LAND USE AND LAND COVER DYNAMICS IN LOWER AWASH RANGELANDS, ETHIOPIA

M.Sc. Thesis

Wondimagegnehu Shibru

June, 2016
Jimma

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Submitted to the School of Graduate Studies Jimma University College of Agriculture and Veterinary Medicine in Partial Fulfillment of the requirements for the Degree of Master of Science in Natural Resource Management (Watershed Management)

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Department of Natural Resource Management

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I have completed my thesis research work as per the approved proposal and it has been evaluated and accepted by my advisers. Hence, I hereby kindly request the Department to allow me to present the findings of my work and submit the thesis.

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We, the thesis advisers have evaluated the contents of this thesis and found to be satisfactory, executed according to the approved proposal, written according to the standards and format of the University and is ready to be submitted. Hence, we recommend the thesis to be submitted.

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DEDICATION

This manuscript is dedicated to my beloved Parents Seregent Shibru Lemma and my mother W/ro Beyenech Eshetu

STATEMENT OF AUTHOR

First, I declare that this thesis is my original work and all sources of material used for this thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for the M.Sc.degree at Jimma University, College of Agriculture and Veterinary Medicine and is deposited at the University Library to be made available to borrowers under rules and regulation of the Library. I also declare that this thesis can be submitted to any other institutions anywhere for the award of any academic degree, diploma, or certificate, if the University found it necessary.

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BIOGRAPHICAL SKETCH

The author was born on January 16/04/1969 at Gursum, East Harerghe Oromia National Regional State, Ethiopia. He attended his elementary and secondary school at Holeta Yekatit 25/67 comprehensive high school. He joined to the then Alemaya University of Agriculture on October , 1984/85 and has graduated in 1988/89 academic year in field of Agriculture (Animal Science) in Bachelor of Science(Bsc). After his graduation, he served Ministry of Agriculture, ,Ethiopian Science and Technology Commission and now he is working in the Ministry of Federal Pastoral Development Affairs in different position

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ABBREVIATIONS (ACRONYMS AND ABBREVIATIONS)

ANRS	Afar National Regional State
AFEDB	Afar Finance and Economic Development Bureau
AOI	Area of Interest
CSA	Central Statistical Agency
EMA	Ethiopian Mapping Authority
ERDAS	Earth Resources Data Analysis System
ETM+	Enhanced Thematic Mapper
FAO	Food and Agriculture Organization
GLCF	Global Land Cover Facilities
GPS	Global Positioning System
GIS -	Geographical Information System
IAS	Invasion of Alien Species
Ha	Hectare
LULC	Land Use/Land Cover
LULCC	Land Use /Land Cover Change
M.a.s.l	Meter above sea level
NASA	National Aeronautics and Space Administration
RLM	Range Land Management
IHDP	International Human Dimension Program
IR	Infrared
NRC	Natural Resources Canada
SPSS	Statistical Package For Social Science
TM	Thematic Mapper
USGS	United States Geological Survey
WFP	World Food Program

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ABSTRACT

Change detection is one of multi temporal analysis in remote sensing that is important for studying the dynamics of environment. Change detection is useful in many applications such as land use changes, habitat fragmentation, rate of deforestation, coastal change, urban sprawl, and other cumulative changes through spatial and temporal analysis techniques such as GIS and Remote Sensing along with digital image processing technique. The objective of this study was to estimate the spatiotemporal changes pertaining to land use land cover (LULC) ,the driving forces behind these changes and its impact on the biodiversity and the livelihood of pastoralists in Lower Awash Range Lands. An integrated approach utilizing remote sensing and geographic information system (GIS) was used to extract information pertaining to LULC change. Satellite images of LandSat TM 1986, LandSat ETM+ 2001 and LandSat ETM 2014) were used. In addition, individual interviews with 134 randomly selected households, discussions with focus group and key informants, and field observations were also incorporated for the study. All images were classified using object-based image classification technique. Accuracy assessments were conducted for 2014. Change analysis was carried out using post classification comparison in GIS. LULCs were successfully captured with overall accuracies 88.52% and Over all Kappa value of 0.87. When the 2014 LU/LC classification compared with 1986 LU/LC classification, there were changes that showed decrease or increase in particular land use land cover. The land use land cover categories, which showed increments are bush land, irrigation land, water body, built up area and bare land have increased by 21448.64 ha (+27.24 %) 4665.9 ha (+43.81%) 50.87 (+ 108.93%) 8825.93ha (+786.91%) and 32208.8 ha (+57.40%) respectively. On the other hand shrub land and grass land decreased by 9637.1ha (-51.67%) and 57563 ha (-94.42%) respectively. Based on the analysis, changes were observed in the spatial extent of different LULC types over a period of 30 years. Significant changes were observed in the spatial extent of bush land, bare land, shrub land, water body, residential area and irrigation land. From the study it was found that the major driving forces for these changes were population growth and drought expansion of agriculture. Drought, infrastructural development such as roads and town establishment, land tenure change from communal to private use right, Sedentary settlement expansion growing human population, increased demand for firewood and construction followed by deforestation, over grazing, State farm expansion, climate change/rainfall variability, flooding, and soil erosion are the major drivers of land use/cover change in the sub-basin. According to the survey and focus group discussion, 100% of the pastoralist, 95% of agro-pastoralist agreed on the impacts of LULC change on loss of biodiversity and ecological services of the study area. The LULCC in relation to P. juliflora invasion have intense effects on the biodiversity of the study area which in turn affect the capacity of the area to deliver ecosystem goods and services. Therefore, the existing policy framework needs to focus upon mitigating the impacts of forces (natural, economical, demographic, economical, infrastructural and political) factors responsible for LULC change so as to ensure sustainable development of land resources.

Key words: Land sat image, GIS, remote sensing, Land use land cove change , drivers of change ,socioeconomic indicators, biodiversity, rangeland Afar pastoralists ,

1. INTRODUCTION

Land use and Land Cover Change (LULCC) information constitutes key environmental information for many scientific, resource management, policy related issue, as well as for a range of human activities. Since the 1970s, concerns about changes in LULC have emerged in the research on global environmental since these changes are closely linked to the sustainability of socio-economic development and livelihood of people (Lambin *et al.*, 2003). There is complex and dynamic LULC change at various scales, which have global environmental implication. The conversion of grassland, woodland and forest land to crop and pastor land has risen dramatically in the tropics (Shiferaw, 2011). LULCC has been a key research priority with multi-directional impacts on both human and natural systems (Turner *et al*., 2007) yet also a challenging research theme in the field of land change science.

Land use and land cover change has become a central and important component in current strategies for managing natural resources and monitoring environmental changes (Rawat, 2013). Land use is the intended employment of land management strategy placed on the land cover by human agents or land managers to exploit the land cover and reflects human activities such as industrial zones, residential zones, agricultural fields, grazing, logging and mining among many others (Zubair, 2013). LULCC caused by external and internal drivers have influenced many traditional resource management regimes in arid and semi-arid areas where often a pastoral way of life has been the tradition (Campbell *et al.*, 2005; Reid *et al.*, 2004).

As indicated in Belay (2002), LULC change analysis is one of the most precise techniques to understand how land was used in the past, what types of changes are to be expected in the future, as well as the forces and processes behind the changes. It also yields valuable information for the analysis of the environmental impacts of population pressure, agriculture, urban expansion, resettlement program, climate change, and others. Such analysis is of significant use to natural resources managers, development agents, fund providers, socio-economic development planners, public administrators, and environmentalists because it provides accurate information related to LULC changes.

Although conclusive empirical evidence does not exist to terminate the debate, rangeland degradation is still a widely occurring phenomenon in many African rangelands, threatening national economic values and also the lifestyles of pastoralists. Despite all the rhetoric and the policy discussions, the current pace of degradation is unprecedented both in arid and semi-arid areas (Millennium Ecosystem Assessment, 2005). Like many other developing countries across the globe, significant land-cover changes have occurred in Ethiopia since the last century. These changes were due to anthropogenic activities, in connection with the population increase and due to land use changes, including deforestation, over grazing, and improper cultivation of agricultural land which led to accelerated soil erosion and associate soil nutrient deterioration (Eleni *et al.,* 2013).

Current theoretical evidence indicates that both equilibrium and non-equilibrium dynamics occur in ecosystems across both spatial and temporal dimensions (Briske et al., 2005; Oba et al., 2000; Wessels et al., 2007). The growing population and increasing socio-economic necessities creates a pressure on land use/land cover. This pressure results in unplanned and uncontrolled changes in LULC (Seto, 2002). The LULC alterations are generally caused by mismanagement of agricultural, urban, range and forest lands which lead to severe environmental problems such as landslides, floods etc.

A historical analysis of resource base including land use/cover patterns can be obtained through interpretation of series of aerial photos and satellite images as it has been done in different parts of the world (Gete, 2001; Muluneh, 2003; Reed and Dougill 2008**)**. There have been some studies of land-use/cover changes at regional or local levels, but they often deal exclusively with quantifying land use cover changes using remote sensing tools or they focus on causes of land-use/cover changes through socio-economic surveys. Mapping spatial changes using remote sensing tools gives quantitative descriptions but does not explain or provide understanding of the relationship between the patterns of change and their driving forces (Olson *et al*., 2004).

Some recent advances in remote sensing play a major role in linking social models with the spatial dynamics of land-use changes (Mottet *et al*., 2006; Serra et al., 2008). However, studies such as these linking land cover changes with drivers are rare and the few attempts have been mainly outside the rangelands in Ethiopia (Garedew *et al.,* 2009; Reid *et al*., 2000).

Land as a finite and a potentially productive natural resource represent our basic food production facility. However, the diversity of residents and intensive use of the resources through the increasing of population coupled with economic activities and global market drive unprecedented land use and land cover changes (Ezeaku and Davidson, 1992). These changes lead to transformations in the hydrological, ecological, geomorphologic and socioeconomic systems and which are often neglected by both rural and urban administrations. Thus, special attention and continuous assessment are required for monitoring and planning for a given area development and decision making.

Much of the riparian forests that supported traditional Afar Pastoralism have been bulldozed under and replaced by irrigated or abandoned fields. It is difficult to conceive of these areas many of them now damaged by soil salinity and bush encroachment. An evaluation of agricultural development in the Awash is nonetheless important because the Awash exemplifies general development trends in Ethiopia (Kloos and Legesse 2010). According to (Diress *et. al.*, 2010) the arid and semi-arid rangelands in Northern Afar of Abala Wereda experienced substantial and increasing rates of land-use/cover changes during 35 years. As a result of continued migration of people from neighboring areas together with the increased sedentarization of pastoralists, more alluvial dry-season grazing areas were converted to crop-land (1973–2007).

Lower Awash rangeland especially Dubti Wereda has witnessed remarkable LULC change, resulting in deterioration range land and pastoral productivity of land. This deterioration of the land is because of the nature of the topography, population size increment, invasion of alien species, over grazing which enforce the inhabitants to abandon their livelihood or change their land use practice. This resulted in an increased LULC change and its modification and alterations in status over time without any detailed and comprehensive attempt(as it is provided by Remote Sensing and GIS techniques) to evaluate this status as it changes overtime with a view to detecting the LULC change and its impact on the livelihood and the local ecosystem.

The Afar rangeland in Lower Awash of Ethiopia is one notable example where significant information gaps persist regarding the current situation of land use pattern in Lower Awash

Rangeland. Information derived from such types of studies is very critical for rangeland use planning, sustainable management, increasing productivity and environmental protection. It is also important to find out the direction and the rate of changes in land use/land cover, intensity of changes and condition of range resource. Moreover, it helps to investigate the spatial patterns of land use/cover, potential uses and limitations for particular uses of rangeland and similar uses in the area. Land use land cover change in the arid and semi-arid Northern Afar rangelands, Ethiopia, (Diress *et al*.,2010) used a combination of remote sensing data, field observations and information from local people to analyze the patterns and dynamics of land-use/cover changes from 1973 to 2007.

This change could be partly associated with a change and weakening of the traditional management of the Afar rangelands. Local communities are always aware of the environmental changes taking place in their surroundings (Sulieman *et al.*, 2012). This makes it essential to integrate scientific and local knowledge so that communities are able to fully realize their capacity to monitor and respond to the challenges of degradation and environmental change (Stringer and Reed, 2007).

LULC change can impact the socio-economic status of the rural population (Lambin and Giest, 2003). Agricultural productivity, which may determine rural income levels, wealth and education, can be affected by the consequences of LULC changes. Therefore, this study has map and offer an increased understanding of the patterns of land-use/cover changes over time by linking this to the main drivers of change, its impact on the biodiversity and on the livelihood of pastoralist in arid and semi-arid Lower Afar rangelands. Understanding of the complex interaction of these changes in their temporal and spatial patterns and processes is the baseline to formulate focused and targeted policy and development interventions in Afar pastoral areas development and environmental management.

1.1 Objective of the Study

1.1.1 General Objective

The overall objective of the study is to contribute to better understanding of LULC dynamics and its implications in Dubti Wereda, Lower Awash rangelands.

1.1.2 Specific objectives

- To assess the extent and rate of LULC change 1986-2014.
- To identify the major driving forces of the land-use/cover changes in the study area
- To examine the effect land use land cover change on the local biodiversity and pastoralist livelihood.

1.2 Research Questions

In order to meet objectives, the study the research Questions were.

- What is the land use/land cover change in the study area between 1986-2014?
- What are the driving forces of land use/land cover change?
- What the consequences of land use land cover change on the livelihood of the pastoral community?
- What is the impact of LULC change on the local biodiversity?

