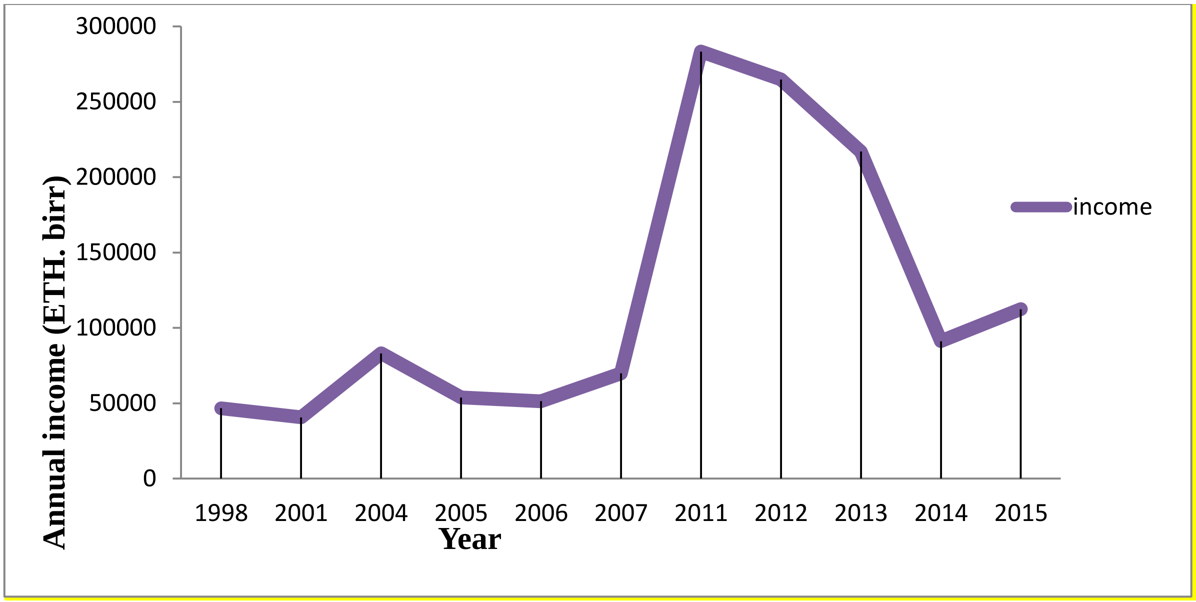

Figure 14: Annual income of from tourist in Wanchi Crater Lake Source, Wanchi Community based Ecotourism Biro.

During the 2011 year they gain maximum services from ecotourism ecosystem services provided by water body (Wanchi Crater Lake) rather than forest land and other land use types. During this year there was a little availability for tourists such as availability of lodge which constructed by some owner from key informants and community based ecotourism association. Currently this lodge is out work (non-functional). The service provided by this lake decreased through time due to detrition of natural land scape and decrease water quality due to sediment load. Wetland has contributing significant roles in providing ecosystem functions and producing a number of products and services-that are socially and economically important to the local community. The result is in line with Gemechu (2010), reported that, lake Abijata and its wetlands provide the necessary services for eco-tourism development and economic base for the local communities. Adem *et al*. (2008) also reported that, in the face of degradations of natural resources and lack of alternative options, there is ecotourism loss through time in Abijata Shala Lake National Park which degraded by anthropogenic activities.

4.3.5. Change of ecosystem service response to land use/cover changes

The result of change in trend of major LULC classes respect to the total change in trends of ecosystem services and the correlation between them was showed in (Table 8) below.

Table 8: Correlation of ecosystem services response to land use/cover change over time.

