# ADDIS ABABA UNIVERSITY

# COLLEGE OF NATURAL AND COMPUTATIONAL SCIENCES

# SCHOOL OF EARTH SCIENCES

## IMPACT OF LAND-USE/LAND-COVER CHANGES ON LAND SURFACE TEMPERATURE IN ARSI ZONE, EASTERNETHIOPIA

**A thesis submitted to**

***The school of Graduate Studies of Addis Ababa University in partial fulfillment of the requirements for the Degree of Masters of Science in Remote Sensing and Geo-informatics***

**BY**

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***A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES OFADDIS ABABA UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTERS OF SCIENCE IN REMOTE SENSING AND GEO-INFORMATICS***


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This is to certify that thesis prepared by MORKA ABEBE FEYISA, entitled: “Impact of Land-Use/Land-Cover Changes on Land Surface Temperature in Arsi zone, Eastern Ethiopia” and submitted in partial fulfillment of the requirements for the degree of Masters of Science in Remote sensing and Geo-informatics complies with the regulations of the University and meets the accepted standards with respect to the originality and quality.

Signed by the Examining committee:

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## List of Acronyms

| | |
|---|---|
| **CSA** | Central Statistical Agency |
| **DEM** | Digital Elevation Model |
| **DIP** | Digital Image Processing |
| **DN** | Digital Number |
| **ENVI** | Environment for Visualizing Images |
| **ERDAS** | Earth Resources Data Analysis System |
| **ETM+** | Enhanced Thematic Mapper Plus |
| **FAO** | Food and Agricultural Organization |
| **GIS** | Geographic Information System |
| **GPS** | Global Positioning System |
| **LST** | Land Surface Temperature |
| **LU/LC** | Land-Use/Land-Cover |
| **LU/LCC** | Land-Use/Land-Cover Change |
| **NDVI** | Normalized Difference Vegetation Index |
| **OLI** | Operational Land Imager |
| **QGIS** | Quantum GIS |
| **TIRS** | Thermal Infrared Sensor |
| **TM** | Thematic Mapper |
| **TOA** | Top of Atmosphere |
| **UHI** | Urban Heat Island |
| **UNEP** | United Nations Environmental Program |
| **USGS** | United States Geological Survey |
| **UTM** | Universal Transverse Mercator |

# Abstract

*Impact of Land-Use/Land-Cover Changes on Land Surface Temperature in Arsi zone, Eastern Ethiopia*

*Morka Abebe, Msc. Thesis*

*Addis Ababa University, May 2018*

*Unmanaged Land-use/land-cover change is one of the main environmental problems and challenges, which strongly influences the process of urbanization and agricultural development. The world has faced with the problem of overwhelming increase in land surface temperature (LST) as compared from year to year. The present study has investigated the impact of land-use/land-cover (LU/LC) change on LST in administrative zone in Ethiopia. The research was conducted in Arsi zone, located in Oromia region, Eastern Ethiopian. Land-use/land-cover, LST and NDVI were extracted from Landsat TM (1997) and Landsat 8 OLI/TIRS (2017) using GIS and remote sensing tools. Land surface temperature was done using split window algorism. Changes in LU/LC, which occurred between 1997 and 2017 in the study area was evaluated and analyzed using geospatial tools and verified against field data. The result of LU/LC change indicated that farmland covered more than 40% during the study periods (1997–2017) and followed by shrub land covering more than 37%. The study indicated that most areas having lower LST in 1997 were changed to higher LST in 2017.This happened due to the increased in different LU/LC changes especially attributed to the decreasing of vegetation cover in the study area. By linking the LU/LC classes and LST parameter using zonal statistics as figure, it has been found that, LST has negative correlation with vegetation cover. Land surface temperature result showed that the eastern and some north western parts of the study area exhibited relatively higher temperature. This is mainly due to altitude, slope and LU/LC types and changes. On the other hand, the central parts and around mountains Chilalo,Kaka and Gugu area exhibited relatively low LST values ranging from 5.11°C to 9.02°C. This is mainly due to high NDVI value or denser vegetation cover. While the eastern and some north western part has high LST value reaching up to 44.90ºC. Therefore, the visual comparison of 1997 and 2017 images showed that the LU/LC type and NDVI status and condition play a major role in variability of LST values. Continuous land-use/land-cover change may not be stopped easily. However, different measures have to be taken by environmental experts and the concerned bodies to minimize the influence of changes in the LST on environments. This study showed that geospatial tools and techniques can give fast and reliable results for evaluating LST increases and variability at regional scale and its impact on the environment in a shorter analysis and evaluation.*



***Key words**: LU/LC, LST, NDVI, Landsat image, GIS, Remote sensing*

# CHAPTER ONE

# 1 INTRODUCTION

## 1.1 Background of the Study

Land is defined as an arrangement of activities and inputs people under take in a certain land cover type to produce changes or maintain it, (FAO/UNEP, 1996).Land Use should be matched with land capacity and at the same time it should respect the environment and global climate system (FAO/UNEP, 1999). Land use is continually changing over time and the main driving force is the human needs. Population is increasing and it causes transformation of natural ecosystem into human landscapes. Human settlements, needs for farm land and especially, large urban and industrial areas significantly modify their environment. Changing from permeable and moist land uses to impermeable and dry one with paving and building material can sharply affect energy balance and land surface temperature (Guo*et al* ., 2012), as well as many other surface properties like the amount of evaporation, surface infraction, run off rate, drainage system, etc. It is therefore critical to have detailed information of temporal and spatial land use changes and its rates. The climate in and around cities and other built up areas is altered due to changes in Land use Land cover (LU/LC) and anthropogenic activities of urbanization.

Land Surface Temperature (LST) is a crucial parameter in investigating environmental, ecological processes and climate change at various scales, and it is also valuable in the studies of evapotranspiration, soil moisture conditions, surface energy balance and urban heat islands. Land Surface Temperature is also important in global change studies, in estimating radiation budget and heat balance studies as control for climate models. Knowledge of the surface emissivity is crucial for estimating the radiation balance at the earth surface. For densely vegetated surfaces there is a little problem as their emissivity is relatively uniform and close to unity. However, for arid areas like (Rossow and M. Rothstein, 2001) having sparse vegetation the problem is difficult since the emissivity of the exposed soils and rocks is highly variable.

One of the causes of Global warming in Africa is mainly related massive LU/LC changes. The change in LU/LC leads to environmental changes, variations in rainy seasons and fluctuation in Sea Surface Temperature (SST) and LST. This massive LU/LC are due to the rise in the need of the land for settlement and agriculture and other intervention in human activities. Land is a limited (scarce) natural resource which can be changed when the number of population is rises.

Remote Sensing (RS) and Geographic Information System (GIS) or geospatial tools are now providing new capabilities for advanced environmental management. Satellite data facilitate synoptic dissection of the earth system, patterning and changes from local to global scales over time. Therefore, attempt has been made in this study to evaluate, analyze and to map out the status of LU/LC and LST in Arsi zone Ethiopia. Remote sensing and Geographic Information System also used for evaluating and processing meteorological data such as rainfall, temperature and also used to generate important information for the concerned body to use as input in environmental management.

## 1.2 Statement of the Problem

According to (Naissan and Lily, 2016) global climate appears to be changing at an unprecedented rate. As an effect of this phenomenon, both urban and rural areas experience too warm temperature condition which is increasing from time to time. The earth's environment is dynamic system including many interacting components (physical, chemical, biological and human) that are constantly changing (Emilio, 2008). One of the most important factors that are responsible for the increments of land surface temperature is land use land cover change. At recent time, global warming and environmental change related problems are the major issues for both developed and developing countries. These environmental problems are mainly attributed to the expansion of urban and increasing of needs of land for agricultural and industrial activities. Practices such as deforestation, over grazing, unplanned land use for settlement and other activity leads our environment to warmer temperature. According to the observations, the Land Surface Temperature (LST) for Arsi zone in Oromia Region has been increasing from season to season. This affects a number of socio-economic activities and environmental productivities. Thus, what signifies the relevance of this study is a wide array of applications that gives information on LST and LULC status of the area as input for planning and decision making. According to (Aires, 2001, Sun and Pinker, 2003) LST is the key parameter in land surface processes, not only acting as an indicator of climate change, but also to its control of upward terrestrial radiation, and consequently, the control of the surface sensible and latent heat flux exchange with the atmosphere.

The basic argument why this research study is under taken in Oromia Regional state , Arsi zone is that:

- The areas is characterized by diverse vegetation,
- Variable climate patterns
- Different topographic patterns
- Different LU/LC in general, and accelerated Land -Use Land- Cover changes
- This Master of Sciences (M.Sc) thesis is a unique study addressing the problem with this perspective and dimension that means there is no research has been conducted recently in this study area related.

Understanding the influence of LULC change on LST is a fundamental input to the land management and planning strategies that needs to focus on LST mitigation, and the adaptation of the area to the challenges of climate change.

## 1.3 Objectives of the study

### 1.3.1 General objective

The general objective of this Master thesis research is to assess the impacts of LULC dynamics on LST change in Arsi zone using Geographic Information System and Remote Sensing data and techniques.

### 1.3.2 Specific objectives

- To examine temporal and spatial change in LST as a function of LULCC,
- To analysis the relationship between LST and NDVI over the last two decades,
- To produce LULC and LST maps of the study area using multi-temporal Landsat imageries.

## 1.4 Research question

The following research questions have been formulated in order to achieve the above mentioned objectives:

- What is a spatiotemporal pattern of LULC change in the study area?
- What is the role of Normal Difference Vegetation Index (NDVI) in LST?
- What are the major driving factors of LULC changes of in the study area?
- What is the correlation between LULCC and LST in the study area?

- What is the impact of LULC dynamics on land surface temperature changes?

## 1.5 Significance of the study

The change in LU/LC leads to environmental changes. Extensive LU/LCC are due to the rise in the demand of land for settlement and agriculture and other intervention in human activities. Land is a scarce natural resource that can change when the number of population increases. Rapid LULCC induces considerable Land Surface Temperature (LST) variations that in turn affects rainfall and also causes seasonal fluctuations in coupling with Sea Surface Temperature (SST) change (C. Wloczyk *et al.*, 2006) In order to mitigate such environmental change and its influence on LST variations in Arsi zone, Oromia Region, this M.Sc. study has been conducted with the following significant goals:

- The study provides information about the trend of LULC changes of the study area.
- It provides information about the general direction of LST changes in the study area.
- The results of this study could be used as input for government policy making.
- It can be used for decision making processes related to land use planning and in consideration of LST changes through time.
- In addition to these, the results of this study can serve as basis for further studies on LST increase and the data collected and produced will be used as input to further studies.
- It also provides better understanding on LULC, LST and the trends of changes and their driving factors.

## 1.6 Limitation of the Study

The study was conducted with all possible efforts in collecting the required inputs as both primary and secondary data with clear procedural analysis and technical interpretations. However, the following limitations were encountered in this study:

- Required geo-spatial information and performance about current and past LULC/LST practice and status of the structures are not available at required level.
- The routine process to get data from different organizations.
- The limitation of internet bandwidth for down-loading images.