1.3 Significance of the Study

Land use and land cover change studies are important tool for land manager and decision makers in formulating appropriate land use policy as well as locating development program for sustainable use of rangelands. The result of this study would provide information relevant to contribute rangeland management plan. The study Provide basic information on the status and dynamics of the land use and cover of the area. It is also identifies the rate of land cover changes in different times. The study also provides major drivers of change of land use and land cover change in the area. it also provide the opportunity to understand the impact of land use land cover change in the area on the livelihood of the local community and the environment where they live in. The outcome of this research provide base line information for eventual research follow up, by identifying specific and important topics that should be looked in greater detail for those who are interested in the area.

2. REVIEW OF LITERATURE

The change of land use and land cover (LULC) is a result of complex relations between some biophysical and socio-economic situations that may occur at different temporal and spatial scales. . Land use and land cover change (LULCC) are associated with large negative impacts on ecosystems observed at local, regional and global scales. High rates of water, soil and air pollution are the consequences of observed LULCC. Biodiversity is reduced when land is changed from a relatively undisturbed state to more intensive uses like farming, livestock grazing, selective tree harvesting, etc (Ellis, 2011).

2.1 Land Use Land Cover Change Concepts and Definitions

Land**:** is a delineable area of the earth's terrestrial surface, encompassing all attributes of the biosphere immediately above or below this surface including those of the near surface climate the soil and terrain forms, the surface hydrology (including shallow lakes, rivers, marshes, and swamps, the near-surface sedimentary layers and associated groundwater reserve, the plant and animal populations, the human settlement pattern and physical results of past and present human activity (Ellis, 2007).

Land use**:** how people utilize the land for socio-economic activity such as urban land, agricultural land, forest land, water land, and grazing land. That included industrial, residential zones, agricultural fields, grazing, logging, and mining among many others (Thanut et *al.*, 2008). 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 (Ellis, 2007).

Land Cover**:** refers to the physical and biological cover over the surface of land, including water, vegetation, bare soil, and/or artificial structures (Ellis, 2007). Land-cover denotes the surface cover over land, including vegetation, rock and human-modified surfaces such as buildings. Land-cover is a characteristic of the land that can be observed physically by remote sensing. This is different than land-use, because a single land-cover type can be used in various ways by humans (Ellis *et al.*, 2009). Land cover refers to the surface cover on the ground, whether vegetation, urban infrastructure, water, bare soil or other features (Lillesand and Kiefer, 2004). Land cover originally referred to the kind and state of vegetation, such as forest or grass cover but it has broadened in subsequent usage to include other things such as human structures, soil type, biodiversity, surface and ground water land use land cover change because (LULC) it engross the interaction of biophysical, social, ecological, and human behavioral attributes over time and space (Thanut *et al*., 2008). Generally, land cover does not coincide with land use land-use/cover change is a dynamic process driven mainly by anthropogenic activities and natural phenomena (Lambin *et al*., 2000; 2003).

Changes in land-use have occurred at all times in the past, are presently ongoing, and are likely to continue in the future (Lambin *et al.*, 2003). LULC changes are caused by natural and human drivers, such as construction of human settlements, government policies, climate change or other biophysical drivers (Buddhi, 2004). These changes have beneficial or detrimental impacts, the latter being the principal causes of global concern as they impact on human well-being and safety. For instance, deforestation and agricultural intensification are so persistent when they aggregate globally and significantly affect key aspects of Earth Systems and development as whole (Lambin *et al.*, 2003).

2.2 Remote sensing & GIS Tools for Land Use and Land Cover

Remote sensing technology allow us to make observations, take measurements (i.e. measuring the reflected and/or emitted electromagnetic energy from the Earth's features), 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 (satellite image) in many fields including natural resources management (Lillesand *et al.*, 2004). Satellite remote sensing provides a large amount of data at spectral and temporal resolutions by using the appropriate combination of bands to bring out the natural and man-made features that are most related to a certain project for detecting changes. The data obtained from satellites imagery used for a wide assortment of change related application areas such as vegetation and ecosystem dynamics, hazard monitoring, hydrology, land use and land cover change etcetera (Bedru, 2007).

2.3 Land use Land Cover Change in Ethiopia

Ethiopia's heterogeneity of topography is one of the major factors for the existence of a variety of environmental features ranging from low land to high land. The heterogeneity of the land resource endowments has resulted in a number of diverse agro ecological conditions and existence of 15 land use patterns, 48 cropping patterns, 19 livestock patterns and at least 6 farming systems have also been identified (MoA, 2003). However, the major land use forms are grazing and browsing, cultivation and forests and woodlands. More than 50% of Ethiopia's land is utilized for grazing and browsing. It has to be noted here that grazing and browsing occurs in cultivated areas, in woodlands and forests, bush lands, shrub lands, grasslands and in un utilizable lands. Cultivation forms the second largest (nearly 23%) land use while forests and woodlands cover about 7 percent of the country. Over 16% are bare land, in the form of exposed rock, salt flats and sand (Messay, 2011).

2.4 Pastoralism and Land Use Land Cover in Lower Awash

Afar pastoralists have historically occupied the northern part of the Great Rift Valley which runs through the eastern Horn of Africa in the northeastern Ethiopian lowlands, the eastern third of Eritrea, and northern and central Djibouti (Shehim, 1985 and Unruh, 2005).The Afar pastoralists primarily depend on livestock for food and asset accumulation. They traditionally have kept large herds of camels, sheep and goats, and cattle, along with donkeys (Getachew, 2001). Some afar have more recently integrated farming, commerce, and wage employment with their pastoral livelihoods.

The Afar pastoralists are in dramatic transition from traditional mobile pastoralism to sedentary life since the 1960s, resulting in high competition between different land-use types (farming and pastoralism). The change from being traditional pastoral to settled life (agro pastoral) has been associated with a change in land-use/cover, and emerging livelihood adaptations. Although pastoralism still remains important for the majority of Afar households, it has shifted from being a core economic activity to being an insurance against failures in other livelihood activities for some groups of households (Diress, 2010).

The utilization of rangeland resources for different purposes depends on various factors. The most important aspects may include physical, biological and the socio–economic characteristics of the area. Unless these are known, prescribed kinds and levels of land use in specific area are impossible (Stoddart *et al*,. 1975; Heady, 1999; Tueller, 2000). Therefore, inventory of resources are useful for rational utilization of rangelands. Moreover, maintaining and improving rangeland condition which is essential not only for environmental benefits (controlling erosion, preserving species diversity and supporting multiple uses like recreation) but also for determining sustainable, optimal grazing capacity and maximum profitability for livestock production (Tueller, 2000) require the knowledge of the biological, physical and socio-economic characteristics of the system.

In contrary, degradations in biological and physical rangeland resources have become serious challenges, bearing negative impacts on the pastoral ecosystems, livestock production and livelihoods (Vetter, 2005). The factors include reductions in total vegetation covers and palatable plant species, increases in undesirable and unpalatable plants and depletions in soil quality and nutrients due to various forms of soil erosions (Haileslassie *et al*., 2005; Wolde *et al*., 2007). The global economy is approaching crisis because of our neglect and misuse of the ecosystem that sustain us (Aronson *et al.,* 2006). Unfortunately, rangeland degradation is less understood by policy makers, development planners and researchers (Gemedo-Dalle, 2004; Vetter *et al*., 2006), rather confused with desertification (Mortimore, 2005).

Because it has been used so intensively for so long, the Awash valley in north-eastern Ethiopia provides a realistic yardstick for evaluating the benefits and liabilities of irrigated agriculture. The valley contains only 4 to 5 percent of all the land area that is suitable for irrigation in Ethiopia (Awulachew *et al*., 2007). Some of this land has also been under irrigation for four or five decades and long term effects are now apparent. Like no other part of Ethiopia, the Awash valley illustrates what lies in store for pastoral areas if African governments pursue a policy of modernizing agriculture by displacing mobile livestock production in favor of irrigated crop agriculture.

For centuries the Afar had used the Awash River valley as a source of grazing for their livestock. Their herds congregated in the valley in the dry season or during droughts and spread out onto the surrounding plains when it rained. This oscillation provided the herds with access to two feed sources abundant riparian grazing supported by the flooding of the Awash river, and sparse but extensive grazing dependent on local rainfall. Rainfall in Afar is low and highly variable from year to year (Cheung *et al.*, 2008).

Flood plain grazing supported by river water drawn from more reliable highland sources was essential for stabilizing the system and preserving life whenever the local rains failed. Four decades later, much of the riparian forests that supported traditional Afar pastoralism have been bulldozed under and replaced by irrigated or abandoned fields. It is difficult to conceive of these areas – many of them now damaged by soil salinity and bush encroachment ever returning to natural vegetation and pastoral use for the Awash Valley there probably is no turning back. An evaluation of agricultural development in the Awash is nonetheless important because the Awash exemplifies general development trends in Ethiopia (Kloos and Legesse 2010).

The major land using activities prevailing in the lower Awash are settlements and built-up, extensive livestock production, crop production, wildlife, and natural vegetation. Lower Awash sub basin has been ill treated by chronic challenge dramatic land use and land cover changes during the last three to four decades. During this time, very rapid and fast land use and land cover changes was observed due to high infestation *Prosopis julliflora*, expansion intensive irrigation based crop cultivation, land degradation and increasing of exposed bared land with increasing rates

2.5 Major Land Use and Land Cover Change Driving Forces

Driving forces are generally subdivided into two broad categories: proximate causes and underlying causes. Proximate causes are the activities and actions which directly affect land use, e.g. wood extraction or clearing land for agriculture. Underlying causes are the ‘fundamental forces’ that trigger the proximate causes, including demographic pressure, economic policy, technological development, institutional and cultural factors (Geist *et al.*, 2002, Vancker *et al.*, 2003). The underlying factors have a multi scale sources. Global factors that influence local agricultural marketing or international tourism can be indirectly responsible. Regional factors like the presence of road, access to market, political turmoil and armed conflict may be a direct source of influence in the decision process of land use. Loss of productivity coupled with population boom may be considered local factors. Thus the proximate causes are only manifestations of the underlying causes.

2.6 Change Detection

Land use land cover changes decision makers require quantitative information on the spatial distribution of land use types and their conditions as well as temporal changes. Undoubtedly the Remote Sensing and GIS technology has enabled ecologist and natural resource managers to acquire timely data and observe periodical change, remote sensing device records response which is based on many characteristics of the land surface, including natural and artificial cover. An interpreter uses the element of tone, texture, pattern, shape, size, shadow, site and association to derive information about land cover. The generation of remotely sensed data/images by various types of sensor flown aboard different platforms at varying heights above the terrain and at different times of the day and the year does not lead to a simple classification system. It is often believed that no single classification could be used with all types of imagery and all scales. Other classification schemes available for use with remotely sensed data are basically modification of the above classification scheme (Markus, 2003).

Change detection is the process of identifying difference in the state of an object or phenomenon by observing it at different time's .In remote sensing, change detection and monitoring involves the use of multi-date images to evaluate differences and quantitatively analyze the temporal effects of the phenomenon between acquisition data of images. Change detection is used for numerous functions, example; land use and land cover change; forest and vegetations change; forest mortality, damage assessment; deforestation, regeneration and selective logging; wetland change; forest fire; landscape change; urban change and environmental change (Peres, 1995).For wide acceptance of remote sensing has been increased in the application of remote sensing for natural resources management (Abdel *et al.,* 2008).

The basic principle of change detection from remote sensing images is based on the difference in reflectance or intensity values between the images taken at two different times due to changes on the Earth's surface. Some commonly used image change detection algorithms are image differencing, image ratioing, image regression, principal component analysis (PCA), and change vector analysis. A review of these algorithms may be found in (Jensen ,2005).

2.7 Complementary Use of Remotely Sensed and Socio-Economic Data

Land is an essential asset and means to sustain rural livelihood. However, due to recent rapid growth in human population, the land-use land cover of the earth has been transformed especially in developing countries (Codjoe, 2007). Recently, social and physical scientists have begun to study the issue of integration of physical variables derived from remote sensing with collected socioeconomic and demographic data. Such integration leads to a better understanding of human impact and of human drivers of environmental and social changes.

Other studies reflect the growing need for the social science community to use remotely sensed data in combination with demographic and socioeconomic data to study land-use change dynamics or to better understand the spatial distribution of population and socioeconomic phenomena (Radeloff *et al.*, 2000). In addition, they also began to examine the correlation between biophysical and social variables. Conducted a case study that illustrates the correlation between environmental variables extracted from Land sat data and socioeconomic data from the census indicate that a combination of satellite data and census data determine livelihood assessment with an environmental perspective Lo and Faber (1997).

2.8 Urban Land Use Land Cover Dynamics

Due to several reasons, most of the urban centers expand to the surrounding environment. The outskirts of urban areas, usually referred to as rural-urban-fringe, are characterized by farming land/irrigated fields, forest cover and source of water supply. The trend of urban growth towards the urban-rural-fringe has an impact on the surrounding ecosystem. One of the major impacts of urban land cover change is diminish in surrounding forest and agricultural land. It is also likely that large amounts of valuable agricultural or irrigated lands are converted to non-agricultural areas (e.g. built up areas). Urban land cover change is a very important phenomenon, which characterizes the nature of the cities and their surrounding areas (George, 2005).

The expansion of urban sprawl is mainly caused by the high rate of population growth, and the accompanying loss of agricultural lands, forests and wetlands, escalating infrastructure cost, increases in traffic congestion, and degraded environments, becoming the major concern to citizens and public agencies responsible for planning and managing urban growth and development (Bauer *et al.*, 2003).