LULC Classes	**Change in trend**	Change in Prov.	Change in Regu.	Change in Cult.
Water body	-1	-1	-1	-1
Shrub land	-1	-1	-1	-
Grazing land	-1	-1	-1	-
Forest land	-1	-1	-1	-1
Enset farm land	+1	+1	+1	+1
Crop farm land	+1	-1	-	-

	Provision services	Regulation services	Cultural services
change	0.632	1.000**	1.000**

**. Correlation is significant at the 0.01 level (2-tailed).

NB: prov= provision services, Reg = Regulation services, Cult. = Cultural services, Sup. = Supportive services

Negative sign (-) = show that services that not provide relative ES for e.g. shrub land not used as cultural services, (+1) = show that increasing through time both change in area and relative importance, (-1)show that decreasing through time both change in area and relative importance

From the above (Table 8) to see the relationship between change area coverage of land use/cover change and change of ecosystem services provided by each major land cover the Pearson correlation analysis was performed. The correlations of these total ecosystem services; provision services, regulation services, cultural services provided by each land uses were quantified. During this analysis first area change which occurred in 30 years was taken from matrix of classified image of walga watershed, then the total ecosystem services which obtained from the matrix table 7 of each ecosystem services obtained. For instance to get total change forest provision services first total relative importance of forest during the past 15 years minus relative importance of forest present day which scaled by community of walga watershed then the result obtained where taken. Strong positive correlation obtained through simultaneous change of land cover with simultaneous change of ecosystem services except for provision services.

From (Table 8) ecosystem services (regulation and cultural) services showed strong positive correlation with land cover change in-contrary to provision services this is due to fertility loss in the area that means high coverage of land degradation. As crop farm in the area increased there is decreasing of food provision services though time. In Walga watershed improper use of agricultural land, reduction of forest cover and cultivation of steep slopes and the fragile nature of the soil results soil erosion as a series problem of the area which results loss of crop production through time. Hillsides and farmlands are highly affected by sheet and rill erosion from respondents and field observation.

Similar scenario stated by Felipe *et al*. (2014), the amount of each ecosystem services supplied in a given area depends on both the per hectare provision of service in a given type of land use and the total area of each land use and the relative importance of each land use type in supplying ecosystem services and the significant interactions among ecosystem services change depending on the spatial scale at which measurements and analysis done.

4.4. Change of Livelihood Strategies as Result of Land Use/Cover Change

The major livelihood strategies identified in the Walga watershed during the two periods were farm dependence and non-farm dependence categories (Table 9). Farm dependent and non-farm dependent activities during the first past 15 years were crop producing system (cereal crop, lentils and oils), homestead (enset, tomatoes and vegetables), livestock production including small ruminants and poultry and their products such as milk, batter, skin and charcoal production and firewood collection, migrate to nearby urban area for labor force, reducing or skip the number of meal each day, bee keeping, petty trade (traditional drink which is spatially practiced by women), Casual labour, tourism income and remittance were the major livelihood strategies practiced in the study area.

Table 9: Main livelihood strategies practiced by community in Walga watershed.

S.no	Types of Livelihood strategies	Before 15 years old		After 15 to Current year	
		Sample	%	Sample	%
1	**Farm dependence**	**91**	**66**	**60**	**44**
	Crop production	40	29	21	14
	Horticultural crop	15	11	31	23
	Livestock production	36	26	9	7
2	**Non- farm dependence**	**44**	**34**	**75**	**56**
	Bee keeping			5	4
	Charcoal production and firewood collection	24	18	13	10
	Tourism income	8	6	8	6
	Migrate to nearby area for labor force	5	4	12	9
	Petty trade	7	6	12	9
	Remittance			5	4
	Casual labor			10	7
	Reducing or skip the number of meal each day			10	7

4.6.1. Households livelihood strategies during the past 15 years

From the result of household survey farm dependent and non-farm dependent households livelihood strategies were undertaken. However it is varies from time to time, community sub-watershed to community sub-watershed. Among the total surveyed household, during the past fifteen years 91 samples (66%) household populations depend on agricultural land production for their livelihood. During this period field crop cultivation represents the main farming activity, where the majority of household involved. The major fields crops are Barley, Bean, Peas, Wheat and Teff which were varies from community sub-watershed to watershed which is depend on topography of the area. With respect to the type of crop production farmers in the community micro watershed concentrate on field crop rather than horticultural crops such as enset, tomatoes and vegetables. The majority of household were engaged in livestock rearing (26%) followed by horticultural crop production (11%) activities.