## 1.7 Scope of the study

This study focused on the use of RS and GIS Technology for assessing the impacts of LULCC on LST selection. The scope of the study was limited to the Arsi zone, eastern Ethiopia**.**

## 1.8 Organization of the Thesis

This master thesis research is organized into six (6) chapters as follows:

The first Chapter introduces introduction, statement of problem, objectives of the study, research questions, and the scope of the study, significance of the study and limitations of the study. Chapter two concentrates on literature review related to this study. This section presents a brief understanding of LULCC, LST and NDVI in general. The third chapter focuses on the general methodology followed, description of the data used in the study and detail explanation of the study area. Chapter four explains the results, which presents the detailed results from image classification and collected data. In this section LU/LC maps generated using maximum likelihood classification, LST and NDVI result presented. Moreover, change analysis of LU/LC and LST, spatial map was prepared for comparison of changes in each year. Chapter five presents the discussion part and the last chapter six presents' conclusions and recommendations. In this section, key findings and critical points that need further treatment has been forwarded as a recommendation for decision makers and for future research.

# CHAPTER TWO

# 2 LITERATURE REVIEW

This chapter presents similar works that has been conducted in different geographic areas, the basic concepts and the inter-relationships among LU/LCC, LST, and NDVI, the applications of RS and GIS in LST studies. Furthermore, it tries to explore the findings of relevant studies that have been carried out studied previously in different areas and identification of the gap. for the current study area.

## 2.1 Concept of land-use/land-cover change

The earth's surface has been changed considerably in the past decades by humans as a result of human induced factors such as deforestation, agricultural activities and urbanization. Land is the ultimate resource of the biosphere, and the terminology Land-Use /Land-Cover (LU/LC) has been used as one in different research. However, these two terms explain two different issues and have different meanings. Land-cover refers to the observed biophysical cover on the earth's surface, including water bodies, vegetation, soil and hard surfaces. Land-use is the exploitation/utilization of the land by human activities for the purpose of settlements, agriculture, forestry, and by pasture altering land surface processes including biogeochemistry, hydrology and biodiversity (Di Gregorio and Jansen, 2000). In this context, as variation in the surface component of the landscape and is only considered to occur if the surface has a different appearance when viewed on at least two successive occasions (Lemlem, 2007). The definition also given by FAO (1999) for land-use is as the arrangements, activities and inputs people undertake in a certain land cover type to produce change or to maintain it. According to Lambin and Meyfroidt (2010), transition in LU/LC can be caused by negative socio-ecological feedback that comes from a rigorous (severe) degradation in ecosystem services as a result of socio-economic changes and innovations.

## 2.2 Causes of land-use and land-cover changes

Changes in the land-use reflect the history and perhaps, the future of humankind. Such changes are influenced by a variety of factors related to human population growth, economic development, technology and environmental changes (Houghton, 1994). Land-cover changes, which is conversion of the land-cover from one type of to another and modification of the conditions within a category and land-use change occurs initially at the level of land parcels when land managers decide that a change towards another land utilization type is desirable (Meyer and Turner, 1992). Population growth is one of the major factors for LU/LC change. People are the most important natural resources, which is mutually inter-related and interdependent for their sustainable development (Santa, 2011).However, Land-use reflects the importance of land as a key and finite resource for most human activities such as forestry, agriculture, industry, energy production, recreation, settlement and water catchment and storage (http://www.ciesin.org/docs/002-105/002-105b.html). During the past three centuries, the extent of earths cultivated land has grown by more than 45% increasing from 2.65 million km² to 15 million km² and at the same time, other natural resources (land-cover) such as forest has been shrinking due to agricultural land expansion and urbanization(Santa, 2011). High rate of deforestation in many developing countries is most commonly associated with population growth and poverty (Mather and Needle, 2000). Land-use/land-cover changes have become major problems for the world, and it is a significant driving agent of global environmental changes (FAO, 1999). Such a large-scale land-use classes through the increase of agricultural land at rural area, deforestation (clearance of trees), and urbanization and other natural phenomena and human activities are inducing changes in global systems and cycles. However, the major change in land-use, historically, has been the worldwide increase in agricultural land (Houghton, 1994). Climate change refers to long term or permanent shift in climate of the area. Some of the evidence for climate change includes increased frequency of the occurrence of drought, global temperature rise, tropical cyclones, flood, and reduced annual rainfall reduction in glacial cover over mountain and rising sea levels (Alemayehu, 2008).

United States Environmental Protection Agency (USEPA, 2004), identified the general causes of LU/LCCs are:

- Natural processes, such as climate and atmospheric changes, wildfire and pest infestation.
- Direct effect of human activity such as road and illegal house construction and deforestation (clearance of trees).
- Indirect effects of human activity is such as, water diversion leading to lowering of the water table.

## 2.3 Land-use and land-cover change in Ethiopia

In Ethiopia, the availability of natural resources changes and management differs significantly from place to place. This variability is because difference in biogeography and topography climate. Land-use/land-cover changes are accelerating, by human actions, but also producing changes that affect humans (Agarwal *et al.*, 2002). The dynamics of LU/LC alters the existence of different biophysical resources, including water, vegetation, soil, animal feed and other (Ali, 2009). Previous studies reported that, in Ethiopia there have been considerable LU/LCC in different part of the country and the expansion of cultivated land at the expense of woodland and forest land and it were stretched into sloppy area due to scarcity of land. Especially in the highlands of Ethiopia, agricultural practices and human settlement have a long history and recently a highland population pressure including depletion of natural resources and unsustainable practices (Miheretu *et al*., 2017).

## 2.4 Remote Sensing (RS)

Remote sensing is the capability to gather information without being in direct contact with objects (Lillesand and Kiefer, 2000). The modern use of the term RS has more to do with technical ways of collecting airborne and space borne information. The earth observation from airborne platforms has 150 year of history, although the majority of the innovation and development has taken place in the recent decade’s years (Zubair, 2006). The first earth observation-using balloons in the 1860s were regarded as an important benchmark in the history of remote sensing (Lillesand and Kiefer, 2000).

Information is gathered by instruments at the natural level by our naked eyes, or by cameras (radiometric which measure radiation). Satellite based remote sensing provides valuable information that can be used in the assessment of the various aspect of atmospheric environment, climatology, meteorology, ecology, agronomy and environmental protection (Kern, 2011). The essence of RS is measuring and recording of the electromagnetic radiation emitted or reflected from the earth’s surface (Hardegree, 2006). This technique enables us to investigate and know the tendency of LU/LC change through time.

## 2.5 Geographic Information System (GIS)

Geographic Information System is a system designed to capture, store, manipulate, analyze, manage and present spatial or geographic data (Coppin and Bauer, 1996). The data type in GIS can be classified into two major groups as spatial and non-spatial data. The spatial data are the data that have location value and that non-spatial data are a data, which describe more the spatial data in the form of a table. According to Burrough (1990), data in GIS is composed of three dimensions that mean spatial (geographic), time and attribute. Some people believe that GIS as the system of hardware and software, which contribute to analyze applications or information processing (Maguire, 1991). Geographic information system is not only digital store of spatial objectives.

According to Foresman (1998), the combination of computer technology and cartography in the 1960s paved the way for the possibility of using techniques of super imposing and overlaying maps in fields other than cartography. The power multiplication, which results from the integration of climate, environment, terrain, agronomic, economic, social and institutional management data, makes available for managers and scientists alike a new and powerful modeling.

## 2.6 Role of Remote Sensing and GIS in Land-use and Land-cover change

Remote sensing and GIS techniques have been widely used over the world for the study of historical changes in LU/LC and LST analysis. Remote sensing has been used to identify vegetation cover, air pollution, LST and other surface characteristics (Zha, 2012; Weng, 2004). Furthermore, understanding the correlation between LST and LU/LC is important to manage the land. It provides a large variety and amount of data about the earth's surface for detailed analysis, change detection with the help of various airborne, and space born. With the availability of historical RS data, the reduction in data cost and increased resolution from satellite platforms, RS technology appears ready to make an even greater impact on monitoring land-cover change. Land-use/land-cover changes can be analyzed over a period using Landsat sensors such as Landsat Multi Scanner (MSS) data and Landsat Thematic Mapper (TM) data by image classification techniques (Gumindoga, 2010). Since 1972, Landsat satellites have provided repetitive, synoptic, global coverage of high-resolution multispectral imageries. Their long history and reliability have made them a popular source for documenting changes in LU/LC over time(Turner *et al.*, 2003) and their evolution is further marked by the launch of Landsat 7 (Enhanced Thematic Mapper Plus sensors) by the United State in 1999.

According to Macleod and Congation (1998), the following are four LU/LCs change detection (aspects of change detection), which are important when monitoring natural resources:

- Distinguishing the nature of the change
- Detection/finding of the changes that have occurred
- Measuring the area extent of the change
- Assessing and investigating spatial pattern of the change

The basis of using RS data for change detection is that changes in land-cover result in changes in radiance values, which can be remotely sensed.

## 2.7 Land Surface Temperature (LST)

Land Surface Temperature denotes the temperature on the surface of the earth or it is the skin temperature of the earth surface phenomena (Kayet *et al.*, 2016). From the satellite's point of view the 'surface 'looks different for different area at different times (Kumar and Singh, 2016). Remote Sensing and geospatial tools play crucial role in quantifying and estimating LST. Land Surface Temperature can be derived from geometrically corrected Landsat Thermal Infrared (TIR) band 6 and Landsat 8 thermal infrared (TIR) band 10 and 11 (Khin *et al.*, 2012). Land surface temperature of a given area can be determined based on its brightness temperature and the land surface emissivity, which is calculated through applying the split window algorithm (Rajeshwari and Mani, 2014). According to Kerr *et al.*, (2004) LST gives information about the difference of the surface equilibrium state and vigorous/vital for many applications. Land surface temperature also defined as, the monitoring of surface temperature based on pixel derived observation through RS (Paramasivam, 2016). The characteristics of urban land surface temperature is depending up on its surface energy balance, which is governed by its properties such as orientation, sky and wind, openness to the sun and radioactive ability to reflect solar and infrared and also ability to emit infrared availability of surface moisture to evaporate and roughness of the surface (Voogt, 2000). Land-use/land-cover changes due to changes in surface temperature (ST) which makes both urban and rural managers to estimate the urban ST and its surrounding rural area for urban planning as well land management in general (Becker *et al.*, 1990).

## 2.8 Urban heat island

Urban heat island (UHI) is an urban area or metropolitan area that is significantly warmer than its surrounding rural areas due to human activities. The term heat island describes built up areas that are hotter than nearby rural areas (Sobrino *et al.*, 2012). Urban heat island also defined as phenomenon/events that occur when air and ST in urban areas became significantly greater than those experienced in near by area and land-cover change has become a central component in current strategies for managing natural resources and monitoring and environmental changes (Sobrino *et al.*, 2012). According to the Intergovernmental Panel on Climate Change (IPCC) Report, climate change has contributed to a significant increase in the global meantemperature (IPCC, 2014). There are number of contributing factors, which play significant role in creation of urban heat island such as low albedo materials, wind blocking, air pollutants, human gathering, distractions of trees, and increased use of air conditioner (Nuruzzaman, 2015).