3. MATERIALS AND METHODS

3.1 Description of the study Area

3.1.1 Location

The study was conducted in Dubti Wereda which is located in Afar Regional State, with the geographic co-ordinate of 11^{o} 24" 30"N- 12^{o} 1" 37"N and 40^{o} 22" 32"E- 41^{o} 24" 47"E. Dubti is one of the 32 Weredas in the Afar Region State and is located at a distance of 580 km north-east of Addis Ababa. The study area has a total of 226,283.5 ha of land. The Woreda is bordered on the south by the Somali Region, on the southwest by Mille, on the west by Chifra, on the northwest by Administrative Zone 4, on the north by Kori , on the northeast by Elidar, on the east by Asayita, and on the southeast by Afambo. The capital city of the region Semera is found in the Wereda. Dubti lies between 350 up to 400 m a.s.l (Afar Regional Atlas, 2009).

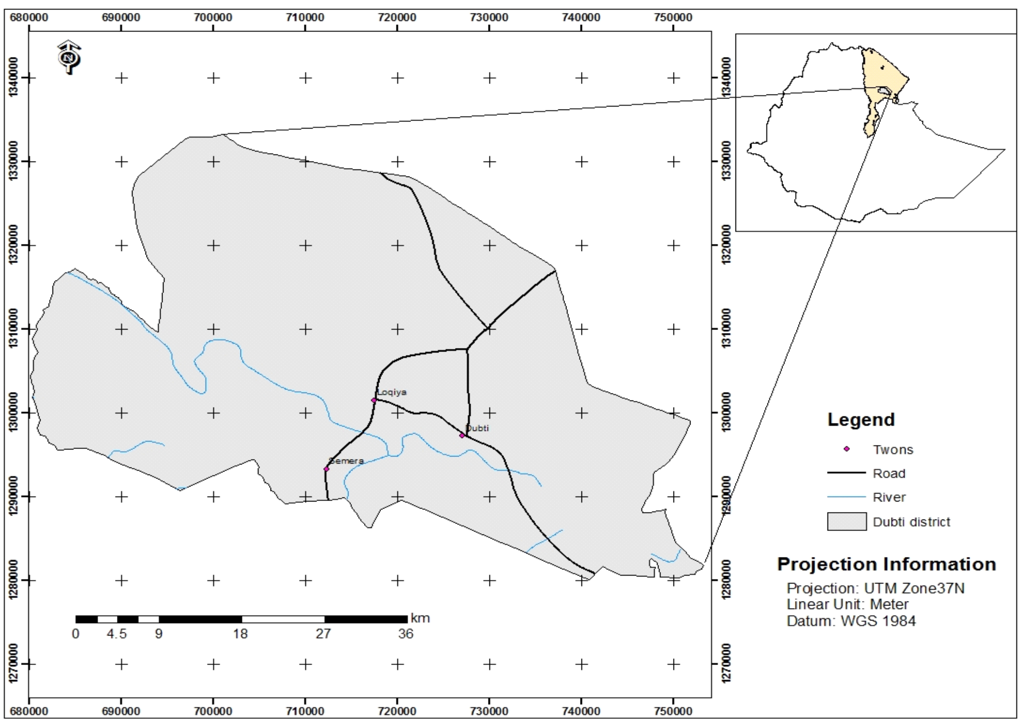

Figure 1 Location of the study area

3.1.2 Climate

The area is commonly known with very wide diurnal, seasonal temperature fluctuations and high intensity of solar radiation due to the dry atmospheric condition and clear skies. The major rain seasons with in the study area are named as Karma (which represents the rainy season which starts at the month of mid-June to mid-September, Dedae (which represents the rainy season which starts at the month of October and ends at November, and Segum (which represents the rainy season which starts at the month of March–April. The area has mean annual rainfall of 200 mm. Mean minimum and maximum temperatures are 25^0 C and 42^0 C respectively.

3.1.3 Physiographic nature of the study area

The average elevation of the Dubti Wereda is 300 m.a.s.l. The study area is almost flat land and resent alluvial deposit of alluvial and out wash fans are common in the plain areas that extend along both sides of the Awash River. The Southern part of the study area is characterized by flat to almost flat land form with many narrow residual hills and ridge. The Dubti Pattern, consisting of sandy ridges alternating with basins of clay and silty soils. In general, the region is characterized by large areas of sandy to loamy soils with vast areas of alluvial plains traversed by many seasonal streams draining the Awash River.

3.1.4 Population

Based CSA (2007) Dubti Wereda has a total population of 65,314, of which 32,400 were living in rural areas where as the remaining 32,914 are living in urban areas. The production system of the Afar region is dominated by pastoralism (90%) from which agro-pastoralism (10%) is now emerging following some permanent and temporary rivers on which small scale irrigation is developed (Afar Regional Atlas, 2009).

Pastoral and agro-pastoral production systems which mainly dealt with extensive livestock production systems are the major farming and/or production systems on which most of the livelihoods of communities depends on. Nonetheless, other supplementary activity are also one of the production systems helping local society livelihoods like employment at Tendaho Sugar Project, petty trades, small scale mining (AFEDB, 2011).

3.2 Methods

In present study, different methods of data collection and analysis were employed. This section shows the general methods used in this study. After acquiring satellite imagery, ground truth was done, image processed, accuracy assessment and change detection was done (Figure 2).

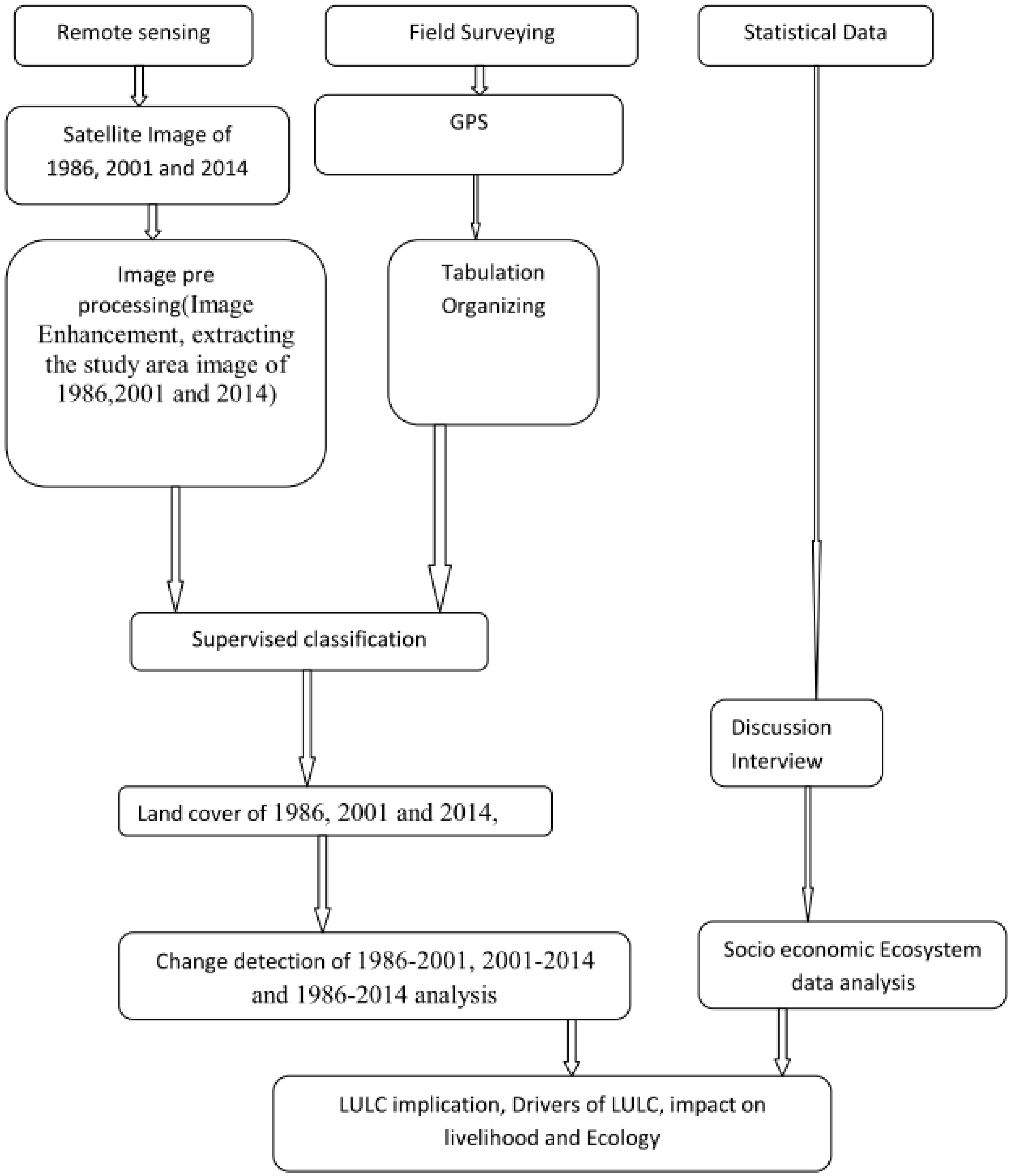

Figure 2 Methodological framework of the study

3.2.1 Satellite data and pre-processing

The Landsat imagery data include Landsat Thematic Mapper (TM), and Enhanced Thematic Mapper (ETM+) scenes of the year 1986 and 2001 and 2014, respectively. These datasets were acquired from United States Geological Survey (USGS). Images of the same season were selected to reduce the effect of seasonal discrepancies on the classification result ((Zhang Lu, 2004).). The multi-temporal Landsat images used in this study are indicated in (Table 1).

Table 1 Multi temporal Landsat Images used

Image	Path /Row	Acquisition Date	Spatial Resolution (m)
Landsat TM	167/52	Jan 12, 1986	30X30
Landsat ETM+	167/52	Mar 12, 2001	30X30
Landsat ETM	167/52	Mar 12, 2014	30X30

Source: GLCF and USGS website.

Since the acquired satellite image was already geo-referenced, there is no need of geo-referencing of the acquired satellite image. Then the original satellite image was subset by using ArcGIS 10 and ERDAS Imagine 9.2 software.

Image enhancement was used to increase the details of the image by assigning the image maximum and minimum brightness values to maximum and minimum display values, it is done on pixel values, and this makes visual interpretation easier and assists the human analyst. The original low dynamic range of the image is stretched to full dynamic range which is from 0 to 255 by using histogram equalization.

The LU/LC classification was done on the basis of reflectance characteristics of the different land use land cover types by using false color composites. This was supplemented by a number of field visits that made it possible to establish the main land use land cover types. For this study a supervised classification scheme with maximum likelihood classifier decision rule was used by following three stages, assigning training sites, classification and outputs.

After classification was made in order to check the precision of the classified LU/LC map. Ground–truthing was used to gather field data useful for the classification and verification of the satellite imagery. The field survey was carried out and historical land-use information was collected from key informants who were knowledgeable about land-use change patterns during the respective period (1986-2014). (56) GPS points (Annex 2) were recorded in the field to be used for training for the 2014 imagery and to determine the land use and land cover classes for the image classification process.

3.2.2 Land use land/cover classification

Nomenclatures of Land cover Classes**:** The land cover classes used in this study was adopted from the classification scheme used by the Ministry of Agriculture of Ethiopia and based on classification criteria for East African rangeland (Pratt and Gwynne, 1977) and based on the previous studies made in the similar study area (Diress *et al*., 2010; Getachew *et al.,* 2001).

Based on the satellite images and ground truthing for the recent image, the land use land cover classes analyzed for changes were: bush land, shrub, grass land, irrigation land, water land, residential area, and bare land (Table 2).

Table 2 Land class nomenclature

Land use/Land cover	Description
Bush land	Bush land Land with >20% bush or shrub cover (<5m in height)
Shrubby Grass land	The shrubby grasslands are former grassland sites where shrubs and bush have increased in density to be co-dominant with herbaceous plants in terms of cover
Grassland	Grassland with <20% bush or shrub cover, Grass and herb cover with scattered trees and shrubs, areas with permanent grass cover used for livestock grazing including communal and protected areas.
Irrigated land	Land with annual and perennial crops
Water body	Area covered with water
Bare land	Areas with no vegetation, which occur in rangelands including gullies and exposed rocks.
Built up areas	Urban and rural settlements in the study area.

3.2.3 Change detection analysis

The most commonly used techniques. Ernani and Gabriels (2006) mention that change detection analysis involves a broad range of techniques used to identify describe and quantify differences between images of the same scene at different times or under different conditions. Lu *et al.*, (2004) highlight the importance of selecting a suitable change detection technique to be used in a specific application area.

The LUCC change dynamic in the study was detected and quantified by analyzing the classified multi-temporal satellite images of 1986, 2001 and 2014. A post classification comparison change detection algorithm employed to determine change in land cover in time intervals, 2001-1986, 2014-2001and 2014-1986. The change detection process analyzed and discusses with integration of the socio economic data of the study area. The values were presented in terms of hectares and percentages. In order to quantify changes of certain LULC types during a certain time period, the calculation formula followed was:

$$\text{Percentage LULC change} = \left(\frac{\text{Area}_{\text{final year}} - \text{Area}_{\text{initial year}}}{\text{Area}_{\text{initial year}}}\right) \times 100 \qquad \text{-------equation 1}$$

where Percentage LULCC is the change of a certain LULC type for a certain time period; Area $_{\text{final year}}$ and Area $_{\text{initial year}}$ are the area of a certain LULC type at the beginning and the end of a time period, respectively; A positive value means that there is an increasing trend for a specific time period for an area of a certain LULC type; otherwise, a deceasing trend is occurring for the area assessed.