The farmers also practiced non-farm land activities in addition to farm land cultivation activities. Land like other parts of the country, is the property of the State but, farmers have only the right to use land themselves or rent to others. About 18% of them do some kind of charcoal production and fire wood collection followed by petty trading (7%), tourism income activities especially community of “haroo mikaa’el” micro watershed due to the presence of Wanchi crater lake, migration to nearby urban area for labor force (4%) respectively.

4.6.2. Current livelihood strategies at community level

According to the respondents view during the present day the total number of household head who depend on agricultural land diminished to 44% compared to the past decades. While non-farm dependent household head increased through year to 56% out of total sample sizes. According to the respondents land shortage is cited among the priority problems faced by farmers, especially for those young household heads. Due to this reason especially the current young household enforced to expand arable land by clearing forest for the cultivation purpose.

Majority of farming household respond to declining land productivity by abandoning existing degraded cropland and moving to new lands for cultivation without an appropriate conservation measures which leads loss of productivity. Due to this reason majority of households engaged in changing their livelihood strategies away from crop production towards horticultural crop production and non-farm activities that are undertaken to generate additional income for survival and cope with these difficulties of loss of productivity due to soil erosion problem of the study area. This finding is in line with Dirribsa and Tassew (2015) who have reported that, households engage in diverse livelihood strategies away from purely crop and livestock production towards farm, non-farm and off-farm activities that are undertaken to broaden and generate additional income for survival and cope with this harsh and difficult environment.

Therefore ploughing the steep slope which is not recommended for cultivation by their hand rather than oxen (Figure 15) was observed in the walga watershed especially around wanchi

Crater Lake and Jate micro watershed. Because of absence of alternative source of livelihood, the people encroach in to the forest land, cultivate the fragile steeply slope, resulting in land degradation, forest and grazing land are diminishing which leads to decreasing the number of household who depend on livestock production through time. Due to this reason they diversify their livelihood strategies to save their live rather than to live better life, they undertaken degradation of natural ecosystem in the catchment by clearing forest (Figure 15).

Farmers expressed their concern about the increase number of households who depend on non-farm dependent; increase the numbers of landless young over year due to population incensement through time. According to information collected from respondents half of the population in walga watershed not owns the land. Hence the land was distributed during the Derg regime and there has not been further redistribution of land since then, except formal and informal land transfer through kinship. Access to land by this group entirely depends on the willingness and capacity of their parents to informally transfer a small proportion of their own holdings. Due to this reason farmers enforced to expand their livelihood strategy farm dependence to non- farm dependence activities spatially the poor household heads. Due to high population increase in the catchments, they enforced to expand arable land and rely on enset farmland as source of income, food, fodder, construction material (fencing), fuel wood. This study is in line with Laila *et al*. (2013) who reported that enset is drought tolerant, multi-purpose crop which has, since ancient times, been part of a sustainable cropping system with high agro biodiversity in Ethiopia.

Figure 15: Illegal encroachment of shrub and bush land for farmland (Wanchi Gedam and Shegeg CWS.

Elders said that, they gave a piece of land to their newly married sons for house construction and to grow some crops. This form of continued land reallocation and transfer has resulted in fragmentation of landholding to the extent that the farm sizes are no more economically viable. The landless groups are ranked as economically most disadvantaged groups and they undergo various forms of coping mechanisms such as working as laborers on others farm, and involve in petty trading activities, migrate to nearby area for labor force and remittance.

Livestock play an important role in the farming household, through improving fertility, saving financial and through direct food product. Hover-ever during the present day the numbers of house hold who depend on production of small ruminants diminished to7%. Farmers complain that due to due to shortage of animal feed and water supply, absence of pasture land due to severe land use land cover change recurrent high land degradation, expansion of grazing land to settlements and arable lands, fragmentation of shrub land to gully erosion, in the community watershed and existence of livestock disease such as, Anthrax (“Abbaa sangaa”), Foot and mouth, internal and external parasite are the lead decreased number of livestock and major problem for their livelihood strategy of community watershed.