## 2.9 The impact of land-use/land-cover change on land surface temperature

One of the major factors that are responsible for the increase of LST is LU/LCC, and different researchers agree with that land-use change and unplanned use of land resources lead to increasing LST. According to (Oluseyi *et al.*, 2011) have studied that spatially there are correlations with changes as reflected in the characteristics of individual land-use classes or categories. This study emphasize the changes in LST of the various land-uses between 1995 and 2006 in the case of Anyigba Town; Kogi State, Nigeria. It shows that there was 1ºC variation and increase in surface temperature of vacant land, built-up area and stream, while cultivated land and vegetation also had increases of 0.95ºC ,respectively. The influence of LU/LCCs on LST is different at different latitude, for example in South Asia and East Asia tropical temperate regions (Shukla, 1990). The relationship between land-use changes, biodiversity and land degradation across East Africa shows that the original land-covers were transformed to grazing land, farmland and settlement area (Matimal *et al.*, 2009).

According to Yue *et al.* (2007), the relationship between NDVI and LST with integrated remote sensing application to quantify Shanghai Landsat7 ETM+ data was used. The result shows that different LU/LC classes have significantly different impacts on LST, and the NDVI was calculated using the Enhanced Thematic Mapper Plus sensor in the Shanghai urban environment.

## 2.10 Normalized Difference Vegetation Index

Normalized Difference Vegetation Index is the difference of near infrared and visible red reflectance values normalized over reflectance and calculated from reflectance measurements in the near infrared (NIR) and red portion of the spectrum (Burgan and Hartford, 1993). The NDVI values range from -1 to 1, the negative values are indicative of water, snow, clouds, non-reflective surface and other non-vegetated, while the positive value expresses reflective surfaces such as vegetated area (Burgan and Hartford 1993).Vegetation has a direct match/correspondence with thermal, moisture and radioactive properties of the earth's surface that determine LST (Weng, 2004). In addition to NDVI, Normalized Difference Moisture Index (NDVI) also used as an alternative indicator of surface urban heat island effects in Landsat imagery by investigating the relationships between land surface temperature and NDVI. The index is expressed as NDMI= (NIR-IR)/ (NIR+IR), it evaluates the different content of humidity from the landscape elements, especially in soils, rocks and vegetation's and it is an excellent indicator of dryness. Values greater than 0.1 are symbolized light colors and they signal high humidity level, where as values close to -1 symbolized by dark colors represents low-level humidity level (Mihai, 2012). Previously, different researchers outside Ethiopia did researches in relation to the impact of LU/LCCs on LST. However, in Ethiopia there are some papers related to the proposed title. For example, (Gebrekidan, 2016) studied modeling land surface temperature from satellite data, the case of Addis Ababa, which presented in Africa hall, United Nations conference center Addis Ababa; Ethiopia (ESRI Eastern Africa Education GIS conference which held from 23−24 September, 2016). The study mainly focuses on modeling LST of Addis Ababa city, which acquired Landsat 5 and 8, from 1985 and 2015. Finally, the results show that negative correlation was found between NDVI and LST and the study indicates the need for urban greening and plans to increase vegetation's covers to sustain the ecosystem of the city and to minimize urban heat island effect. According to streutker (2003), one of the promising of studying urban surface temperature is using remote sensing or air born technology. Evaluation of land surface temperature from remotely sensed data is common and typically used in studies of evapotranspiration and desertification processes. Further, (Walsh *et al*., 2011) stated that urban area such as buildings and roads and infrastructures or anthropogenic factors contribute to increase atmospheric temperature. The wide use of land surface temperature for environmental studies, have made remote sensing of land surface temperature important academic issue during the last decades. Indeed, one of the most important parameters in all surface atmosphere interactions and fluxes between the land and the atmospheric is land surface temperature (Buyadi *et al*,. 2013).

# CHAPTER THREE

# 3 MATERIALS AND METHODS

## 3.1 Description of the Study Area

### 3.1.1 Location

This M.Sc. research has been conducted in Arsi zone which is located in the Eastern Ethiopia, Oromia Region. The northern part of the study area is located at about 120 km from Addis Ababa. The study area is bounded by Latitude $7^0$ 10'40.6'' - $7^0$ 53' 55''N and Longitude $38^0$ 46' 36'' - $40^0$ 44' 0.2''E. The area is entirely found in tropical zone having its associated climate. With respect to its relative location the zone has physical contact on North by Adama special zone, on the South by Bale, on the South West by the West Arsi zone, on the North West by East Shewa and on the East by West Hararghe. The notable mountains in Arsi zone are mounts Chilalo, Kaka and Gugu. Among these mountains, mount Chilalo is the highest peak in Arsi zone. The administrative center of this zone is Asalla and the other towns which was found in Arsi zone are Abomsa, Asasa, Bokoji ,Sagure Kersa, Dera,Etaya, Sire,Arsi Robe and Huruta.

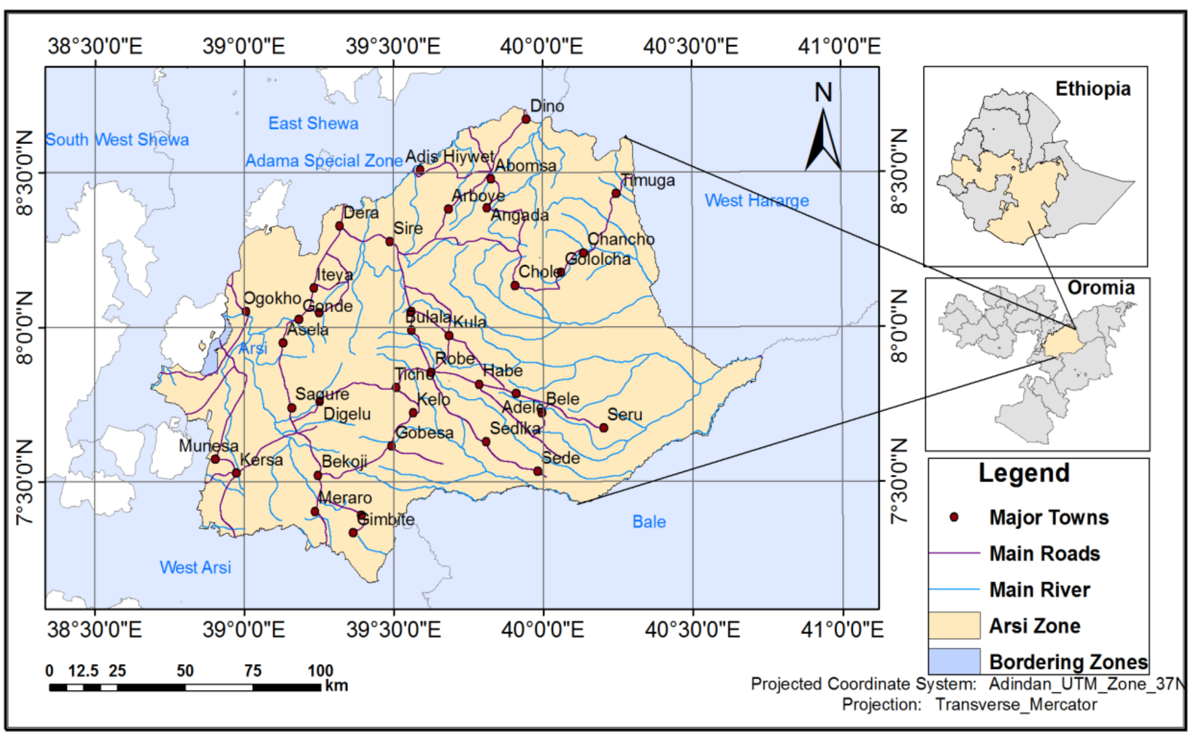



**Figure3.1** Location map of the study area

### 3.1.2 Population

According to Central Statistics Agency (CSA) (1994) national census report is the total population of Arsi zone was 2,637,657 of among which 1, 323, 424 were men and 1,314,233 women with spatial area of 20694.41 km$^2$ . Arsi zone has a population density of 133.05 % while 305,701 or 11.59 % are urban inhabitants, a further 7,098 or 0.27% were pastoralists. A total of 541,959 house hold were counted in this zone, which results in average of 4.875 persons to a household, and 523,342 housing units and the detail information is presented in below (Fig. 3.2)

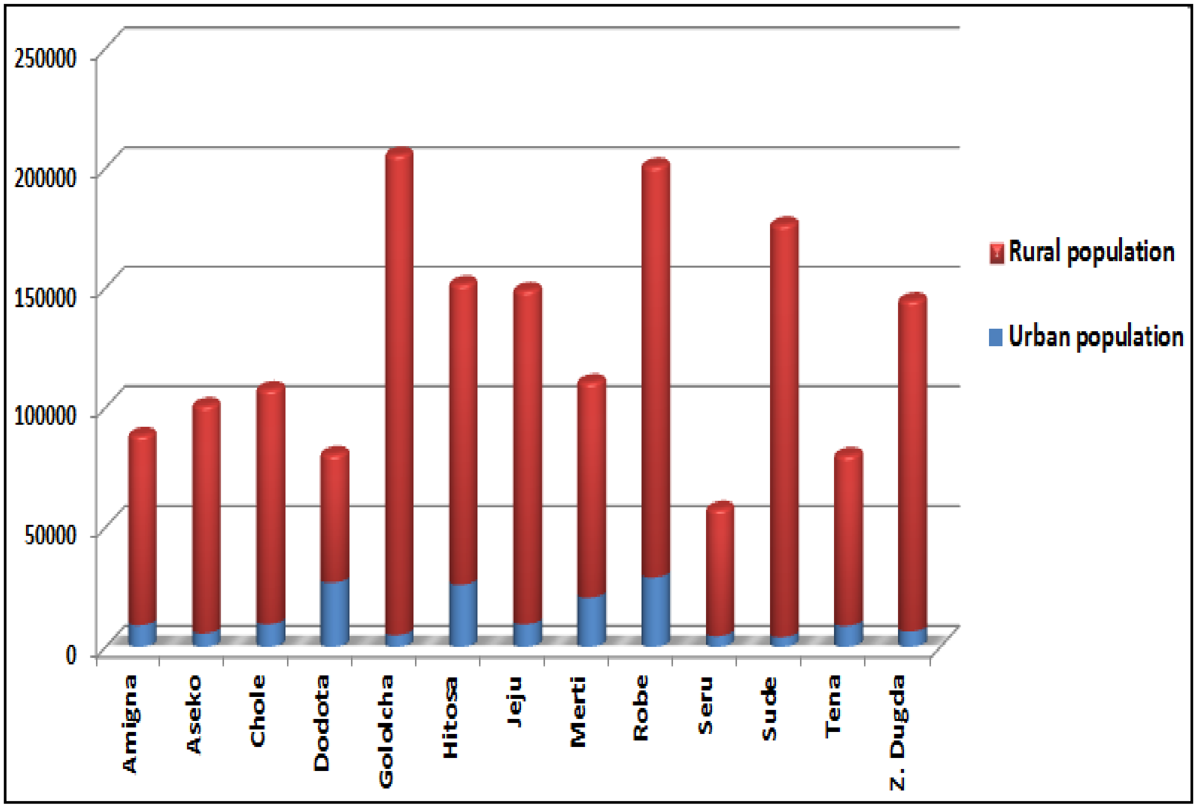



**Figure.3.2**: Population projection values of Arsi zone at woreda level.

### 3.1.3 Topography

The altitude variation of Arsi zone ranges from 881 to 4287 m a.s.l. From of the total land sizes of the zone, the land form types in the study areas is classified into seven major physiographic classes. These are smooth plain, irregular plain, escarpments, hills, breaks, low mountains and high mountains (Deep Canyons) classes. The elevation of the study area is indicated in bellow (Fig. 3.3)