Rate of LULC change for the two periods from 1986-2001 and 2001-2014 were computed using the following simple formula.

$$r = (Q2-Q1)/t \qquad \text{----equation (2)}$$

Where, r = rate of change
Q2 = recent year land use/ land cover in ha
Q1 = initial year land use/ land cover in ha and
t = interval year between initial and recent year

Technique is based on multi-temporal and multi-spectral remotely sensed data, which have great potential as tools for understanding landscape dynamics, including detection, identification; mapping and monitoring differences in land use/land cover change over time, irrespective of causal factors. However, change detection is useful in such diverse applications as land-use analysis, habitat fragmentation, urban sprawl, and assessment of deforestation as well as other environmental changes (Ramachandra and Kumar, 2004).

3.2.4 Accuracy of image classification

Accuracy assessment is an important process that must be completed to determine how correct the classified image is. Jensen (1996) pointed out that if through remote sensing, land use and land cover maps are produced and statistical results are to be useful, then it is important to conduct a quantitative assessment of the classification accuracy. This is important for post-classification change detection analysis. The accuracy of a classification is usually assessed by comparing the classification with some reference data that is believed to accurately reflect the true land cover classes. The overall accuracy is measured by counting how many pixels were classified consistently in the satellite image and on the ground and dividing this by the total number of sample pixels in each class indicates the probability of a reference pixel being correctly classified and is a measure of omission error.

Kappa is used to measure the agreement or accuracy between the remote sensing derived classification map and the reference data as indicated by the major diagonals and the chance agreement, which is indicated by the row and column totals (Jensen 2003). Producers
accuracy is the total number of correct pixels in a category divided by the total number of pixels of that category as derived from the reference data (column total).

Alike to the overall accuracy kappa coefficient is an indicator used to estimate the accuracy of classification. The Kappa coefficient usually lies on a scale between 0 and 1, where one indicate complete agreement, and is often multiplied by 100 to give a percentage measure of classification accuracy, Kappa values has usually classified into 3 groups: a value greater than

0.80 represents strong agreement, a value between 0.40 and 0.80 represents moderate agreement, where as a value below 0.40 represents poor agreement (Rahman, *et al*., 2006).

3.3 Socio Economic and Biodiversity Survey

The pastoralists' perceptions and values served not only as a means of verifying and assuring the remote sensing-based LULC analysis but also for providing insights on how these changes happened. Moreover, local communities provide information that is not detectable with the type of remote sensing data that has been used in this study, including major social and natural events happing in the past 3 decades, changes in plant species and livelihood of the local communities due to land use land cover change in the area.

Structured questionnaire and checklist were used for collecting data and information in relation to Land use land cover change to fill the information gap that arise from the imagery analysis. In addition non-interactive observation of activities and conversation were made. Information on the history of the area, land use and land cover change, production system, and environmental changes were gathered from informed sources such as elders, development agents and government offices.

A multi stage random sampling procedure was applied to select the refined number of sample units. First, Dubti Wereda selected purposively because the land use land cover changeover of the last decades is high, the pastoral system of the local community is distorted in the near past because of the irrigation project and other development interventions in the District. Secondly, 6 kebeles 1 from pastoral and 3 agro pastoral and 2 pre urban were selected randomly from the total number of 15 kebele. Thirdly, the minimum size refined for the study was determined using Cochran (1977) sample determination formula i.e 134 households.

To give equal chance for each Kebele during sampling proportionate probability sampling (PPS) technique were used to determine the number of respondents from each kebele. Accordingly, $ni = (Ni/N)*134$ Where: “N” is the Grand population of the six kebeles,“Ni” is the total population in each kebele and “ni” is the total sample size from each kebele. From each sampled kebele female households proportionally included. So from Iyrolaf Gebelaytu, Debel and Helebye, Aredo and Hanakis, Saha and Mosle, Dubti (Gali-Meda) and Logia (Delala-Genda) 33, 30, 26,14, 17 and 14 respectively house hold respondents were selected. Groups containing 8-10 elderly people with deep knowledge of the study sites were selected for an in-depth interview and focus group discussions. However, key informant group discussions were also conducted to gather other relevant qualitative information.

Interviews were conducted during April and May 2014.Questionnaire interviews with pastoralists were designed to be broader to cover all range of information. Interviews included questions pertaining to personal characteristics of respondents; land use change drivers of LULC; information regarding changes in range species and water resources; Questions on pastoralists' perception on LULCC and major driving forces. Questions were also posed about change in livelihood and adaptation measures that have been followed by pastoralists, Land use land cover change and its impact on livelihood and ecology of the pastoralists.

a) *Structured Interview***:** Cross-sectional primary data were collected using a pre-constructed questionnaire designed to obtain information about the social characteristics of respondents, drought and its effects on the study area, the impact of land-use change on agricultural production, livestock production as well as pasture rand land condition and alternative livelihood strategy. The questionnaire was built on the author’s background knowledge of the study area, group discussions with the key informants, and numerous questionnaires completed during previous research in the region. Moreover, a discussion with five pastoral community members was carried out for further improvement of the questionnaire. The interviews were carried out by personal contact. The interview was done within the respondent’s territory and in interviewing atmosphere where interruption or correction is none.

b) *Focus Group Discussion (FGD)**:*** To complement the household survey, basic descriptive information were collected at the Kebele and village level in each survey site. This technique helped to acquire useful and detailed information, which might be difficult to collect through the household survey. A total of six focus group discussions comprising six to eight members (clan leaders, two key informants, one women representative and one youth representative) were made. It is one of the most commonly used qualitative data collection approaches.

c) *Key Informant Interview:* To obtain information about historical changes in the study area, an interview was held with five elderly rural people from each village. The information focused on the changes in land use and land degradation, crop productivity, cultural practices and grazing species composition (for example disappeared, decreased, increased and invader plant species). However, in the local community, narration is the only means for documenting such information from generation to generation, and this knowledge may disappear with the death of the knowledgeable elderly persons, if other means of documentations were not used. This information can play important roles in restoring the degraded agricultural and pasture lands. The key informants were Local elders, clan leaders, religious leaders, male and female individuals, this was done to complement the questionnaire and to have a detailed in sight in land use land cover change.

d) *Direct Observation:* Field observations were made in the study area This informal technique will help to generate ideas and acquire useful and detailed information about land use land cover changes in the study area.

Secondary data and information was also collected from various published and unpublished sources.

3.3.1 Data analysis

Data collected from interviews were coded, computerized and analyzed using the Statistical Package for Social Science (SPSS) version 20.00. Descriptive statistics and correlations analysis were used to explain the socio-economic characteristics of the respondents as well as the relationships between different factors, for example factors driving land-use change patterns, and to determine rural people's attitude and perception towards land-use change and its impact on their livelihoods.

4. RESULTS AND DISCUSSION

4.1 Land Use and Land Cover Categories

The result of the study has enabled to define seven land use land cover categories, which were: bush land, shrub land, grassland, water body, residential area, irrigated land and bare land which comprises of 226283.5 ha of land

The land use land cover classification for 1986 from Land Sat TM image (Figure 3.) showed that, bush land 78732 ha (34.79%), shrub land 18652 ha (8.24%), irrigated land 10651 ha (4.71%), grassland 60965ha (26.94%) water body 46.5 ha (0.02%), built up areas 1122 ha (05%), and bare land 56115 ha(24.80%)

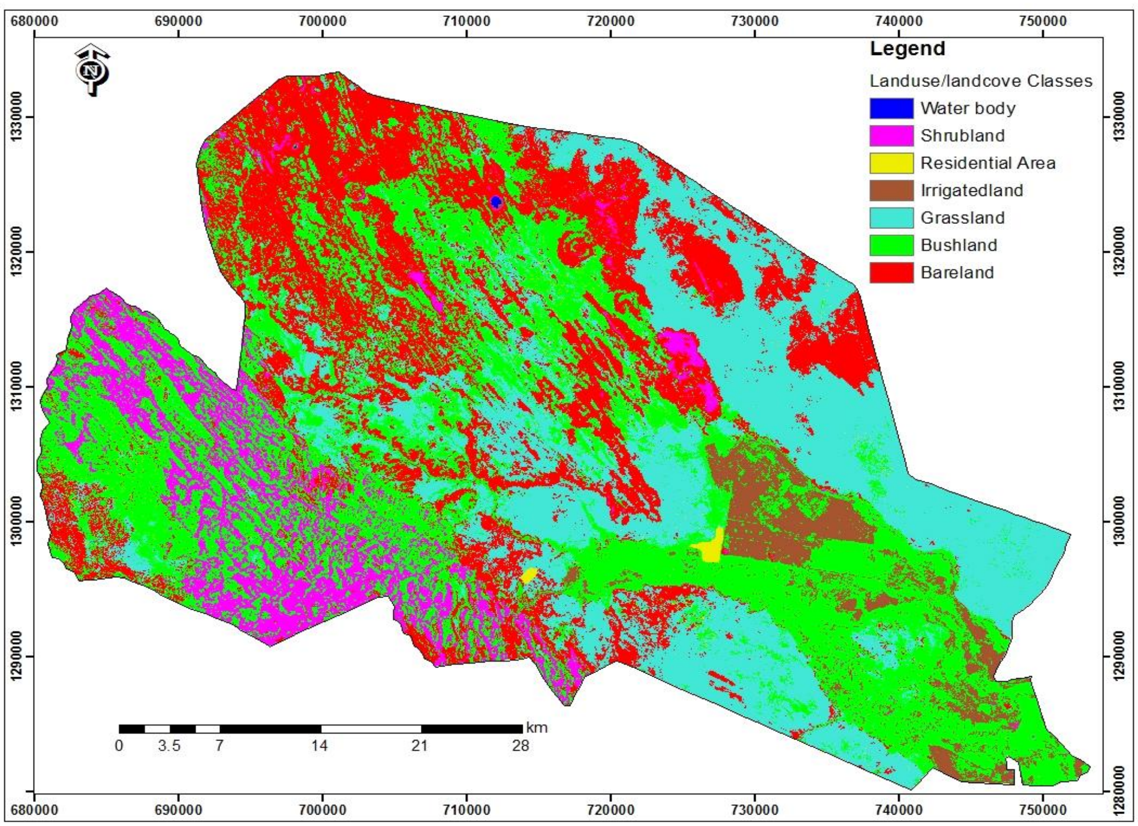

Figure 3 LULC classification map of study area for 1986

In 2001 (Fig 4) , bush lands were also accounted for the largest part 89991 ha (39.77%) and bare land 62516.3 ha (27.63%), grassland 38788.6 ha(17.14%), shrub lands 18341.1 ha (8.11%), irrigated land 12147.3 ha (5.37%), Built up areas 4453.4 ha (1.97%) and water body 45.8 ha (02%),

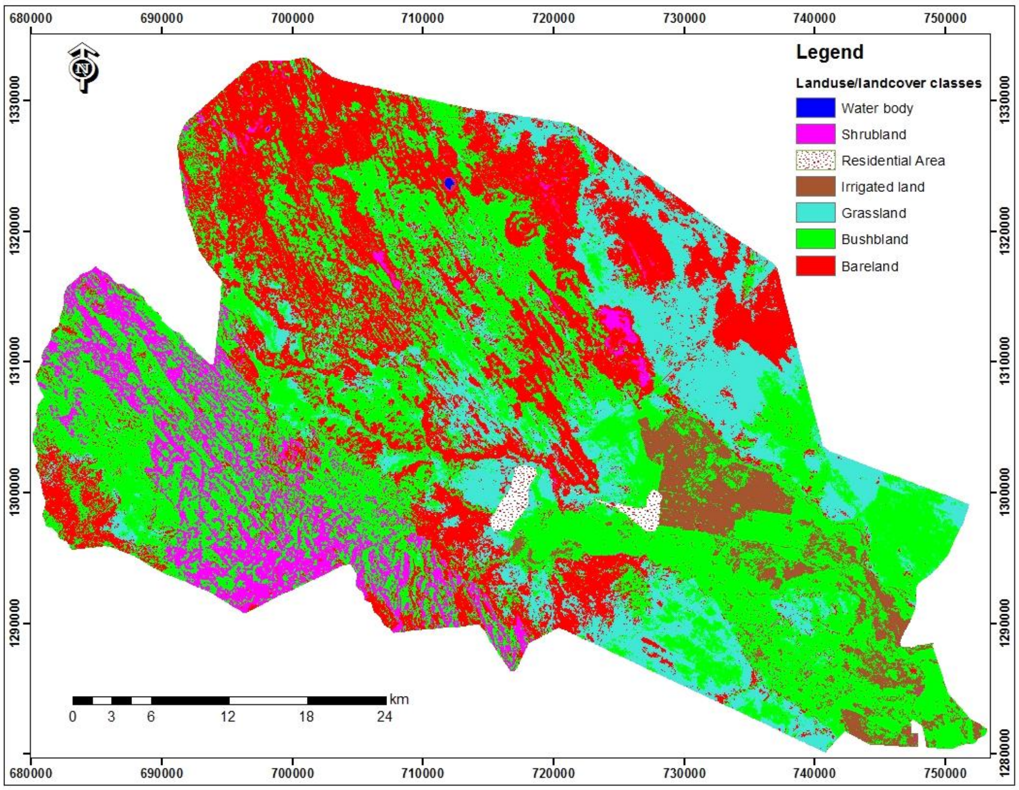

Figure 4 LULC classification map of study area for 2001

Furthermore, land use land cover classification for 2014 from ETM+ satellite image (fig 5.) showed that bush land, bare land and irrigated land accounted 100,181ha (44.27%) , 88323.7 ha (39.03%), 15317 ha (6.77%) respectively. While residential area, shrub land, grassland and water body accounted 9947.53ha (4.40%), 9014.7ha (3.98%), 3402 (1.50) and 97.57 ha (0.04%) respectively