Horticultural crop is which include enset sometime called “false banana” in local name also called “Warqee” is one the major livelihood strategies used as multi-purpose by intercropping such as, tomatoes, cabbages and other vegetables are the common practiced by community watershed for their livelihood and as income source. Therefore enset is one the major livelihood strategy in the current year in in expense of livestock production and failure of crop due to loss of productivity though time. Occurrence of intensive and continuous crop production over moderate to steep sloped and marginal forest areas have accelerated soil and water erosion, and degraded forest resources Tesfaye (2003). According to the farmer response due to severe land degradation in the watershed they expand enset which is one of the perennial crops used for food, fodder, and fuel wood as well as income source for their livelihood strategies.

People valued enset for their livelihood strategies among the other crops produced in the area. For instance, the community of walga watershed that I have asked about enset they described “Enset is our life; without it there is no life and we cannot improve our livelihood” it is using us as food security throughout the year.

In case of walga watershed, farmers living in the catchment and neighboring areas clearing the remaining forest used as fuel wood for maintaining their livelihood as a source of income Charcoal wood production and fire wood collection were one of the major livelihood strategies for the community of in both decades. During off farm (summer up to harvested season), the poor household (who define themselves as a poor) have facing food shortage and these households are engaged themselves to sell charcoal and fuel wood and other engaged themselves in daily labor to earn the livelihood. However many of respondents’ response that as they have faced shortage of fuel wood due to the extinction of indigenous tree species in the community watershed the number of household who depend on charcoal production reduced. Due to the shortage fuel wood they started expansion of eucalyptus tree species in the community watershed.

The landless household are ranked as economically most disadvantaged groups and they undergo various forms of coping mechanisms such as working as laborers on others farm, and involve in petty trading activities, borrow grain and money, and migrating to the neighbor countries were expanded through the time. Farmers also reported that migration is the main work related strategy, in the community watershed including rural urban migration. Seasonal and daily wage labor, hiring children as herders, seasonal labor migration for harvesting cereal crops to their neighbors urban areas.

Reducing consumption and meal were common in our country in specific walga community watershed. Change the food cereal to vegetables, spatially potatoes and enset are common food consumed in the area rather than cereal crop, pulses and lentils. They consume cereal crop by mixing with enset. From the above (Table 9) production of Livestock production decreased through time a move from livestock product to annual crop such as enset and vegetables were occurred.

5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

Global environmental changes in land use/cover, ecosystem services and livelihood are increasingly on scientific and governmental agenda. Land use/cover change, ecosystem services (ES) and livelihood strategies practiced by rural communities are highly interdependent. Change of land use/cover (LULC) results degradation of ES and reduces alternative livelihood strategies. This study presented that the spatiotemporal LULC change using remote sensed data to quantify LULC for past three decades (1985-2015) and surveyed associated ecosystem services and rural livelihood strategies. In our study a very dramatic changes are observed among LULC change, ecosystem services and rural livelihood strategies. The LULC pattern of change different categories shows variation among different LULC classes during 1985, 2000 and 2015 periods.

With increasing population pressure forests, shrub lands and grazing lands were dramatically converted in to crop and Enset farm lands. Because of depletion of forest and shrub lands from the catchment area, soil erosion was enhanced over time increasing land degradation and resulting in sedimentation of Lake Wenchi consequently causing visual intrusion and affecting ecotourism. Though the farm lands were increased over time, the increment in food production was not parallel to the population growth leading to the change in livelihood of the local communities.

A trend to shift from mainly relying on crop cultivation to Enset cultivation has been a prominent response to population growth and land degradation since recently. Which serve the community as source of food as well as fodder for livestocks. Despite that even if there is conversion of forest to crop land and increasing of crop area coverage seen in the catchment, however due to increasing coverage of land degradation (91.9%) during investigated period, which leads decreasing productive capacity of crop farmland results loss food provision services. Rapid growth of population size, shortage of land and high increasing demand of food enforce community intensified the pressure on land without any conservation measures which results land degradation.