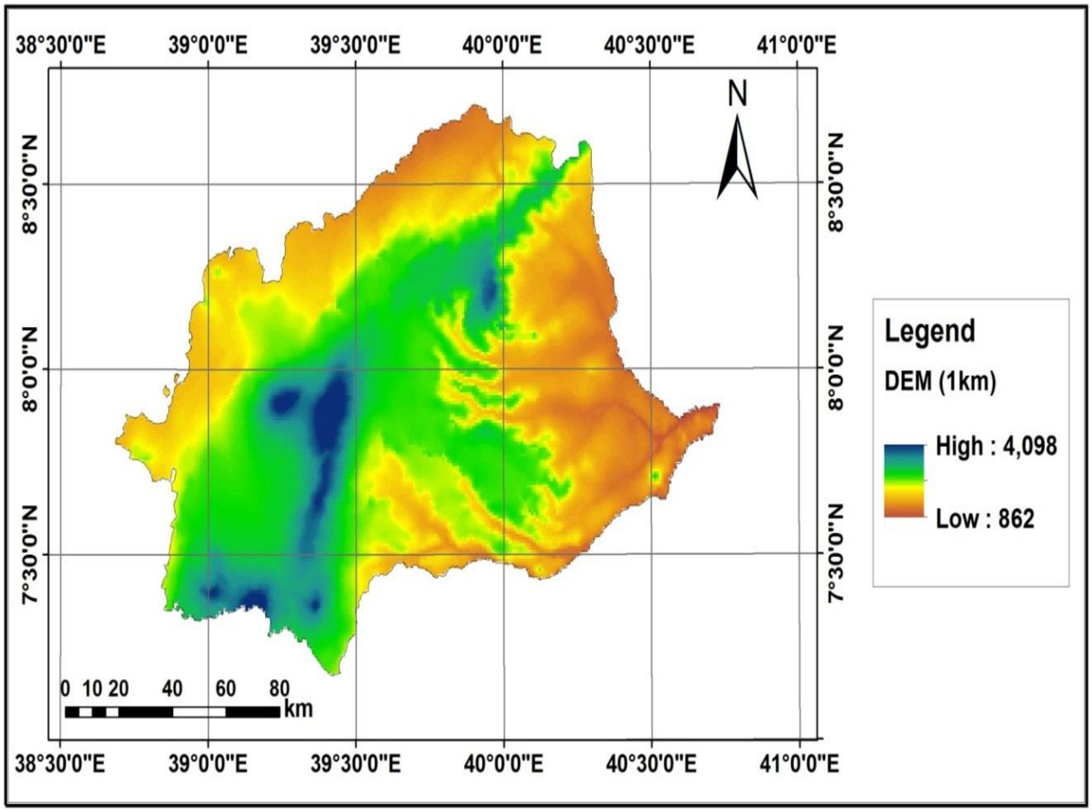



**Figure 3.3:** Digital elevation map (DEM) of the study area.

### 3.1.4 Slope

The slope was derived from a preprocessed DEM. According to the FAO slope classification which depend on land surface percentage rise (Sheng,1993) (Table 3:1), the study areas is classified into seven slope zones, which extends from nearly level (less than 1%) to extremely steep (greater than 35%) follows ( Table3.1 and Fig.3.4).

**Table 3.1:** Slope classification of the study area (FAO class)

| No. | Slope (%) | Slope category |
|---|---|---|
| 1 | 0-1 | Nearly Level |
| 2 | 1-3 | Very gentle sloping |
| 3 | 3-8 | Gently sloping |
| 4 | 8-15 | Moderately sloping |
| 5 | 15-30 | Steep sloping |
| 6 | 30-35 | Very steep sloping |
| 7 | >30 | Extremely steep |

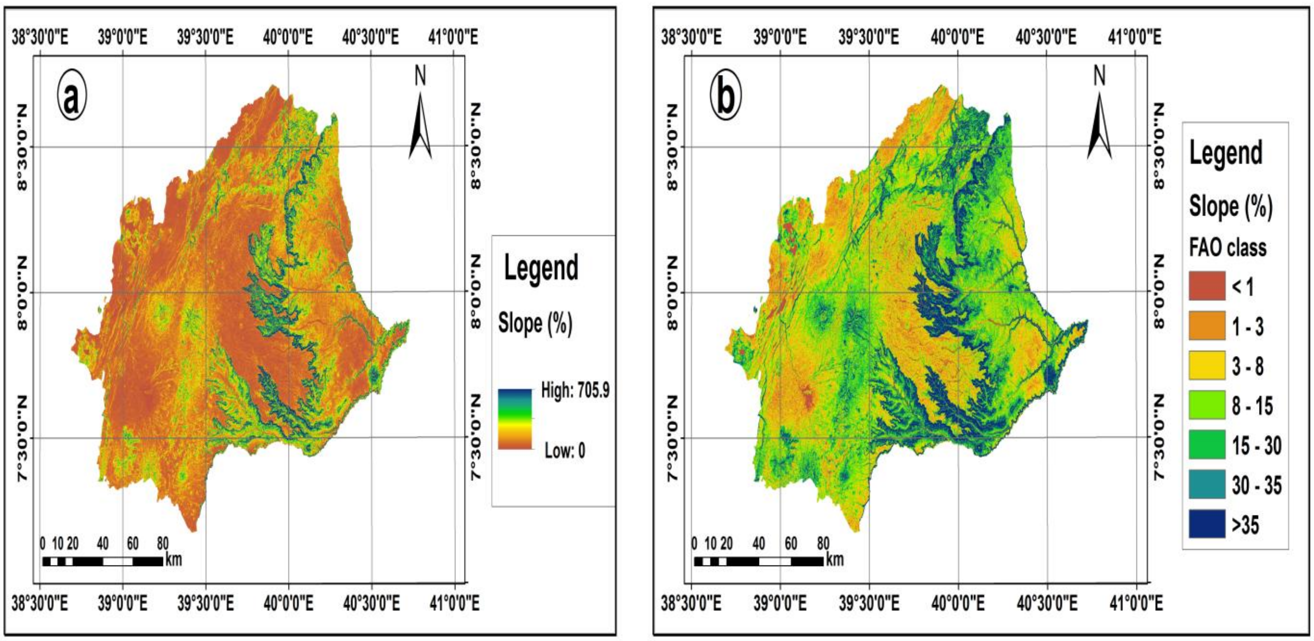



**Figure 3.4: a**) Slope Map and b) Slope Class of the Study Area.

### 3.1.5 Climate and Vegetation

**A. Rainfall**

Spatial interpolation technique was carried out by estimating and evaluating regionalized value of 15 National Metrological Agency (NMA) rain gauge station records. In order to evaluate mean annual precipitation of the study area, the general formula for spatial interpolation is as follow:

$$Zg= \sum_{i=1}^{ns} \lambda_i zs_i \qquad (1)$$

Where Zg is the new estimated value at the required points, $ZSi$ is the recorded known value at point $i$, $ns$ is the total number of observed points and $\lambda = (\lambda i)$ is the weight contributing to the interpolation. From other interpolation techniques, an Inverse Distance Weighted (IDW) deterministic, nonlinear interpolation algorithm is preferable technique for rainfall data interpolation by most scholars, which was selected for interpolating precipitation data for the entire study area. This algorithm estimates cell values by averaging the values of nearby sample data points. The closer a point is to the center of the cell that is being estimated, the more weight it is given. It was calculated as follows:

$$\widehat{Vi} = \frac{\sum_{i=1}^{n} \frac{1}{d_i^p} v_i}{\sum_{i=1}^{n} \frac{1}{d_i^p}} \qquad (2)$$

Where $\hat{V}i$ is a value of the unknown points to be estimated $V_i$ is known sampled points values dpi and dpn is the distances from the n value points to the power of p of the points that estimated and the results of interpolated centers are displaced as follow (Fig 3.5).

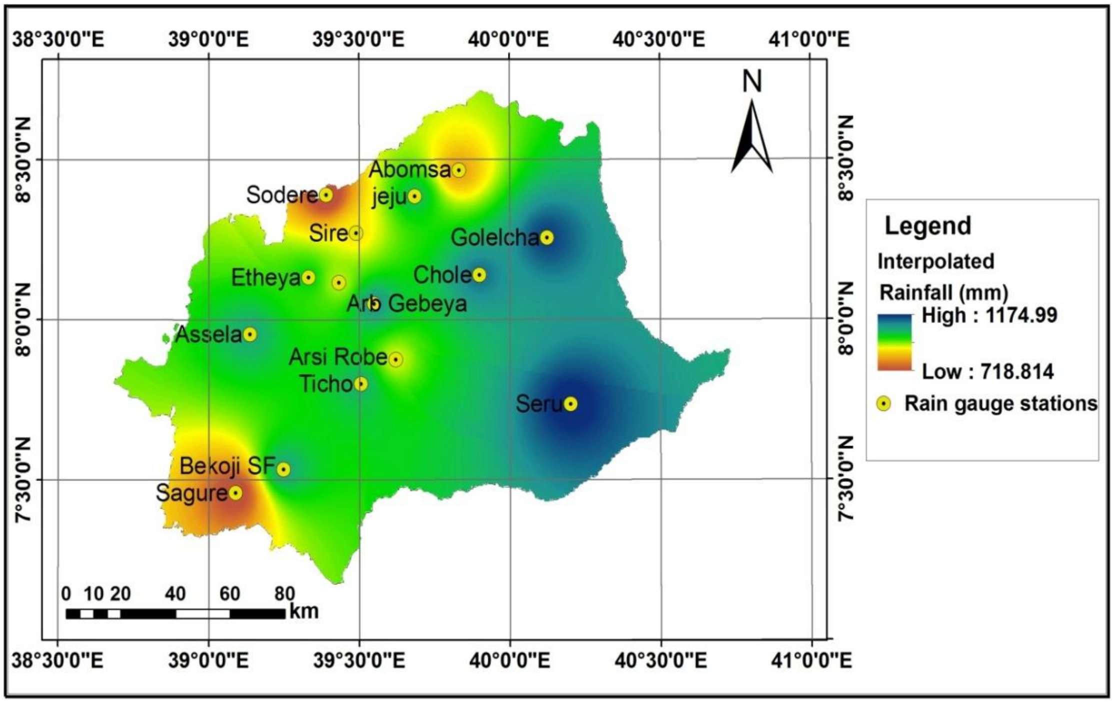



**Figure 3.5:**Interpolated mean annual rain fall (mm) of 15 rain gauge station records.

### B.Climate

According to NMA,the average minimum and maximum temperature of Arsi zone is 10 to 24 respectively. The rainfall of the zone characteristic by bimodal pattern. The annual average rainfall in Arsi zone is 1000mm with a seasonal distribution. The main rainy season, these accounts approximately 60% of the annual precipitation, covers the period between the beginning of June and end of September, while the short rainy season is during March and May.