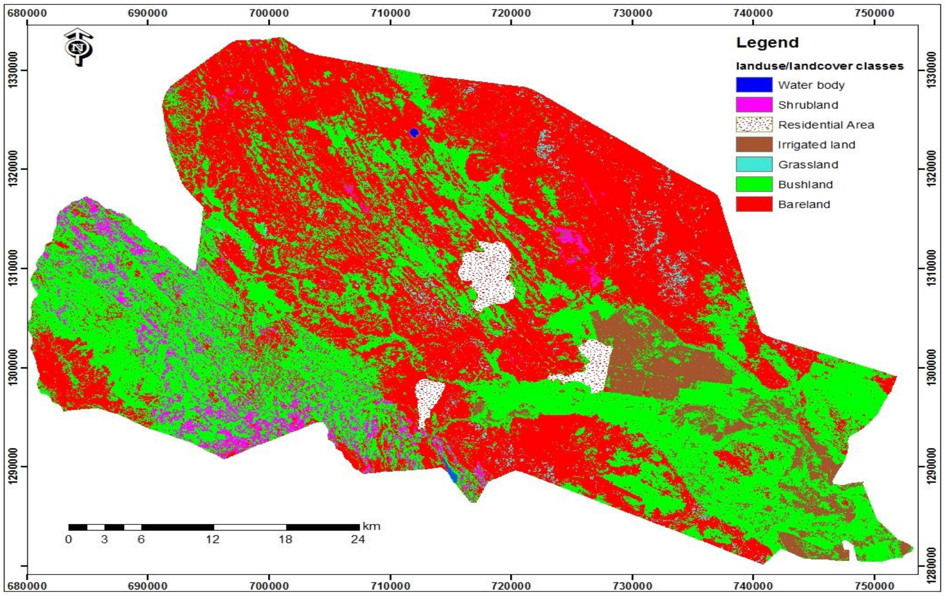

Figure 5 LC classification map of study area for 2014

4.2 Accuracy Assessment

As shown in (Table 3) the overall accuracies for the Land cover map of the study area for the period of 2014 was 88.52. Producer’s accuracy in 2014 land cover map ranged from the lowest 80% to the highest 100%. Overall kappa value for the study was 0.87. Based on this, 2014 the LU/LC classification of this study lies on the kappa coefficient that shows strong agreement.

Table 3 The accuracy level of each Land cover category TM 2014

Class Name	Reference total	Classified Total	No. of corrected	Producers Accuracy (%)	Users Accuracy (%)
Irrigated land	7	7	6	85.71	85.71
Grassland	8	10	8	100	80
Bushland	10	10	9	90	90
shrubland	8	7	6	75	85.71
Water body	5	6	5	100	83.33
Bareland	8	7	7	87.5	100
Built up areas	10	9	8	80	88.89
Total	56	56	49		
Over all accuracy (%)		*88.32*			
Over all kappa value		*0.87*			

4.3 Land Use and Land Cover Change Detection

The change detection was made based on the classified maps of 1986 and 2001. When 2001 land use land cover classification compared with 1986 land use land cover classification there is change that shows decrease or increase in particular land use land cover. Positive values suggest an increase whereas negative values imply a decrease in extent (Table 4).

The land use land cover categories that shows increase are bush land irrigation land , residential area and bare band increased by 11258.6 ha (+14.30 %) 1496.2 ha (+14.05%), 3331.8 ha (+297.06%) and 6401.4 (+ 11. 41 %) respectively. The average rate of change for these LULC classes was 750.6 ha/year, 99.4 ha/ year , 222.1 ha/ year and 426.8 ha/year respectively. On the other hand, shrub land, grass land and water body decreased by 310.7 ha (-1.67 %,) 22176.4 ha (-36.38%)and 0.9 ha (-1.93%); the average rate of change for these LULC classes was 20.7 ha/ year, 1478.4 ha/year and 0.06 ha/year respectively (Table 5).

When the 2014 LU/LC classification compared with 2001 LU/LC classification, there were changes that showed decrease or increase in particular land use land cover. The land use land cover categories, which showed increase are bush land irrigation land settlement and water body accounting 10190 ha (+11.32%), 3169.7 ha (+ 26.09%) 51.77 ha (+113.03%) 5494.13 ha (+123.37%) 25807.4 ha (+41.28); also the average rate of change for these LULC classes was 679.3 ha/year, 211.3 ha/year, 3.5 ha/year 366. 3 ha/year and 1720.5 ha/year respectively. On the other hand land use land cover categories like shrub land and grass land decreased by 9326.4 ha (-50.85%) and 35386.6 ha (-91.23 %); also the average rate of change for these classes was 621.8 ha/year and 2359.1 ha/year respectively.

When the 2014 LU/LC classification compared with 1986 LU/LC classification, there were changes that showed decrease or increase in particular land use land cover. The land use land cover categories, which showed increase are bush land, irrigation land water land residential area and bare land has increased by 21448.64 ha (+27.24 %) 4665.9 ha (+43.81%) 50.87 (+ 108.93%) 8825.93ha (+786.91%) and 32208.8 ha (+57.40%)); also the average rate of change for these LULC classes was 714.9 ha/year, 153. 5 ha/year, 1.7 ha/year 294.2 ha/year and 1073.6

ha/year respectively. On the other hand shrub land and grass land decreased by 9637.1ha (-51.67%) and 57563 ha (-94.42%); also the average change for these classes was 321.2ha/year and 1918. 8 ha/year respectively.

Table 4 Land use/ land cover change in 1986, 2001 and 2014 in Lower Awash

Land use land cover type	Absolute Area cover in (Ha)						Cover change between periods (%)[a]					
	1986		2001		2014		1986-2001		2001-2014		1986-2014	
	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%
Bush land	78732	34.79	89991	39.77	100181	44.27	11258.6	14.30	10190	11.32	21448.64	27.24
shrub land	18652	8.24	18341.1	8.11	9014.7	3.98	-310.7	-1.67	-9326.4	-50.85	-9637.1	-51.67
Irrigated land	10651	4.71	12147.3	5.37	15317	6.77	1496.2	14.05	3169.7	26.09	4665.9	43.81
Grassland	60965	26.94	38788.6	17.14	3402	1.50	-22176.4	-36.38	-35386.6	-91.23	-57563	-94.42
Water body	46.5	0.02	45.8	0.02	97.57	0.04	-0.9	-1.93	51.77	113.03	50.87	108.93
Built up area	1122	0.50	4453.4	1.97	9947.53	4.40	3331.8	297.06	5494.13	123.37	8825.93	786.91
Bare land	56115	24.80	62516.3	27.63	88323.7	39.03	6401.4	11.41	25807.4	41.28	32208.8	57.40
Total	226,283.5		226283.5		226283.5							

Table 5 Rate of land use/ land cover change in the study period

Land use land cover type	1986-2001		2001-2014		1986-2014	
	Area change in (ha)	Rate of change (ha/year)	Area change in (ha)	Rate of change (ha/year)	Area change in (ha)	Rate of change (ha/year)
Bushland	11258.6	750.6	10190	679.3	21448.64	715.0
shrubland	-310.7	-20.7	-9326.4	-621.8	-9637.1	-321.2
Irrigated land	1496.2	99.7	3169.7	211.3	4665.9	155.5
Grassland	-22176.4	-1478.4	-35386.6	-2359.1	-57563	-1918.8
Water body	-0.9	-0.1	51.77	3.5	50.87	1.7
Built up area	3331.8	222.1	5494.13	366.3	8825.93	294.2
Bareland	6401.4	426.8	25807.4	1720.5	32208.8	1073.6

*Bush land***:** The 1986 TM satellite image LULC classification showed that total amount of bush land in 1986 was 78732 ha it covered 34.79 % of the total study area. This LULC category was increase to t 89,991 ha in 2001, accounted 39.77% of the total area. The second comparison made during 2001 to 2014 also showed further increase of bush land from 89,991 ha 9.77% in 2001to 100181ha that cover 44.27% . The average rate of change during fifteen years of 1986 to 2000 was 714.9 ha/year. When compared this with the rate 1986 to 2000 to that of 2000 to 2014 679.3 the change is less than by amount 35.6 ha/year.

Shrub land: Based on the two, 1986 and 2000, satellite image classification, shrub land decreased by 310.9 ha. The 2001 to 2014 LU/LC change comparison showed that the shrub land decreased by 9326.4 ha from 18341.1 ha (8.11%) to 9014.7 ha (3.98%) and its average change rate was 321.2ha/year. The change happened due to most of the shrub land converted to agricultural areas and residential area.

*Cultivated Land**:*** This LU/LC showed increasing pattern of change. The area of land that was occupied by agriculture in 1986 was 10651 ha (4.71%), however, it increased to 12147.3 ha (5.37%) in 2001. The cultivated land still increased by 2014 to 15317 ha (6.77). it is believed that Irrigated agricultural land areas expanded at the expense of grass land, and shrub land

The observed trends of increasing agricultural land and built-up areas and decreasing grass land in the area could be explained by: First, the expansion of Tendaho Suger plantation which accounts around 25,000 ha of land. Second the population growth and the recurrent drought in the areas forced the pastoralists to shift their livelihood to agro-pastoralist mode of production and by this around 4,000 ha of modern irrigation land prepared by the government and handed over to agro-pastoralist. The current Ethiopian government has encouraged pastoralists to engage in agro-pastoral activities. Overall high farmland expansion characterized most parts of the country during the past 15 years (Abate, S 2011).

Grassland: The area under the grass land category highly declined through the study year. In 1986 it was 60965 ha (26.94%) reduce to 38788.6 (17.14%) and further reduced to 3402 (1.50%). Grassland seemed to decline in different areas of the country where sedentary economic activity and permanent settlement was common (Emiru *et.,al* 2012). According to Diress *et al.*, 2010, as a result of continued migration of people from neighboring areas together with the increased sedentarization of pastoralists, more alluvial dry-season grazing areas were converted to cropland in the second period (1986–2007).

Water body: The total water body cover in 1986 and 2001 was only 46.5 0.9 ha and 45.8 ha which is 0.02% and 0.02% respectively. In 2014 the water coverage of the study area increased beyond double and reached 97.47 ha which occupy 0.04% of the total area. This increment was due to the construction of Tendaho dam. The Tendaho reservoir increases the total water surface area of the region by 17.14% making the total surface area of the water bodies about 991 km2. The reservoir also has a large network of canals and provides irrigation to 600 km2 (60,000 ha). The main canal has 72 km long, 22 m bed width, and 2.5 m depth which feed to several hundred kilo meters of secondary and tertiary canals (Hussien *et al.*, 2010).

Built up areas: The majority of the residential area in the study area located in Dubti, Logia and Semera Towns. This LULC category has been increasingly though out the study years. The total area covered by residential area in 1986 it was only 1122 ha occupy 0.50% of the total study area. The 2000 to 22014 LU/LC change detection indicates that the area covered by open residential areas was 4453.4 ha (1.97%) and 9947.53 ha (4.40%) respectively.

The increments in built up areas attributed to a number of factors, mainly the capital city of the regional government was changed from Asiyita Wereda to Dubti Wereda to Semera by 2001. Apart from this the Tendaho Cotton State farm evolved to huge Sugar plantation and this had contributed influx of many settlers from the highland in the area as a daily laborer and professional to Dubti town and the neighboring Logia town. The town of Semera is a newly established in 2000 ever since it serves as capital city of the region it is s expanding at rapid rate, new government infrastructure and offices and residential houses have been constructed. Establishment of Semera dry port and Semera University had contributed a lot in expanding the town. In connections with the sugar plantation Dubti Town is expanding in all direction. Logiya town expanding at fast rate being a center of commerce and services for truck drivers.

Bare land: The major land cover defined as exposed surface consists bare land, exposed soil or sand surfaces with scattered shrubs. It is characterized by it's almost a no or very few cover of vegetation. In 1986 it occupies56115 hectares of land that accounts 24.80% in 2001 it expanded to 62516.3 hectares that account 27.63% and in 2014 it further increased to 88323.7 hectares which is 39.03 % of the entire study area. The rate of change between 1986 and 2001 was 426.8 ha/year and the rate of change between 2001 and 2014 was 1720.5 ha/year.

4.4 Major Land Use and Land Cover Change Driving Forces

From a range of natural, economical, demographic, economical, infrastructural and political factors, 10 drivers were listed by the informants as being important to land-use/cover changes in the study area. As it is shown in (fig 6), Drought, infrastructural development such as roads and town establishment, land tenure change from communal to private use right, Sedentary settlement expansion growing human population, increased demand for firewood and construction followed by deforestation, over grazing, State farm expansion, climate change/rainfall variability, flooding, and soil erosion are the major drivers of land use/cover change in the sub-basin that are listed by the Wereda and Kebele informants. Drivers of land use/cover change vary both spatially and temporally in the study area.