Change of the livelihood strategies from farm dependent livelihood to other activities such as migrate to nearby urban area for labor force, reducing or the number of meal per day, petty trade, casual labour, and remittance were also other commonly seen trends. In general LULC has highly affected the ecosystem service obtained from them and the livelihoods of local communities.

5.2. Recommendation

In order to minimize impact of LULC in walga watershed to conserve the ecosystem and bring about sustainable use of the resources, the following recommendations are suggested:

- Steep slopes should be used for afforestation purposes or cultivation of fruit tree such as Apple instead using them for crop cultivation which enhances soil erosion.
- Strong policy should be enhanced and put into practice to discourage the drastic change in land use/cover and conserve the ecosystem in the way the services obtained from them are enhanced.

- Ecotourism development which is used for multi-purpose for rural household as well as environmental conservation the responsiveness should be taken by Wereda, Zonal as well as Regional Government to enhance Wanchi community ecotourism development through solving conflicts among the resource users.

- Giving awareness for the community to use alternative energy source such as: solar energy, energy saving stove, biogas, and rural electrification rather than relying on firewood.

Future line work:

- Enset (*Ensete ventricosum*) which is categorized under intensively managed ecosystems for multi-purpose uses, should be promoted and after careful variety selection and putting disease prevention and control system take into place by researcher.
- More detail study of the degradation amount in relation to fertility loss due to soil erosion, sediment yield to the Wanchi Crater Lake and catchment characteristics should be made using adaptable models; so as to guide the implementation of wide-

ranging and sustainable land management and watershed development by giving more attention to erosion prone area.

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7. APPENDIX

Introduction

This exercise is forms of parts of data collection activity toward my research on the topic "*Assessing Land use/land Cover, Ecosystem Services and Livelihood changes in Walga Watershed, South West Shewa Ethiopia*". This questionnaire aims to obtain reliable information for rural community like u in this selected micro sub-watershed on livelihood strategies practice through time, major ecosystem services provided by different land use land cover classes such as, grass land, forest land, water body, homestead area (enset farm land), crop farmland. Thus you have been randomly selected for the purpose of this research to represent other households in this micro watershed. Thus, the fact that you have been selected is quite coincidental and your participation in this questionnaire is voluntary. So I kindly request you provide answers to the questions as honestly as possible.

I greatly appreciate your cooperation in advance!

Thanks!!!!!!!!!!

Appendix 2: Household Questionnaires

Appendix 1: General Information of Respondents

Field enumerator ___________________ Date_____________

Respondent's Name ______________________________ District ______________Name of micro sub watershed______________Gender: A. Female B. Male

GPS coordinates of residence (coordinates): North: ________________East: _________________Altitude (m.a.s.l.):__________________ precision (m) --------------.

Appendix 2: Change in ecosystem Services as a result of Land use/Cover Change

Which of the following LULC types you own and the most associated ecosystem services you .A usually collect from each LULC types during each time interval. Please give measurement giving (5=Very important, 3=important, 2=medium, 0=not important).

Tables of Appendix 1: Major ecosystem services provided by different land use/cover classes

Year	**Types of LULC**	**Types of Ecosystem Services**													
		Provision services						*Regulation*			*Cultural*				*Supporting*
		Food production		Water(drinking, cooking,	Fuel wood	Timber	Fodder	Climate regulation	Flood (erosion) protection		Spiritual service	Aesthetic information		Recreation and Ecotourism services	Habitat provision
1985-2000 G.C	*forest land*														
	farm land														
	Shrub land														
	Grazing land														
	Built-up														
	Degraded land														
	Water bodies														
	Inset Farm land														

Continued

Year	**Types of LULC**	**Types of Ecosystem Services**													
		Provision services						***Regulation services***			***Cultural services***				***Supporting services***
		Food production		Water(drinking, cooking, Irrigation)	Fuel wood	Timber	Fodder	Climate regulation	Flood (erosion) protection		Spiritual service	Aesthetic information	Educational service	Recreation and Ecotourism services	Habitat provision
2000-2015 G.C	*forest land*														
	farm land														
	Shrub land														
	Grazing land														
	Built-up														
	Degraded land														
	Water bodies														
	Inset Farm land														