### C. Vegetation

The vegetation distribution of the area is mainly dependent on the climate condition of the area. The climate condition of the study area is characterized as tropical. On these types of climate, vegetation is scarce and typical example that is found in the area is shrub, Acacia and scattered trees of Eucalyptus. Eucalyptus trees, which is, grown by local communities in soil conservation program that is applied in the main Ethiopian rift to protect soil from erosion. Agriculture is the main stake in Arsi zone and, the types of crops cultivated in the area are Teff, Wheat, Barley, Maize and Sorghum. The harvesting season is between October and December during which the long rain season recedes.

## 3.2 Primary data

The primary data includes Landsat satellite image (Landsat data): Thematic Mapper (TM) 1997 and Landsat8 Operational Land Imager/Thermal Infrared (OLI/TIRS) obtained from USGS. Digital Elevation Model (DEM) data with the pixel resolution of 30*30m was used in mapping the elevation and slope of the area and field data, GPS point and field data (photo of different classes of LULC) were used.

### 3.2.1 Remote Sensing and data acquisition

One scene of Landsat 5 TM (1997) and Landsat 8 OLI/TIRS (2017) cloud free image of the study area with the path of 167 and row 054 were acquired (downloaded) from the website of earth explorer. www usgs.gov, United States Geological survey (USGS) and Landsat8 from https://libra.developmentseed.org.The-acquired data is in world datum (WGS84) projection system.

**Table 3.2**: Data Sources

| No- | GIS data layer | Description | Data Source |
|---|---|---|---|
| 1 | Vector (Polygon) | Zonal Boundary | CSA(2008) |
| 2 | Vector( line) | Roads | CSA(2008) |
| 3 | Vector(polygon) | Settlements boundary | CSA(2008 |
| 4 | Raster Shuttle | Elevation | (SRTM) |
| 5 | Attribute table | Zonal metrological station records | NMA |
| 6 | Raster | Satellite Image | Landsat OLI(2017) |
| 7 | Raster | Slope, Aspect and Drainages | DEM 30m STRM |

### 3.2.2 Secondary datasets

The secondary data sets used for the study were from published data and unpublished documents from varies websites and organization. Interpolated rainfall satellite data were collected from NMA, which includes mean annual precipitation and temperature for all 15 meteorological stations located in the study the areas for 2 decades records (1997-2017). The station data were used in validation and verification of satellite interpolated rainfall surface data. Demographic characteristics, geological topographic and other data were gathered from CSA and geological surveys of Ethiopia respectively.

#### 3.2.3 Tools

In ordered to achieve the objectives of this study, the following hardware and software were also utilized.

**a) Hardware**

- Laptop with a monitor display of 1024x768 pixels, Memory, 3.0GB RAM and 2.1 GHZ processor speed.
- External Hard disc: 1TP storage size.
- Handheld GPS receiver: Garmin with reasonable positional accuracy, used for sample point collection used for LU/LC verification.
- Digital Camera: Resolution, 14.1 Mega Pixel, which used for capturing sample points land cover.

**b) Soft Wares**

The following software packages used for this study were:

- Arc GIS 10.3: used for spatial data analysis and map preparation.
- ERDAS Imaging 2015 for Remote sensing application in order to process multi-temporal satellite images including Image correction, image enhancement, processing (classification for LULC mapping and change calculation, LST calculation and NDVI generation) ,
- Microsoft office package used to write the thesis, undertake statistical analysis, develop data spreadsheets, manage databases, prepare presentation and print the final results.
- Google Earth: used as complimentary in order to check and compare the results during ground truthing and georeferencing.
- Quantum GIS (QGIS): Used for raster manipulation including neighborhood analysis and map algebra,
- ENVI software: used in segmentation of satellite multi-spectral images in order to increase the accuracy of classification.

## 3.3 Methods

The following three–tier methodological approach was employed in carrying out of this research.

1. Thematic layer preparation: Appropriate layers were prepared using Landsat 5 TM image (1997) and Landsat 8, OLI/TIRS (2017) images, Digital elevation model and other thematic and collateral data.

2. Data analysis and integration: Depending on the layers prepared in stage 1, digitization, and data editing, field verification, data validation, data integration, Attribute Table Design and entry were undertaken.

3. Developing decision rule: The following consecutive procedures were undertaken knowing the influence of LULC and vegetation on LST is useful for land management and planning strategies focused on LST mitigation and the adaptation of the study area to the challenges of climate change.

Over view of the methodology and the approach followed for the thesis research work is illustrated in the following methodological flow charts (Figure3. 6).

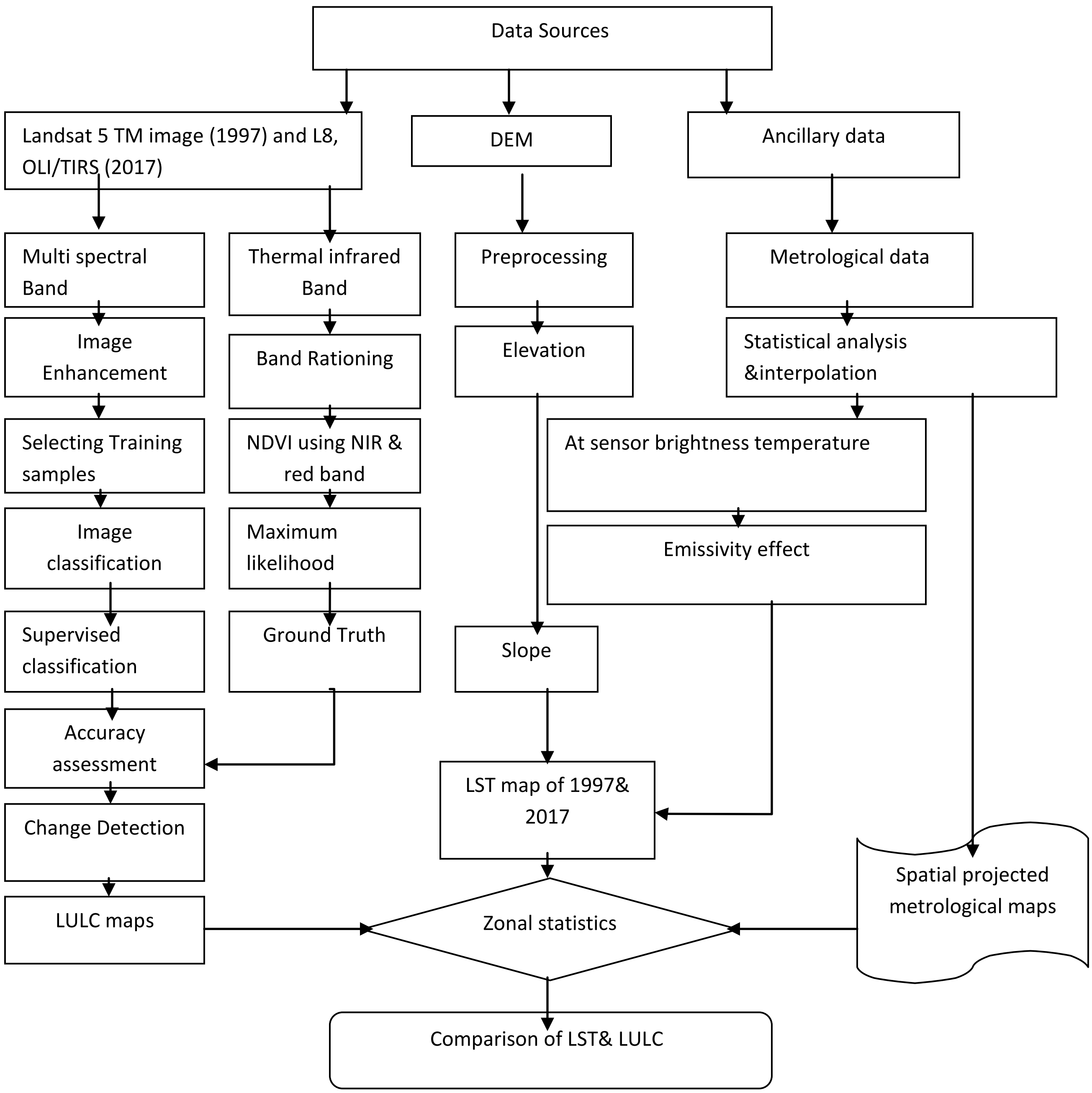



**Figure 3.6:**Methodological flow chart**.**

### 3.3.1 Data Analysis

Satellite image by its nature have some distortion, noise, haze and stripes. Therefore, before processing the data, image pre-processing activities were done. Preprocessing includes importing, layer stacking, and subsetting of the image based on Arsi zone, geometric correction, radiometric correction, and removal of stripes, pan sharpening and other image enhancement techniques. Radiometric correction is a removal of atmospheric noise to make more representatives of the ground truth conditions based on the sensors. These all previously mentioned activities done were to improve visible interpretability of an image by increasing apparent distinction between the features in the scene.

In addition, the image was also georeferenced using boundary of the zone during geo referencing and reprojecting process, Adindan UTM zone 37N coordinate system was followed for raster and vector data in the study to maintain uniformity. Adindan UTM zone 37N is local datum that Ethiopia used.

### 3.3.2 Digital Image Processing (DIP)

A digital image is a numeric representation of (binary) a two dimensional, image or a digital image is a sampled quantized numeric representation of the scenes and made up of picture element called pixels. Digital image processing involves the manipulation and interpretation of digital images with the aid of computers. In remote sensing digital image, processing historically stems from two principal application areas, the improvement of the information for human interpretation and the processing of image data for computer-assisted interpretation. The whole activities of DIP revolve around increasing spectral reparability of the objects on the image.

## 3.4 Image enhancement

Image enhancement is a procedure applied to image data in order to make more effective display or record the data for subsequent visual interpretation. Normally, image enhancement involves techniques for increasing the visual distinction between features in the scene (Billah and Rahman, 2004).

The main purpose of image enhancement is to improve the interpretability of information in images for viewers, or to provide better input for other automated image processing techniques.