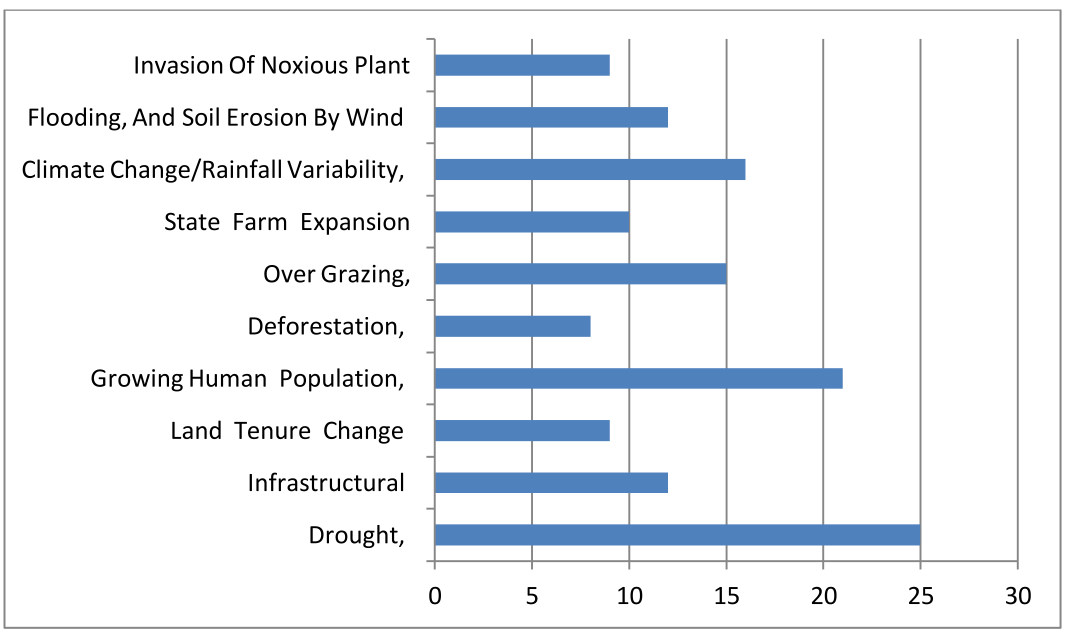

Figure 6 Key driving forces of land-use and cover change perceived and ranked by Sampled HH respondents

The key informants also indicated the linkage between major land-use/cover change transitions and drivers (Table 6). They stated that the expansion of Tendho Sugar plantation was the main cause of change for the rangeland in lower Awash. Since its establishment there were many settlers in the area on permanent this again cause expansion of private farms at the expense of rangeland and bush land and shrub land were used as source of firewood and house construction material (Table 6). The expansion of town, change in the land tenure, weakening of traditional rangeland management, construction of socioeconomic institutions and alarming rate infrastructure development were consider as drivers of land cover (Table 6). Expansion of private and government irrigated farms, reduction of overflow of Awash river in rainy seasons and construction of Tendaho Dam, high demand for firewood and charcoal demand, *prosopis juliflora* encroachment were believed by local resident as the immediate cause for land use land cover change in the areas (Table 6).

Table 6 Linkage between major land-use and cover change transitions and drivers as perceived by the local people

Transition	**Immediate cause**	**Drivers**
Grass land to bush land and bare land cultivated land	• Expansion of *prosopis Juliflora*, overgrazing • Reduction of Awash river overflow in rainy season • Expansion of government and private farms	• Drought • Settlement program • Expansion of towns • Change in Land tenure
Shrub land to cultivated land bare land bush land	• High demand for charcoal and firewood	• Exposition of town and natural resource trade outside lower Awash
Shrub land grass land d to land built up area	• Exploitation of bush or firewood near settlement areas • Construction of many institutions around towns	• Expansion of Town due to high influx of people • Change in political and administrative system
Bare land and shrub land to water body	• Water logging due to irrigation , • Construction of Tendaho Dam,	• Expansion of Tendaho Sugar plantation • Change and weakening in the traditional rangeland management
Cultivated land to bush land	• Invasion of *prosopis juliflora*	• Change range land management
Traditional grazing areas to built up	• Construction of road and institutions in town and outskirt areas	• Land reform program and gradual change in the livelihood of the local pastoralists • Migration of people from the highland areas

4.4.1 Climatic shock, rainfall variability and drought and LULCC

The pastoralists perceived that the occurrence of frequent drought periods was one of the major factors for land use /land cover changes. Drought leads to a death and loss of grasses, and hence reduced availability of feed to animals and induced ecological degradation. The consequences of the drought were therefore a loss of livestock, migration, poverty because of poor grass growth and overall degradation in the rangelands.

Local communities of this study area revealed the occurrence of drought at least every two and three years. According to ADPPFS 2010 Annual report, the region has experienced major droughts every 2-3 years for the past 10 years since 1993 E.C and affecting an increasingly large number of the rural population. Death of animal, shortage of animal fodder, school dropout, reduction in the price of livestock, failure of farming activities in agro pastoralist areas and increased vulnerability of animals to different diseases are the major effects of drought among others in the project area. According to group discussion, earlier the grassland bush and shrub land were used to completely or partially flooded by Awash River depending on the intensity and duration of the rains in the highlands in rainy season. However, the construction of Tendhao dam prevented flooding in the area due to this huge area of dry season feed sources grassland had gradually changed to bare land.

4.4.2 Flooding and LULCC

According to key informants pastoralists agro pastoralist that live along these river basins have been affected by flood hazards particularly from July to September whenever the Ethiopian highland summer rains come and as a result of the changing morphology of the Awash River. Flooding of farmlands, grazing lands, loss of livestock due to drowning and diseases, migration to neighboring areas thereby increasing pressure on grazing land that is not flooded, loss of palatable grasses and siltation of irrigation canals are the major prominent consequences of flood hazard in those areas. However, since 2007 after the construction of Tendaho dam the incidence of flooding in lower Awash has greatly reduced.

Major historical events (i.e., underlying causes of change) and consequent changes drawn from responses of informants are shown in Table 7 also shows the linkage between the perceived drivers and the most important land-use/cover transitions between 1986 and 2014.

Table 7 Major events, causes and consequences of the LULC changes between 1986 and 2014years as seen by local key informants of Afar community

Time Period Event	**Major Causative**	**Consequences**
Before 1986	The expansion of Tendaho plantation	Population Increment in Lower Awash Land alienation and pastoralists neighboring werdas
	Expansion of private irrigation farm	
	Construction of international road to Asseb and Djibouti	Establishment of small town in the District
	The 1975 land reform in principle granted pastoralists right to grazing land	Didn't improve the land right position of pastoralists
Between 1986-2001	Fall of Derg regime and Establishment of New government and establishment of new administrative Weredas	Creation of regional government and causes high immigration
	Ethiopia and Eretria conventional war	High immigration and population increment from the war prone areas
	Drought 1986/87, 1993/94 2000/01	• Range land degradation, Loss of Livestock • Change in herd composition. Vulnerable and highly dependent on food aid and Wild life affected
	Introduction of *prosopis juliflora*	Range land degradation and loss Bush encroachment
	Infrastructure development	Disturbance of ecosystem
	Inter and intra clan conflict	Over grazing over exploitation of natural resources
	Weakening of traditional rangeland management	Range land degradation
Between 2001 -2014	Drought 2003/04 2006 2008/09 2011/12	• Range land degradation, Loss of Livestock • Change in herd composition, Vulnerable and highly dependent on food aid and Wild life affected
	Expansion of Sedentrization and agro-pastoralist way of life	High demand for firewood, charcoal and house construction
	Establishment of several institutional arrangements	In principle official recognition of the pastoral production system
	Expansion of Tendaho Suger plantation	Expansion of Irrigation area occupying dry land pastoralist grazing areas
	Construction of Tendaho Dam	Evection of pastoralists
	Commune Program carried out irrigation farms	Expansion of Irrigation farms

4.4.3 Impact of population dynamics on land use land cover change

According to the key informants increased sedentarization of Afar pastoralists and a high influx of migrants from the highlands regions to the area took place, after the establishment and expansion of Tendhao Cotton Plantation. The situation exasperated particularly after the down fall and Derge Regime and the reestablishment of Tendaho Suger Plantation.

The population size of the district was 42,437 in 1986, 56,586 in 2001, and in 2014 it is estimated to be 88,092 (Table 8**) (**CSA, 2014). The population figure for the year 1986-2000 are computed using backward mathematical projection based on the counted population of census year 2007. The population figures for the years 2008- 2017 are computed using a ratio method. This means, between 1986 and 2001 on average 884 people were added to the district each year, and between 2001 to 2014 on average, 2423 people were added to the district each year (CSA, 2014). The respondents were also asked the causes for such a change were in-migration from the surrounding region (70.2%), natural increase (7.4 %) and both factors (22.4 %). The linkage between land use and population growth, (Ronald and Adamo, 2004) pointed out; environmental changes have many driving forces, but population is being only one of them. Large population size with higher rate of growth causes increased pressure on the natural resource stocks like land for agriculture, trees for fuel and construction, and water, which are at present deteriorating at fast rates in the district.

Table 8 Counted and Projected population of Dubti Wereda, 1986-2014

Year	Total	Urban	Rural
	Both Sexes	Both Sexes	Both Sexes
1986	42437	21393	21044
2001	56586	28526	28060
2007	**65342**	**32940**	**32402**
2014	88092	51376	36716

Source CSA Projection 2014

4.4.4 Expansion of agriculture and settlement on land use land cover change

Modern irrigation farming stared 1960s the lower Awash range land by a British company mainly producing cotton in the area. Since the 2002 the Federal government changed the cotton farm to sugar plantation. The Tendaho reservoir increases the total water surface area of the region by 17.14% making the total surface area of the water bodies about 991 km^2. The reservoir also has a large network of canals and provides irrigation to 600 km^2 (60,000 ha). The main canal has 72 km long, 22 m bed width, and 2.5 m depth which feed to several hundred kilo meters of secondary and tertiary canals (Hussien *et al.*, 2010). Tendhao suger plantation has developed more than 6000 ha modern irrigation land and hand over to the local agro pastoralist to be out growers as compensation for the taken grazing land and small scale irrigation land owned by pastoralists and agro pastoralists(ARPADB 2013 Report). The current Ethiopian government has encouraged pastoralists to engage in agro-pastoral activities. Overall high farmland expansion characterized most parts of the country during the past 15 years (Abate, S. 2011).

4.4.5 Land tenure and conflict on land use land cover change

According to the key informants The traditional land use and land management practices that used to sustain the welfare pastoralists. However, the existing land tenure system exacerbates natural resource degradation in lower Awash. Apart from this inter and intra tribal conflict over natural resource also one of the major driving forces for land use land cover changes in the area. The key informants were also disclosed that the expansion of large scale commercial farming did not take into consideration rangeland and dry time grazing. The Afar region in collaboration with the federal government has stared voluntary Commune program to permanently settle 11,000 pastoralist and agro pastoralist in in 10 commune centers in the Wereda along the banks of Awash River (MoFA, 2010 Annual report). Expansion of state and private farms has aggravated the scarcity of grazing land for pastoralists. ARPADB (2013) indicated that, appropriations of resources for private use jeopardize the principle of communal ownership. It also aggravates conflict among pastoralists that is considered an anomaly. Additionally it blocks the mobility routes, the main risk management strategy. Inter and intra -clan conflicts over rangeland resources mainly grazing land and water points have partly contributed to the decline in the rangeland resources

4.5 Land use and land cover impact on livelihood of the local community

4.5.1 Changes in land-use patterns, 1986-2014

The key informants report that the dynamics of changes in land-use patterns were evident in Dubti Wereda during this period. They narrated that the natural resource situation during the 1980s better than 2010s. Therefore, the rate of deforestation was low and the conditions for palatable species in the pastures were favorable, the soil had a better fertility, and the rate of regeneration during the rainy season was high. The key informants also mentioned that, since the beginning of droughts in the early eighties, natural resources began to degrade, and human and animal populations increased due to human and animal migration from the neighboring Amahara ,Tigray region and from other part of the country.

During the field survey, as per the focus group discussion held on Woreda and Kebele, the major land use land cover changes under taken in the last 30 years are expansion of crop land to mainly grazing and browsing lands (a need to irrigable land), grass lands in to shrub and bush lands (because of bush encroachment) and grass lands in to exposed surface (because of moisture stress). The major factors for the land use land cover changes were mainly due to need for irrigation, expansion of cropland, severity of erosion and others.

4.5.2 Socio-economic characteristic of the respondents

The respondents interviewed in this study were women (24 %) and men (76 %) with an age range of 42 to 65 years,

4.5.2.1 Marital status

As shown in (table 9) out of the 70 male married respondent 52 of them have more than two wives. This could indicate that they have high family size and ultimately which exposed them to share the existing wealth among the extended family of the household. With regard to female respondents 50% of them are married whereas the remaining 46.9% and 3.1% are attributable to widowed and divorced respectively.

Table 9 Marital status of the sampled household

Marital status	,MALE		FEMALE		TOTAL	
	No	%	NO	%	No	%
Married	70	68.6	16	50	76	56.7
Widow	17	16.6	15	46.9	32	23.8
Divorced	15	14.7	1	3.1	16	11.9
Total	102	76	32	24	134	100

4.5.2.2 Level of education

The surveys showed that among the 134 interviewed pastoralists,(Table 10) 108 (80.6%) are illiterates. When interviewed now days the government has constructed sufficient school in the Wereda and youngsters are learning, on the other hand the regional government has failed to provide needed services such as adult education for elders. According to respondents out of 22 respondents who could read and write are 11 (50 %) this are found in the pre urban Kebeles.