Tables of Appendix 2: Change in livelihoods resource as a result of land use/cover change

No	Types of Livelihood assets	During 1985-2000	During 2000-2015
2.1	**Human Resources**		
A	Respondent's Age: ____		
B	Family size	1. Increasing 2. Decreasing 3.The same	1. Increasing 2. Decreasing 3.The same
C	Household life expectancy	1. Increasing 2. Decreasing 3.The same	1. Increasing 2. Decreasing 3.The same
2.2	***Crop grown***		
A	List the most crop grown in your community watershed	1.______________ 2. ___________	1.______________ 2. _______________
B	Purpose of use	3.__________ 5 ________	3._____________ 5 _________________
		4__________ 6. __________	4______________ 6. ________________
2.2	**Productivity of land**		
a	How you compare the productivity of your farm land over this period of time (please put the prod kunt/ha) for the crop you listed under qoest. 2.1 (B)	1. Increasing 2. Decreasing 3.The same	1. Increasing 2. Decreasing 3.The same
b	Do you leave part of your land abandoned?	1. yes 2. No	1. yes 2. No
c	If yes, What is the age of fallow period?		
d	What types of fertilizer you use to make your land more		
2.3	***Livelihood strategies***		
a	Do your families face shortage of food?	1. Yes 2. No	1. Yes 2. No

No	Types of Livelihood assets	During 1985-2000	During 2000-2015
b	If so what are your coping strategy for your livelihood Mail fuel wood type usually used by household for consumption	1. Migrate to another area 2. Selling charcoal/fire wood 3. Borrow grain or money to buy food 4. Migrate to nearby urban areas for labor force 5. Other please secify	1. Migrate to another area 2. Selling charcoal/fire wood 3. Borrow grain or money to buy food 4. Migrate to nearby urban areas for labor force 5. Other please secify
2.3	**Livestock resource**		
a	Numbers of animal you own	1. Yes 2. No	1. Yes 2. No
b	Do you use milk and milk products for sell and consumption		
	If yes how you compare its price over this period of time	Increased 2. Decreased 3. Highly increased 4. No change	Increased 2. Decreased 3. Highly increased 4. No change

Appendix 3: Associated ecosystem services

Tables of Appendix 3: Relative importance of selected ecosystem services provided by LULC classes

Relative importance of (%)total weighted by 135 household samples. where; NI= Not important, MD= Medium, IM= Important, VP= Very important, RI= Relative Importance (0,<u><</u>k<u><</u>1)

ES	**During the past 15 years**						**Current period**					
	Forest land											
	NI(0)	MD(2)	IMP(3)	VIMP(5)	total	RI	NI(0)	MD(2)	IMP(3)	VIMP(5)	Total	RI
Provision Services	0.000	0.400	0.600	1.000		2.437	0.000	0.400	0.600	1.000		0.796
Food production	0.220	0.350	0.330	0.100	1.000	0.438	0.991	0.015			1.000	0.006
Fuelwood			0.022	0.978	1.000	0.991		0.600	0.067	0.333	1.000	0.613
Timber		0.022	0.430	0.504	1.000	0.502	0.822	0.096	0.059	0.022	1.000	0.096
Fodder			0.037	0.970	1.000	0.505	0.822	0.163		0.015	1.000	0.080
Water supply												
Regulation Services						1.766						0.477
Climate regulation			0.059	0.941	1.000	0.976	0.585	0.148		0.267	1.000	0.326
Soil and Water conservation			0.526	0.474	1.000	0.790	0.644	0.311	0.044		1.000	0.151
Cultural Services						2.333						0.320
Spiritual services	0.015	0.185	0.474	0.326	1.000	0.684	0.793	0.207			1.000	0.003
Aesthetic information			0.141	0.859	1.000	0.944	0.430	0.393	0.178		1.000	0.264
Recreation and ecotourism		0.052	0.659	0.289	1.000	0.705	0.889	0.067	0.044		1.000	0.053
Supportive Services						0.757						**0.033**
Habitat provision		0.030	0.563	0.407	1.000	0.757	**0.919**	**0.081**			1.000	0.033
	Shrub land											