## 3.5 Image classification

In remote sensing, Image classification is the task of extracting information classes from a multiband (Multi-spectral) raster image or extracting information based on the reflectance of the object and it serves specific aims; which is converting image data into thematic data. Digital image classification techniques assemble pixels to represent LU/LC classes. Image classification uses the reflectance statistics for individual pixels. Pixels are grouped based on the reflectance properties of pixels called clusters. The users identify the number of clusters to generate and which bands to use. With this information, the image classification software generates clusters. A supervised classification technique is used for this research.

### a) Supervised classification

Supervised classification is a most often used technique for the quantitative analysis of RS image data depending on their reflectance properties. It uses the spectral signature obtained from training samples to classify an image. Image classification toolbar, can easily create training samples to represent classes. With supervised classification, it is possible to identify sample of information classes (any land-cover type) of interest in the image. The supervised classification image of each year involves pixel categorizations by taking training area for each class of LU/LC. After the training area assigned for each class classification activity is performed. For farmland, shrub land, forest and Grassland LU/LC types 60 training site were taken from the study area image where as for bare land, settlement, wetland, and water body LU/LC types 40 training areas were taken as sample. Areas in digital images were marked as signature of individual identity and the field truth verification was adapted to represent LU/LC class (Coppin and Bauer, 1996).

Using Multispectral Band from band 1 to 5 and 7 for TM 1997 and OLI 2017 1 to 7 Bands of the preprocessed images land-use/ land-cover was mapped using supervised classification with the likelihood classification algorithm of ERDAS Imagine 2015 software. In supervised classification, with the help of image processing techniques, the user can specified types of the land-use land-cover classes. The eight major classes studied in Arsi zone were Farm Land (Crops), forest, bare land, grassland, wetland, shrubs, water body and settlement. The advantage of the supervised classification is development of information classes, self-assessment using training sites and training sites reusable. However, information classes may not match spectral classes, the signature homogeneity, and uniformity of information classes may vary.

**b) Maximum Likelihood classification**

Maximum likelihood classification (MLC) is one of the most known methods of classification in remote sensing, in which a pixel with the MLC is classified into the matching classes/categories. It is a statistical decision measure to assist in the classification of overlapping signatures; pixels are assigned to the class (categories) of the highest probability. It was considered more accurate than parallelepiped classification. However, it is slower to extract computations. The MLC tool considers both the variances of the class signatures when assigning each cell to one of the classless represented in the signature file.

**c) Ground Truthing**

A ground truthing activity was carried out in the study area, in which different LU/LC classes were validated. The observed LU/LC includes: farmland,shrubs,forest, grassland, bare land settlement, wetland and water body were ranked from largest to lowest respectively .These LU/LC classes were used in producing the map legends and with the assistance of GPS, training data set used for image classification were acquired. During this ground truthing activities, photos of areas of interest and coordinates from sampled LU/LC classes were captured.

**d) Classification accuracy assessment**

Assessing classification accuracy requires the collection of some original data or a prior knowledge about some parts of the terrain, which can then be compared with the RS derived classification map. Thus, to assess classification accuracy, it is necessary to compare the following two-classification map:

- The remote sensing (RS) derived map
- Assumed true map (it may contain some error).

The supposed true map may be derived from *in situ* examination or quite often from the interpretation of remotely sensed data obtained at a larger scale or higher resolution. The accuracy assessment is performed by comparing the created by RS analysis to a reference map based on a different information sources. Using hand held Global Positioning System (GPS) field survey was conducted in the study area and about 55 points identified. The field survey and Google Earth were used as a ground for evaluation the LU/LC classification accuracy. The final output of classification accuracy was calculated for the years 1997 and 217 LU/LC Map. Land-Use-Land-Cover classes and its description are presented in table 3:3

**Table 3.3**: LU/LC classes and description of the study area.

| **No.** | **LU/LC Class** | **Description** |
|---|---|---|
| 1 | Farmland | Areas used for crop cultivation, both annual perennials and the scattered rural. |
| 2 | Shrub land | Areas covered with shrubs, bushes, small trees, with little useful woods ,mixed with some grasses, less dense than forests. |
| 3 | Forest | A large area covered chiefly with trees and undergrowth. |
| 4 | Grassland | An area of land that mostly contains grasses. |
| 5 | Bare land | Salt flats, beaches, sand dunes, exposed rocks, stripe mines, queries and gravel pits/non-vegetated area dominated by rock out crops, roads, eroded and degraded lands. |
| 6 | Settlement | Area occupied by houses buildings includes road network residential, commercial, and industrial, transportation, roads, mixed urban and other facilities. |
| 7 | Wetland | A land area that is saturated with water. |
| 8 | Water body | Areas covered by natural and manmade small dams, like pond, lake and river. |

To determine and classify LU/LC of the study area; prior knowledge about the area is important. During field observation, eight major LU/LC class were identified.

Steps or processes that were followed to classify land-use/land-cover from a Landsat image were presented in Fig. 3 below

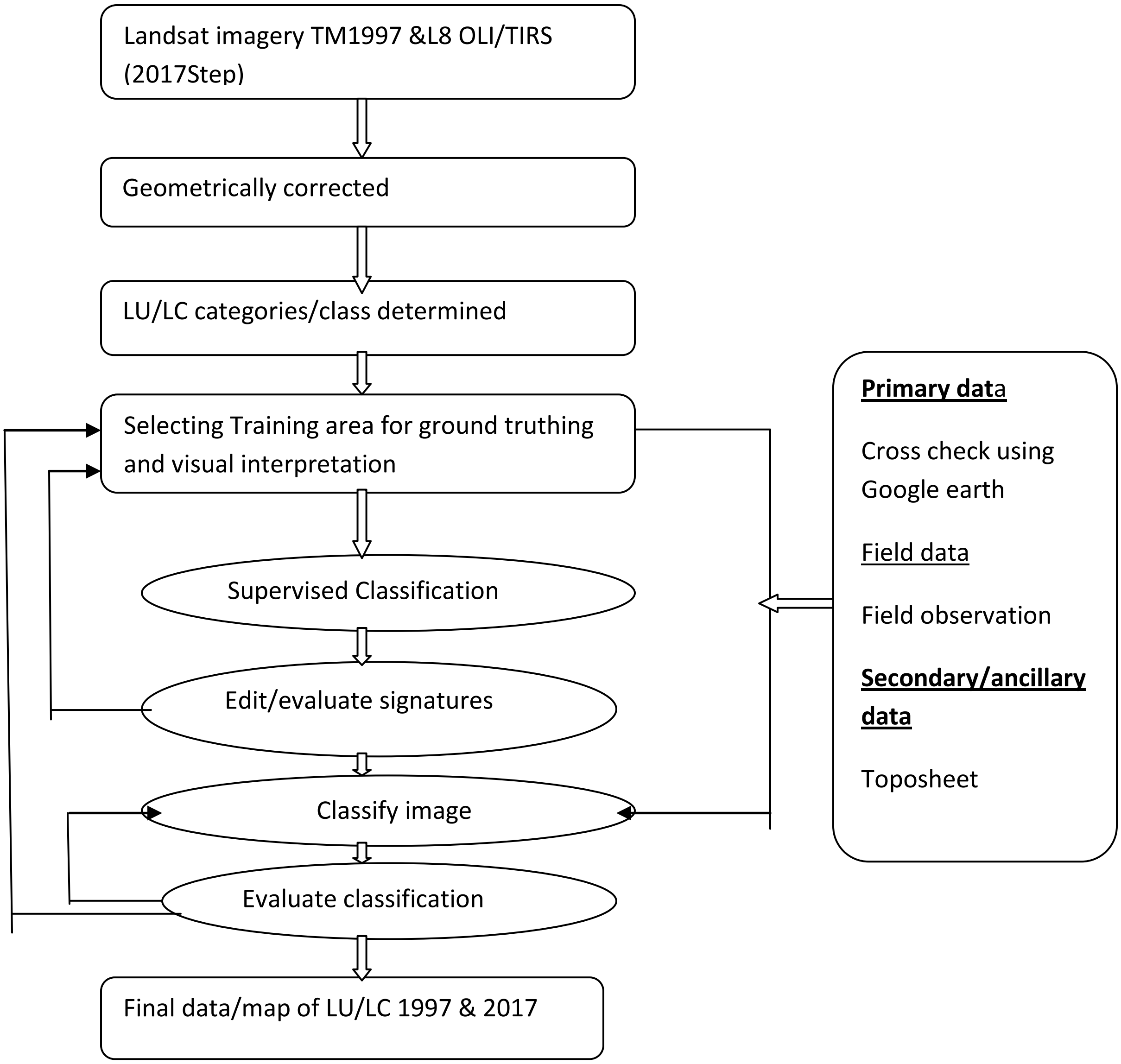



**Figure 3.7:** Steps and procedures followed to classify land-use/land-cover from a Landsat image.

### 3.6 Land-use/Land-cover change detection

Land-Use-Land-Cover change detection was done by involving images of 1997 and 2017. Using GIS techniques thematic image was compared. The cross operation process of mapping LU/LCC over time began with mapping the recent 2017 satellite imagery, then looking back in time to map the 1997 imagery. Post classification is among the most widely used approach for change detection purpose (Chen, 2000). The analysis of LU/LCC maps involved technical procedures of integration using the ArcGIS software techniques. The first task was to develop a table indicating the area coverage in square kilometers and the percentage change for each year 1997 and 2017 measured against each LU/LC classes. Therefore, to calculate LU/LCC in percentage equation (eq. 1) were used (Lambin *et al*., 2001).

$$\text{Percentage change} = \frac{\text{observed change}}{\text{sum of Area}} \times 100 \qquad \text{Eq. (1)}$$

### 3.7 Derivation of Normalized Difference Vegetation Index and Land surface temperature

#### 3.7.1 Derivation of Normalized Difference Vegetation Index

According to Farooq (2012), the reason NDVI relates to vegetation is that, the one which is well vegetated reflects better in the near infrared part of the spectrum. Green leaves have a reflectance of 20% or less in the 0.5 to 0.7 range and about 60% in the 0.7 to 1.0 micrometer range. The value of NDVI is between -1and 1. NDVI was acquired from spectral reflectance measurements in the visible (RED) and near infrared regions (NIR) in the ArcGIS environment.

The index was defined by the following equation 2

$$\text{NDVI} = \frac{NIR-R}{NIR+R} \qquad \text{Eq. (2)}$$

Where,

NDVI=Normalized Difference Vegetation Index

NIR= is the near infrared band 4, R= is the red band 3. Equation 2 is used to calculate NDVI for the sensor TM 1997and OLI 2017.But in case of Landsat 8 NIR is band 5 and the red band is a band 4 (Weng *et al*, 2004).

To calculate fractional vegetation cover (FVC) the following Eq. 3 was used.

$FVC=\frac{NDVI-NDVIs}{NDVIv-NDVIs}$ Eq. ( 3)

Where,

FVC=Fractional Vegetation cover

NDVI= Normalized Difference Vegetation Index

The above equation FVC was used to get fraction an area with vegetation cover using NDVI value.