Table 10 Educational level of the sampled household

Name of kebele	Illiterate		Read and write		Elementary & above		Total	
	No	Percent	No	Percent	No	Percent	No	Percent
Iyrolaf and gebelaytu	29	87.9%	4	12.1%	0	0.0%	33	100.0%
Debel and Halibeye	28	93.3%	2	6.7%	0	0.0%	30	100.0%
Haredo and Hanekis	22	84.6%	4	15.4%	0	0.0%	26	100.0%
Saha and Musle	13	92.9%	1	7.1%	0	0.0%	14	100.0%
Dubti addia ketema	9	52.9%	5	29.4%	3	17.6%	17	100.0%
Logia addis sefer	7	50.0%	6	42.9%	1	7.1%	14	100.0%
	108	80.6%	22	16.4%	4	3.0%	134	100.0%

4.5.2.3 Trend in livestock owned as result of Land use land cover change

As it shown in (Table 11) the trend in livestock owned in the three categories indicate there is considerable change in the past 30 years. 32.1 % sampled household indicated there is a declining trend in their livestock ownership with a range of 75 to 100%, the highly victim were pastoralist when compared to the agro pastoralist and pre urban kebele residents.

Table 11 Trend in Livestock owned by respondents

Category kebeles	**Trend of livestock owned**						Total	
	Decreasing by 25- 50 percent		**Decreasing by 50-75 percent**		**Decreasing by 75 - 100 percent**			
	No	%	No	%	No	%	**No**	**%**
Agro pastoral	28	31.5%	38	42.7%	23	25.8%	**89**	**100%**
Pastoral	3	21.4%	4	28.6%	7	50.0%	**14**	**100.%**
Pre urban	6	19.3	12	38.7%	13	42	**31**	**100%**
Total	**37**	**27.6%**	**54**	**40.3%**	**43**	**32.1%**	**134**	**100.%**

4.5.2.4 Household livelihoods

In recent years, patterns of land use have changed significantly in Lower Awash, largely as a result of frequent drought, land degradation and environmental crises. As indicated in (table 14)A shift in livelihood strategies has been observed in the last 30 years (Table 12) . Out of 134 sampled HH whose primary livelihood were pastoralist 88(65.7%,) and their number reduced to 18 (13.40), agro pastoralist were 15(11.2%) increased to 42 (31.3%), the number of casual worker were increased from 14 (10.4%,) to 25 (18.7%), the number of petty trade 4(3.0%) increase to 6(4.55.2%), the number of HH who depend on social help an remittance increase from 6 (4.5%) to 16 (11.9%) and the number of HH who depend on small scale Natural resource based livelihood has increased from 7 (5.2%) % to 25 (18.7%). In the past three decades, most pastoral households started to adapt new livelihood strategies both keeping animals and growing crops which accelerate competition for land resources overgrazing.

Table 12 Primary means of livelihood 2014 and before 30 years

Name of kebele	**Pastoralist**				**Agro pastoralist**				**Casual worker**				**Petty trade**				**Social aid**				**SS NRB livelihood**				**Total**	
	Before 30 years		**2014**		**Before 30 years**		**2014**		**Before 30 years**		**2014**		**Before 30 years**		**2014**		**Before 30 years**		**2014**		**Before 30 years**		**2014**		**Before 30 years**	
	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
IG	22	67	3	9	8	24	12	36	3	9	7	21	0	0	0	0	0	0	3	9	0	0	8	24	33	100
DH	21	70	1	3	4	13	12	40	3	10	9	30	0	0	0	0	1	3	5	17	1	3	3	10	30	100
HH	19	73	4	15	3	12	16	62	3	11	0	0	0	0	0	0	0	0	4	15	1	4	2	8	26	100
SM	14	100	10	71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	29	14	100
DA	6	35	0	0	0	0	1	6	3	18	4	24	2	12	5	29	3	18	2	12	3	18	5	29	17	100
LA	6	43	0	0	0	0	1	7	2	14	5	36	2	14	3	21	2	14	2	14	2	14	3	21	14	100
Total	**88**	**66**	**18**	**13**	**15**	**11**	**42**	**31**	**14**	**10**	**25**	**19**	**4**	**3**	**8**	**6**	**6**	**5**	**16**	**12**	**7**	**5**	**25**	**19**	**134**	**100**

4.5.2.5 Drought and its effects on household economic activities

Drought is a relative term that can mean different things to people with different profession. From the context of pastoral settings, drought implies two or more consecutive years when rainfall is less than 75% of the long term average (Coppock1994 cited in Yayneshet Tesfay and Kelemork Tafere, 2004)

Afar region has experienced major droughts every 2-3 years for the past 20 years and affecting an increasingly large number of the pastoralists. Migration of animals to the neighboring areas, increase livestock sales, purchase of fodder/getting fodder from NGOs (FAO), slaughtering of calves, and in some kebeles searching of other alternative means of income generating activities such as charcoal selling and employed as a daily laborer in some projects are the major risk minimizing strategies or traditional coping mechanism among others. (DPPFS, 2010 Annual report). According to sample house hold respondent and stone and gravel selling and Charcoal burning constitute the highest percent 29.9% and 17.9% followed by Fire wood selling and selling tree for house construction material selling, which represents 9.7%25.6 % and 7.5 % respectively. Therefore, charcoal and selling of selling of stone and sands for constitutes the main source of income during drought years when agricultural and livestock production decreases (Table 13).

Table 13 Type of over Exploitation of natural resources during drought years as reported by respondents.

Kebeles based on their livelihood	Charcoal production and selling		Fire wood selling		Tree House construction material selling		Stone and gravel selling		HH not involved in Natural resource Selling		Total	
	No	%	No	%	No	%	No	%	No	%	No	%
Agro pastoral	19	21.3	9	90	8	9	19	21.3	34	38.2	89	100.0
Pure pastoral	1	7.1	0	7.1	3	21.4	7	50.	3	21.4	14	100.0
Pre urban kebeles	4	12.9	1	10	2	6.45	14	45.16	10	32.3	31	100.0
Total	**24**	**17.9**	**10**	**7.5**	**13**	**9.7**	**40**	**29.9**	**47**	**35.1**	**134**	**100.0**

Source Field survey 2014

4.5.2.6 The Impact of land-use change on livestock production and pastures

The respondents of the present study indicated that before 3 to 4 decades the conditions of their grazing lands had a very good status. As a result, it was possible to produce the required size and types of livestock with remarkable social organization and cooperation, as there was no conflict for shortages of grazing resources. On the other hand, all the participants' in-group discussion also stated that the range condition of their grazing land had been deteriorating since the past three decades (Figure 7). They stressed that even the condition of the rangelands 10 to 20 years ago were by far better than the present range conditions. Pastoralists further added that even at times of good rains, degraded lands did not recover with the required grass resources. The majority of the respondents ranked the present rangeland conditions of the area under pooor followed by fair rangeland status.

According to key informants many previously economically and ecologically viable rangeland areas are becoming no longer viable. Bush encroachment also becoming a an outstanding caustic factors for rangeland land degradation through inducing rangeland shrinkage and overgrazing through enforcing the concentration of grazing orbits to certain limited areas. Densely populated bush encroachment especially *prosopis juliflora* potentially restricts the free grazing movement of animals.

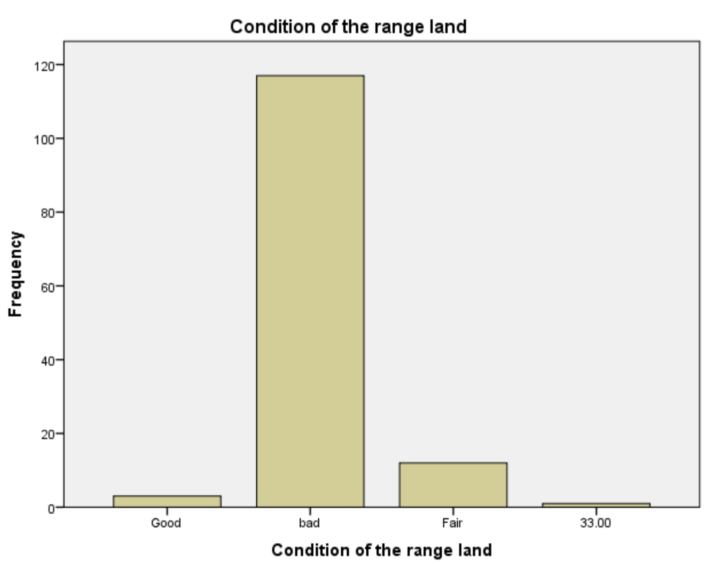

Figure 7 Condition of range land

4.5.2.7 Weakening of tradition land use management institution

Pastoral communities dependent on range land resources have adopted various traditional institutional arrangements to manage and utilize their resources with varying degree of success in achieving sustainable use. They are also empowered with very potential indigenous knowledge gained from so long year experiences, learned from their environment and traditional inherited from generation to generation from their ancestor. Afar pastoralists inhabited in the sub-basin have a very long lasted traditional rangeland management institutes and indigenous knowledge through which they were govern herd mobility pattern, seasonal grazing, and other natural resources.

According to key informants all these traditional institutes are becoming weak and even found at stage of ceasing due to different interrupting factors and limited scarce of natural resources. This in turn resulted in irregular and inconsistence herd mobility pattern and ill competition on limited rangeland resources and, thereby, intra-clan conflicts and degradation of rangeland resources is becoming a substantial problem of the area.

4.6 Impact of LULC on Biodiversity

4.6.1 Loss of biodiversity

According to the survey and focus group discussion, 100% of the pastoralist, 95% of agro-pastoralist agreed on the impacts of *LULC change* on loss of biodiversity and ecological services of the study area. Several plant species have been endangered (Table 15) in areas due to LULC Change.

The major trends were drastic conversions of natural vegetation areas into large-scale mechanized agricultural land. This resulted in a progressive loss and degradation of grazing area in the entire region. Overall, the documented LULC changes may cause an irreversible loss of biodiversity and a depletion of other ecological services provided by natural vegetation

Local elders also indicated that, many useful grass species can be found in different areas of Dubti Wereda. However, some are now at the verge of extinction like Melif (*Andropogon cenchrifprmis schumach),* Musa *(Brachiria eruciformis)*, Rareyita (*Cynodon* *dactylon,)*Beruwelle/denbehu (*Hyparrhenia sp.)*and some like almost completely disappeared from the range land .

4.6.2 Prosopis Juliflora invasion

According to key informants *Prosopis juliflora* is one of the recent land use problem. It is a plant species which adversely affects both the farmlands and pasturelands (Fig 8) The indigenous vegetation are now being replaced by this species and increasingly getting covered with prosopis. The expansion of this dangerous plant significantly affected the growth of pasture and browse for livestock and others health related effects. This has a consequence of increasing costs and labor for clearing canals and farm land. The plant encroaches the grazing land at alarming rate and suppresses the growth of palatable grass species (Table 15). Based on field observation and group discussion held, this phenomenon is a threat to cattle production than goats and camels


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Figure 8 *Prosopis juliflora* invasion

Table 14 Tree and bush spp endangered by LULCC

Local Name (Afar)	**Scientific Name**	**Utilization**
Garssa/Gerssa	*Dobera glabra*	• Feed for Camel and Human being(Its fruit)
Hedayito	*Grewia ferruginea*	• Feed for camel and goat • Used for construction of Afar traditional house • Edible fruit for Human • Used to make bed
Mederto	*Cordia sinensis*	• Feed for goat camel and cattle • Edible fruit for Human

		• The bark used for rope • Used for construction of Afar traditional house • Medicine for malaria
Adebto	*Grewia biscolor*	• Used to make bed • The bark used as a rope for house construction to bind poles • Used as walking stick • Used as fuel wood
Adayito	*Salvadora persica*	• Feed for Camel • Used as tooth brush • Fruits used as spice • Has medicinal value
Keselto	*Acacia nilotica*	• The pod feed for Camel, goats and cattle • The leaves feed for goats • Used for good taste of water in Afar traditional water container which is made by hide • Used for house and fence construction • The bark used to remove hair during hide processing • Used as good quality charcoal and shade tree
Adgento	*Acacia seyal*	• The Gum used as sweet feed • The gum and bark used for hide and skin processing • The pod used as feed for cattle • Used as good quality charcoal and fuel wood
Adedo	*Acacia Senegal*	• Feed for goat, camel and cattle • The Gum used as sweet feed
Gerento	*Acacia oerfota*	• The gum used as feed for children • Used for construction of Afar traditional house • Flowers used as a feed for goat • The leaves used as a feed for camel and goat
Mekarto	*Acacia mellifera*	• Feed for goat and camel

The LULCC in relation to *P. juliflora* invasion have intense effects on the biodiversity of the study area which in turn affect the capacity of the area to deliver ecosystem goods and services. Lawler *et al.* (2006) indicated the invasive plant species threaten native and endemic flora and fauna and disrupt the whole ecological system. According to key informant interview noticed many wild animals have also migrated from the area due to LULCC (Table 16).

Table 15 Wild animals endangered or reduce in the area

Local Name (Afar)	**Scientific Name**	**Common name**
Bieyda	*Oryx gazelle*	Oryx
Goroia	*Struthio camelus*	Ostrich
Da'ema	*E. grevyi*	Grevys Zebra
Bekiela/Tinchel	*Lepus habessinicus*	Abyssinian hare
Segerie	*Madoqua saltiana*	Dik-Dik
Waydido	*Gazella soemmerringi*	Soemmerring's gazelle
Galie fiela	*Litocranius walleri*	Gerenuk
Sera	*Tragelaphus imberbis*	Lesser kudu
Goroja	*Kobus ellipsiprymnus*	Water buck

5. CONCLUSSION AND RECOMMENDATIONS

5.1 Conclusion

This study clearly indicated that remote sensing in integration with GIS is important tool for classification, mapping, change detection and landscape spatial pattern analysis for understanding of arid ecosystem of Afar rangelands. The analysis provides valuable insight into the extent and nature of change that has taken place in the arid environment from 1986, 2001 and 2014. The finding of this paper had generated some baseline information for further development program and research work. Furthermore, the change detection analysis useful for the monitoring of land use/ land cover change over time and space.