Provision Services	NI(0)	MD(2)	IMP(3)	VIMP(5)	Total	RI	NI(0)	MD(2)	IMP(3)	VIMP(5)	Total	RI
	0.000	0.400	0.600	1.000		1.710	0.000	0.400	0.600	1.000		1.431
Fuelwood			0.030	0.970		0.988			0.148	0.852	1.000	0.941
Fodder			0.696	0.304		0.721	0.430		0.200	0.370	1.000	0.490
Regulation Services						1.447						0.129
Climate regulation	0.044	0.104	0.852			0.553	1.000				1.000	0.000
SAW		0.052	0.185	0.763		0.895	0.689	0.289	0.022		1.000	0.129
Supportive Services						0.502						0.000
Habitat provision		0.489	0.511			0.502	1.000					0.000
ES	**Water body**											
	NI(0)	MD(2)	IMP(3)	VIMP(5)	Total	RI	NI(0)	MD(2)	IMP(3)	VIMP(5)	Total	RI
Provision Services	0.000	0.400	0.600	1.000			0.000	0.400	0.600	1.000		0.425
Food	0.637	0.148	0.215		1.000	0.188	0.000				0.000	0.000
Water supply				1.000	1.000	1.000		0.874	0.126		1.000	0.425
Regulation Services						1.025						0.123
Climate regulation		0.437	0.563		1.000	0.513	0.756	0.193	0.052		1.000	0.108
SAW		0.437	0.563		1.000	0.513	0.963	0.037			1.000	0.015
Cultural services						1.902						0.305
Spiritual services		0.015	0.222	0.763	1.000	0.902	0.822	0.141	0.037		1.000	0.079
Recreation				1.000	1.000	1.000	0.489	0.400	0.111		1.000	0.227
Support service						**0.292**						**0.018**
Habitat	0.415	0.296	0.289		1.000	0.292	0.956	0.044			1.000	0.018
ES	**Enset farm land**											
	Before						After					
	NI(0)	MD(2)	IMP(3)	VIMP(5)	total	RI	NI(0)	MD(2)	IMP(3)	VIMP(5)	total	RI

Provision Services	0.000	0.400	0.600	1.000		0.443	0.000	0.400	0.600	1.000		2.338
food production		0.919	0.081		1.000	0.416				1.000	1.000	1.000
Fuelwood	1.000				1.000	0.000	0.311	0.378	0.311		1.000	0.338
fodder	0.933	0.067			1.000	0.027				1.000	1.000	1.000
Regulation Services												1.000
climate regulation				1.000	1.000	1.000				1.000	1.000	1.000
SAW Conservation		0.733	0.222	0.044	1.000	0.471			1.000		1.000	0.600
Cultural services						1.019						1.662
Aesthetic information		0.459	0.541		1.000	0.508			0.104	0.896	1.000	0.959
Recreation and ecotourism		0.815		0.185	1.000	0.511			0.741	0.259	1.000	0.704
ES	Grazing land											
	Before						After					
	NI(0)	MD(2)	IMP(3)	VIMP(5)	Total	RI	NI(0)	MD(2)	IMP(3)	VIMP(5)	Total	RI
Provision Services	0.000	0.400	0.600	1.000		1.385	0.000	0.400	0.600	1.000		0.677
SAWC			1.000		1.000	0.600	0.363	0.637			1.000	0.255
Fodder		0.156	0.304	0.541		0.785		0.889	0.111		1.000	0.422
	Farm land											
	Before						After					
	NI(0)	MD(2)	IMP(3)	VIMP(5)	Total	RI	NI(0)	MD(2)	IMP(3)	VIMP(5)	Total	RI
Provision Services	0.000	0.400	0.600	1.000		1.893	0.000	0.400	0.600	1.000		0.978
Food production			0.037	0.963	1.000	0.985	0.052	0.615	0.252	0.081	1.000	0.479
Fodder	0.037	0.037	0.081	0.844	1.000	0.908		0.504	0.496		1.000	0.499