$NDVIs$= is NDVI for soil and $NDVIv =$ NDVI for vegetation

Equation 4 was used to calculate Proportion of Vegetation that helps in calculating Landsat 8 land surface emissivity (LSE).

Pv = NDVI-NDVImin/NDVImax-NDVImin)$^2$ Eq. (4)

Where,

Pv =Proportion of Vegetation

NDVI=Normalized Difference Vegetation Index

NDVI min= Normalized Difference Vegetation Index minimum value

NDVImax= Normalized Difference Vegetation Index maximum value

### 3.7.2 Radiometric correction

Radiometric correction requires converting a remote sensing digital number to spectral radiance values and data for comparisms. Image processing procedures that are used to correct errors, converting digital number (DN) values to radiance and then reflectance was categorized as a radiometric correction (Prata, A.J., and Caselles, C., (1995). To perform the conversion of digital number to spectral radiance equation (5) was used.

L λ =Lmin+ (Lmax-Lmin)*DN/255 Eq. (5)

Where,

L λ=spectral radiance

Lmin=spectral radiance of DN value 1

Lmax=spectral radiance of DN value of 255

DN=Digital Number

Equation 5 the above, was used to convert digital number into spectral radiance

## 3.8 Conversion at sensor spectral radiance

In radiometric calibration, pixel values, which were represented by Q in remote sensing raw data and unprocessed image data, were changed into absolute radiance values.

The equation 6 was used to perform the conversion at sensor spectral radiance or satellite data scaled into 8 bits.

$$L\lambda=\left(\frac{Lmax\ \lambda - Lmin\ \lambda}{Qcalmax\ - Qcalmin}\right)(Qcal\text{-}Qcalmin) + LMIN\lambda \qquad \text{Eq. (6)}$$

Where,

L λ=Spectral radiance at sensors aperture or the calculated radiance associated to the ground area enclosed in the pixel and referred to the λ wavelength range of specific band.

Lmaxλ=spectral at Sensor Radiance that is scaled to Qcalmax.

Lminλ=Spectral at Sensor Radiance that is scaled to Qcalmin.

Qcalmax=Maximum Quantized Calibrated Pixel values corresponding to Lmaxλ,

Qcalmin=Minimum Quantized Calibrated Pixel values corresponding to Lminλ

Qcal=Quantized Calibration Pixel value (DN)

## 3.9 Conversion of radiance into brightness temperature

Thermal infrared data can be converted from atmosphere reflectance (Lλ) to effective sensor brightness temperature (TB) using thermal constants provided in the meta data file. Remote sensing data (Landsat imagery) thermal band that is band 8 on thematic mapper and enhanced thematic mapper plus needs to be converted from at sensor spectral radiance to effective at sensor brightness temperature. Brightness temperature is the radiance travelling upward from the top of earth atmosphere. To covert Lλ (spectral radiance) to TB equation 8 was used (Rajeshwari and Mani, 2014).

$$TB=\frac{K2}{\left(Ln\frac{K1}{L\lambda}\right)+1} \quad \text{Eq. (7)}$$

Where,

TB=effective at satellite brightness temperature (unit in Kelvin)

K2=calibration constant 2

Ln=natural logarithm

K1=calibration constant 1

$L\lambda$=spectral radiance at sensors aperture

Generally, to calculate LST for the sensor TM subtracting 272.15 from the existed result that is performed from effective at satellite temperature formula in Kelvin.

### 3.10 Zonal statistics

A zone is defined as all areas in the input that have the same value. Zonal statistics function summarizes the value of a raster within the zones of another dataset (either raster or vector) and reports the results as a table and figure. Maps of LU/LC, NDVI and LST were prepared for the year 1997 and 2017. To examine the spatial difference of LST according to varies LU/LC; the result was summarized using the zonal statistics tool of the Arc GIS10.3. Subsequently, summarized LU/LC, NDVI and LST map data were analyzed using excel. Zonal statistics as table and figure is one of important methods that used to examine the correlation between LULC and LST.

# CHAPTER FOUR

# 4 RESULTS

## 4.1 Land-use/land-cover in 1997 and 2017

Land-use/land-cover classification result of 1997 showed that the dominant LU/LC classes were farmland, shrub land and forest. From the total area of 20694.41, farmland accounted for 8311.90 $km^2$ (40.16%), shrub land accounted for 7700.60 $km^2$ (37.21%) and forest accounted for 3,190.14 $km^2$ (15.41%). The other LU/LC classes are the grassland, bare land, settlement, wetland and water body together accounted for 1491.77 $km^2$ (8.11%) of the total area. The water bodies covered the smallest area than all than other classes

Analysis of 2017 image also showed that farmland, shrub land and the forest are the largest proportion of land in the study area with the value of 8,961.04 $km^2$ (43.30 %), 7,639.60 $km^2$ (36.91 %) and 2,684.02 $km^2$ (12.97%) accounted respectively. Other LU/LC classes such as grassland, bare land, settlement and wetland and water body together accounted for 1409.77 (6.83%) of the total area. In 2017, also water body covered the smallest area than all other classes. However, the extent of farmland 2017 increased by 649.14$km^2$ (3.14%) from 1997. Generally, farmland is the major LU/LC of the study area in relation to area coverage, followed by shrub land and forest. Detailed statistical data for each of these classes and LU/LC map of the study period are shown in table 4.1, figure 4.1 and 4.2 bellows

**Table 4.1**:Land-use/land-cover classes and area coverage of 1997 and 2017 in Arsi zone, eastern Ethiopia.

| No | LU/LC classes | 1997 | | 2017 | |
|---|---|---|---|---|---|
| | | $Km^2$ | % | $Km^2$ | % |
| 1 | Farm land | 8311.90 | 40.16 | 8961.04 | 43.30 |
| 2 | Shrub land | 7700.60 | 37.21 | 7639.60 | 36.91 |
| 3 | Forest | 3190.14 | 15.41 | 2684.02 | 12.97 |
| 4 | Grass land | 1087.21 | 5.20 | 935.21 | 4.52 |
| 5 | Bare land | 193.04 | 0.93 | 293.90 | 1.43 |
| 6 | Settlement | 67.07 | 0.32 | 117 | 0.57 |
| 7 | Wet land | 120.02 | 0.58 | 51.68 | 0.25 |
| 8 | Water body | 24.43 | 0.11 | 11.98 | 0.06 |
| 9 | Total | 20694.41 | 100 | 20694.41 | 100 |
| | | | | | |

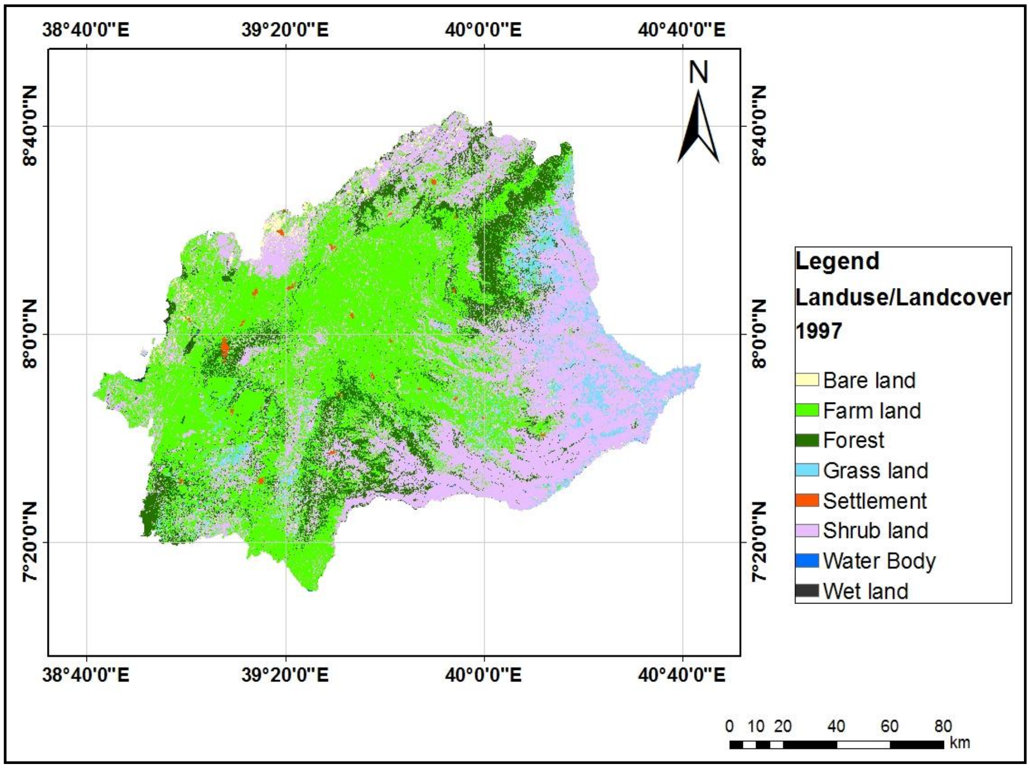



**Figure 4.1**:Land-use/land-cover maps of the study area of the year of 1997

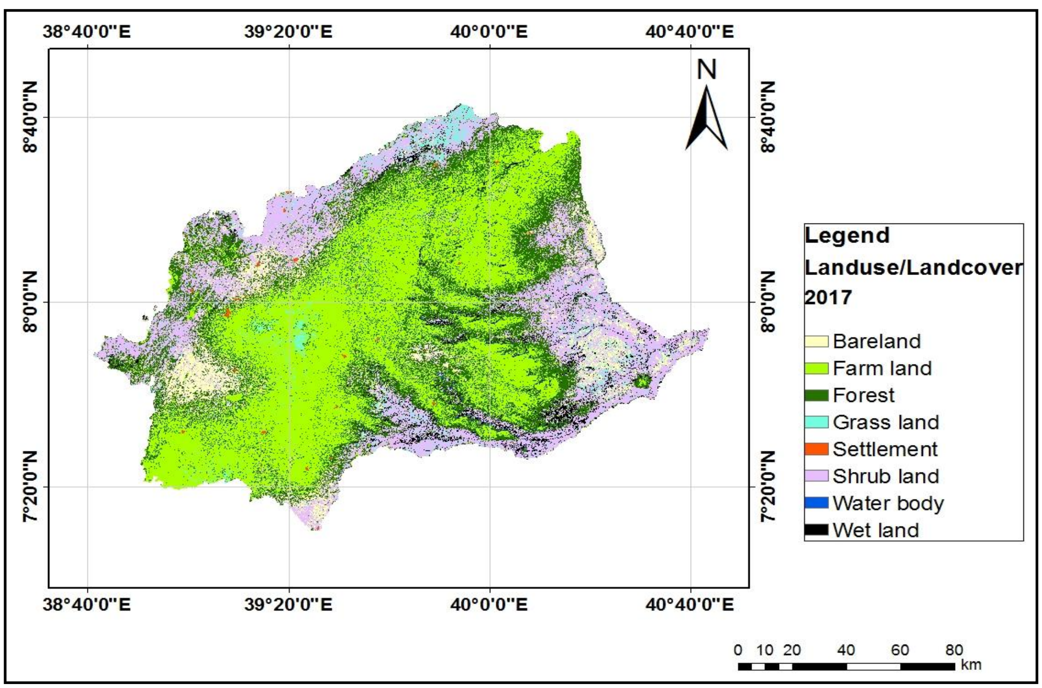



**Figure 4.2:** Land-use/land-cover maps of the study area of the years 2017

Farmland as land use had the largest extent of all LU/LC in the study area during 1997-2017. The extent of farmland increased from 8311.90 km$^2$ (40.16%) 1997to 8961.04 km$^2$ (43.30%) in 2017(Fig 4.3).