This study has been conducted by integrating GIS and Remote Sensing. In order to detect and analyze changes in land cover classes, these techniques were implemented. In the first section, satellite data for the study periods of 1986, 2001 and 2014 and Remote Sensing techniques were applied to generate LULC maps through a maximum likelihood supervised image classification algorithm. The accuracy assessment and change detection processes has also been done. The overall accuracy of land use and land cover maps generated in this study had got an acceptable value of above the minimum threshold.

From the remote sensing of image classification result, Dubti Wereda showed significant change in the LULC over the last three decades. The study was successfully able to detect LULC change and concluded that bush land, built up areas, irrigable land ,bare land and water body cover has increased and on the other hand grass land, shrub land decreased between 1986 and 2014. This can be attributed to environmental degradation, the introduction of invasive alien species like *prosopis juliflora*, weakening of traditional rangeland management, an increase in human population, government agricultural policy for expansion of irrigation land and pastoralist settlement program. From the observed changes expansion of water resource coverage and growth of urban areas can be taken as something positive.

The study also identified major driving force for land use land cover in the study area as perceived by local community. This factors among other include demographic, biophysical, infrastructural, political factors and socio-economic factors, these include over population, infrastructure development, socio cultural change, change in land tenure system and loss of traditional knowledge in rangeland management

The livelihood condition of the study area community had largely affected by the changes on this LULC type. The study results showed that land-use changes between 1986 and 2014 had severely impacted the pastoral livelihood in terms of natural resources availability as indicated by selling of natural resource, degradation of rangeland,. This has increased the suffering of pastoral people as they face food shortages and low incomes that threaten the sustainability of their livelihoods. The drivers and related changes discussed above may therefore influence ecosystem functioning in the rangelands through their impact on the traditional mobility pattern between the wet- and dry-season grazing areas. This may also lead to a decrease in the size of dry-season grazing areas, isolation of crucial habitats such as permanent water sources, particularly for large wild animals, indirectly resulting in changing livestock species composition and directly disturbing some plant and animal species that may be threatened with extinction.

This Land use land cover change cannot be ignored altogether because it has unquestionable consequences in relation to the biodiversity and livelihood of pastoral communities found in the area. Reducing pressure caused by natural and anthropogenic factors such as drought, flooding, expansion of *prospis juliflora* , conflicts, lack of access to markets, volatile food prices and restrictions on mobility and access to key resources unambiguously would be critical as the first step in ensuring the sustainable use of the rangeland of Lower Awash. Furthermore, studies like this one that integrating remote sensing approaches with pastoral land use and their environment would be essential for properly understanding and generating of spatio-temporal information of pastoral rangelands.

5.2 **Recommendation**

The results of this study have shown that Remote Sensing and GIS are important tools in LULC change studies. Therefore, based on the findings of this study, the following recommendations are forwarded for policy development implications and future research directions:

- Population increase has played a major role on LULC change and there should be consider possible national and local strategic mitigation measure for huge migration of people from the highland to the Lower Awash.
- Conservation of the rangeland resources and maintenance of diversity is helpful to make the range resources sustainable.
- Creating off farm job opportunity especially for the youths, should be involved in other jobs like to be professional employee of nearby State farms, service provision and tourism and related activities.
- Design and implementing national and regional programs and projects that enhance the resilience capacity of the pastoralists who are severely affected by the LULCC
- Designing and implementing ecological, economical and socially sound systematic bush encroachment management and scale-up existing best experiences
- Strengthening traditional land resource management and utilization practices and integrating indigenous and scientific land use and management approaches
- The expansion of Tenedaho Sugar Factory in the area should consider the dry time grazing and water for the local pastoralist in providing the by-product of the factory as a supplement feed for livestock.
- Indigenous institutions, which sustain natural resources for centuries, have collapsed thereby triggering adverse land use and cover changes. This situation necessitates the re-establishment of traditional institutions in order to manage rangeland. To this effect, experts and responsible bodies should bring onboard the local leaders to participate in the planning and re-institution process. Equally important is creation of awareness among the indigenous population as well as migrants concerning the long-term impacts of natural resources degradation.

Furthermore, remote sensing satellite imagery are widely applicable for land use and land cover classification and land use/land cover is the most valuable input for land use planning and other development activity. Hence, remote sensing and GIS should be utilized for natural resource management to acquaint the managers and decision makers themselves with up-to-date information.

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Annex

Annex A Questionnaire

The Questionnaires are designed to assess Land Use/Land Cover Dynamics in Lower Awash Rangelands, Ethiopia

Part 1- Background Information of the Respondents

- Name_____________________ Age_______ sex_______ Wereda __________ kebele
  Village _______ Date of interview_______________
- Level of education:
  (1) Illiterate (2) Primary school (3) Secondary school
- For how long did you live in this area (locality)? (Year)______________
  A. less than 10 years B. 20 years C. More than 20 years
- Marital status

  A. Married B. single C. Divorced D. Widowed

- Number of families in the household including the household head______________
- What is the principle source of income for the house hold?
  A. Employment / Salary B. Livestock/Pastoralism C. Ago pastoralism D. Petty trade
- What is the secondary source of income for the house hold?
  A. Employment / Salary B. Livestock/Pastoralism C. Ago pastoralism D. Petty trade

Part 2-Information about Land use change

- Did you recognize the land use changes over the last 28 years?

  A. Yes B. No

- Which one has changed more?

  A. Rangeland B. Agricultural Land C. Settlement Areas D. Wetlands

- What are the responsible causes/drivers of change in the land use and land cover?

A. Artificial/anthropogenic B. Natural C. Both

- What are the anthropogenic processes/factors/that directly or indirectly cause for the land use change? (as perceived by respondents)

A. Population growth, B. Urbanization C. Land shortage D. Infrastructural Development D. Dam construction and irrigation Development E. All

- What are the natural processes/factors/that directly or indirectly cause for the land use change? (as perceived by respondents)

A. Flooding B. Drought/rainfall variability C. Bush encroachment D. All

- Drought occur in the area every a/less than 5 years b/ every then years c/every two years d/unpredictable

- Have you ever noticed any plant species that disappeared/appeared due to the effect of land use land cover change?

  A. Yes B. No

- If yes, give their names;____

  ____

- Have you ever noticed any animal that disappeared/appear due to the effect of land use and land cover change?

  A. Yes B. No

- If yes, list their names. ____

  ____

- Have you ever noticed any wetland appear or disappear due to the effect of land use and land cover change?

  A. Yes B. No

- If yes, list their names/areas/ ____

  ____

- What are the negative and positive effects of urbanization in these areas?
  - Positive impact ____
    ____
  - Negative impact____
    ____

- What are the dynamics of rangeland condition of the area

No	Type of land	Status		Trends in the decades	Possible reason for change
		30 years back	Current		
1	Communal Grazing land				
2	Watering points				
3	Reserved grazing areas				
4	Wet season grazing areas				
5	Dry season grazing areas				

Notice: 1. Good 2. Fair 3. Bad (for the status)

1. Increasing 2. Decreasing 3. Constant (for the trend)

Part 3- Information about Livelihood

- What are the income sources of the household now?

  A. livestock B. crop cultivation C. Agro pastoral D. Pity trade E. Employee

  F. Mining G Others (specify) _______________________________________`

- What are the income sources of the household (clan) before 30 years?

  A. livestock B. crop cultivation C. Pity trade D. Employee

  E. Others (specify) _____________________________________`

- Trend livestock owned

  A. Increasing B. Decreasing C. Constant

- Estimate the livestock population dynamics and trends in previous decades

No	Species	30 years back			Current			Trends in the decades	Possible reason for change
		No	LU	TLU	No	LU	TLU		
1	Oxen								
2	Cow								
3	Sheep								
4	Goat								
5	Camel								
6	Donkey								

Notice: 1. increasing 2. Decreasing 3. Constant (for the trend)

- What is the current irrigated land owned by the household?

  A. Less than 1 hectare B. 1 Hectare C. 2 Hectare D. More than 2 Hectares D. No land

- What problems do you face in your livelihood because of the current land use land cover change?____

  ____

  ____

- Do you agree that urban expansion in to your area is advantageous to your family members (Clan)?

  A. Agree B. Disagree

- Did your household displaced due to land use land cover change

  A. Yes B. No

- If your household is displaced one, how was your social relationship and value within your community after your land expropriation/ displacement?

  A. Very high B. High C. Moderate D. Low E. Very low

- If your household is displaced one, what do you think the livelihood situation after displacement?

- It is better now B. No change C. It is worsening

- Does urbanization bring remarkable change in the life style and cultural in the past 28 years

  A. Very high B. Moderate D. Low

- Can I know the reason behind for your answer in No.10? ______________________________
  ____
  ____

- Were you engaged in any of productive (income means) activities just right after the dispossession/displacement of your land?

  A. Yes B. No

- If 'Yes' is your choice for question no. 12 above, in which of the following activity did you engage (means of livelihood)?

  A. Crop production B. Livestock rearing C. Both livestock rearing and crop production D. Non-agricultural C. Both agricultural and Non agricultural

- If your response for question number 15 above is B, in which of these you engaged yourself?
  - Raising own business
  - Employee of government /state farms/
  - Migration to far areas of urban
  - Migration to far areas of rural
  - Daily labor in the city
  - Remittances /social help/
  - Others specify _______________________________________
- Did you household get income by selling the existing natural resources around your area before 30 years ?

  A. Charcoal production B. Collection of Fire wood for selling

  C. Collection of tree pools for construction D. Mining (selling stone gravel sand etc)

  E. No selling of Natural resources
- Did you household get income by selling the existing natural resources around your area?

  A. Charcoal production B. Collection of Fire wood for selling

C. Collection of tree pools for construction D. Mining (selling stone gravel sand etc)

E. No selling of Natural resources

- Does the income from non-farm activities enable you to buy food items and cover your household food deficiency?_______ If not why? _______________________________

____

- What do you think is major problems you and your family faced while coping up with (to) the urban type of livelihood strategies?
  - Lack of knowledge in financial utilization
  - lack of due follow- up from the concerned institutions
  - Lack of skill (knowledge) for job opportunity
  - Others, specify_______________________________
- Does your family in a position to use efficiently the irrigated farm land though out the year in termsof all agricultural practices and input provision without external support?

  A. Highly dependent B. Partially Dependent C. cultivate independently
- Does the income you earned from the farm could sustainably support your family though out the year
  - A. yes B. No

22. Did your family receive emergency aid (food, medicine, tents etc) in the previous 3 decade for consecutive years?

    A. Yes B. NO
23. For question no 22 if yes what was the cause of emergency

    A. Drought B. Flooding C. Disease outbreak D. Other specify
24. 14. What do you think as better to be done to improve your livelihood status?

____

____

____

Appendix B: Discussion points

Check list for Focus group discussion (FGD)

Date: ______________

- How do you perceive and describe the land use and land cover change in the past 28 years in the Wereda?
- What potential drivers could be listed for the change of land use since the last 28 years?
- How the livelihood of the surrounding community affected due to the land use change?
- Do you agree the pastoralists who were displaced by urban and irrigation cultivation expansion in the last 28 years had properly compensated? If not what was the problems.
- What advantages and disadvantages you believe are the result of urban expansion towards your localities specially interims of social and economic aspects?
- What measures were made to alleviate land use land cove change problems for the community by the government NGOs?
- Discuss the major events undertaken in the Lower Awash in general in Dubti Wereda in particular since the mid1980's up to date.

Annex C GPS Points of Study Area

x	y	Land use taypes
712041.1	1323752.8	Water body
711882.6	132486.8	Bare land
711766.3	1323935.9	Water body
710747.9	1322001	Shrub land
712044.6	1323252.7	Water body
712550.8	132325.9	Bare land
712139.7	1323523.9	Water body
712224.2	1323865.5	Water body
712132.6	1323495.7	Water body
711255.7	1323132.9	Bare land
712498.9	1323756.3	Bush land
711667.8	1323425.2	Bush land
711220.4	1323879.6	Shrub land
712970.9	1323217.4	Shrub land
726650.9	1297393.8	Residential area
741029.6	1287213.3	Grassland
726374.4	1297972.2	Residential area
737233.8	1285009.1	Bush land
728051.9	1297325.6	Residential area
736843.8	1291906.7	Built up area
720436.4	1313009.1	Built up area
732580.7	1300281.9	Irrigated land
736621.1	1285734.5	Bush land
734607	1298227.4	Irrigated land
7384417	1289149.9	Residential area
737008.4	1290755.6	Bush land
732184.5	1294227.4	Irrigated land
728578.9	1303945.7	Irrigated land
738071.8	1297495	Bare land
734184.5	1313325.9	Grassland
7340051	1287910.5	Shrub land
713790.2	1298114.7	Grassland
734332.4	1289403.5	Residential area
713452.2	1296058.4	Grassland
715536.7	1291973.9	Grassland
712156.4	1291016.2	Bush land
708297.3	1299579.5	Bush land
710156.4	1299973.9	Shrub land
710013.8	1297732.7	Built up area

715371.2	1304963.3	Grassland
715233.9	1304833	Shrub land
715818.4	1305435	Bush land
716269.1	1304949.2	Residential area
724424	1312945.7	Bare land
717832.5	1318466.8	Bare land
725043.7	1315537.2	Shrub land
730114.1	1302804.9	Irrigated land
709931.1	1323269.6	Bare land
706902.9	1321382.2	Grassland
707790.2	13222.55	Shrub land
707269.1	1324693.1	Bare land
706395.9	1324649.8	Irrigated land
709311.4	1325973.8	Bare land
707902.9	1325692.1	Bush land
727202.1	1332843.5	Residential area