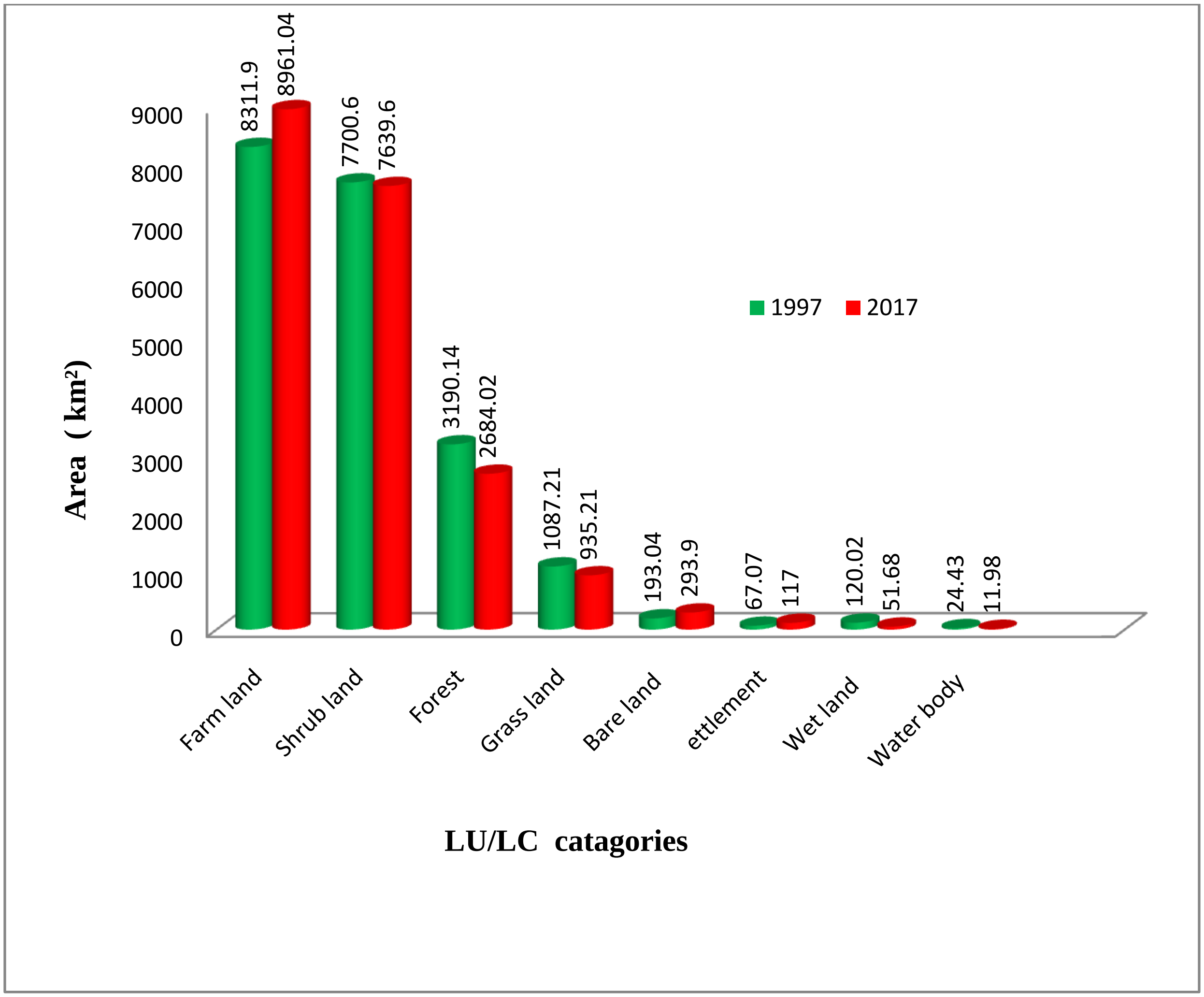



**Figure 4.3**: Land-use/land-cover distribution and changes in the study area during the period 1997-2017.

## 4.2 Spatial extent and change in land-use/land-cover

Land-use/land-cover patterns in the study area have significantly changed in the area between 1997 and 2017. Among the eight major LU/LC classes, farmland and shrub land covered more than 40% of the area in all the study years. Settlement area has been increasing from 1997 to 2017. It has increased from 67.07km$^2$ (0.32%) in 1997 to 117km$^2$(0.57%) by 2017. This amounts to close to 100% increase. Bare land also increased from 1997 to 2017. From193.04 km$^2$ (0.93%) in 1997 to 293.90 km$^2$ (1.43%) by 2017. Shrub land, forest, grassland, wet land and water body have been decreasing from1997 to 207. They are decreased by -61 $km^2$ (-0.29%), -506.12 $km^2$ (-2.44%),-152 $km^2$ (-0.73%), -68.34 $km^2$ (-0.33%) and-12.45 $km^2$ (-0.06%) respectively. Forest is the most decreased land cover during the 20 years covered by this study.

**Table 4.2:** Land-use/land-cover distribution and net changes during 1997–2017.

| **No.** | **LU/LC classes** | **1997** | | **2017** | | **Net changing** | |
|---|---|---|---|---|---|---|---|
| | | $Km^2$ | % | $Km^2$ | % | $Km^2$ | % |
| 1 | Farm land | 8311.90 | 40.16 | 8961.04 | 43.30 | +649.14 | +3.13 |
| 2 | Shrub land | 7700.60 | 37.21 | 7639.60 | 36.91 | -61 | -0.29 |
| 3 | Forest | 3190.14 | 15.41 | 2684.02 | 12.97 | -506.12 | -2.44 |
| 4 | Grass land | 1087.21 | 5.20 | 935.21 | 4.52 | -152 | -0.73 |
| 5 | Bare land | 193.04 | 0.93 | 293.90 | 1.43 | 193.04 | +0.93 |
| 6 | Settlement | 67.07 | 0.32 | 117 | 0.57 | +67.07 | +0.32 |
| 7 | Wet land | 120.02 | 0.58 | 51.68 | 0.25 | -68.34 | -0.33 |
| 8 | Water body | 24.43 | 0.11 | 11.98 | 0.06 | -12.45 | -0.06 |
| 9 | Total | 20694.41 | 100 | 20694.41 | 100 | | |

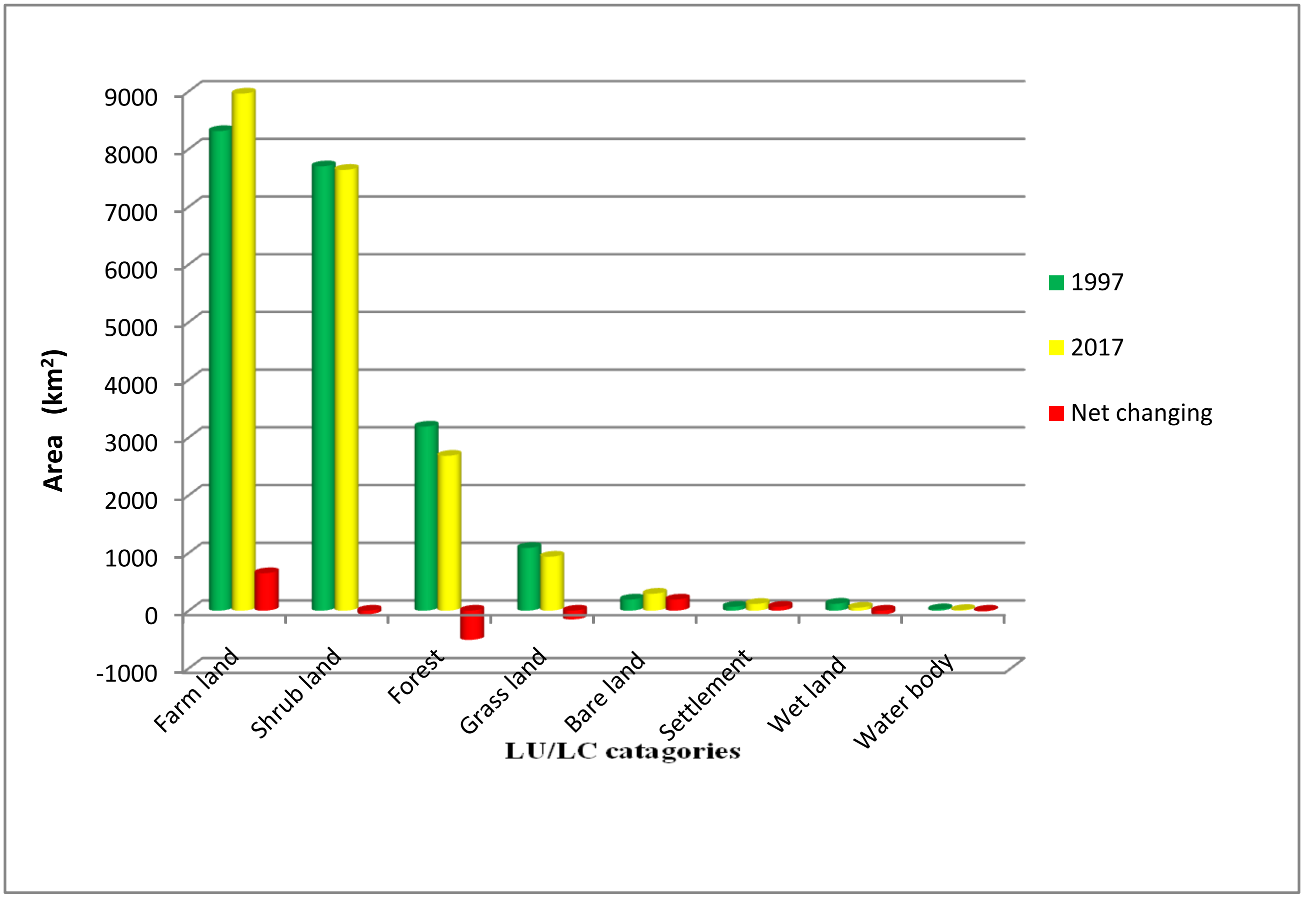



**Figure 4.4:** Land-use/land-cover changes during 1997—2017 in the Arsi zone

## 4.3 Settlement expansion during 1997–2017

An overlay analysis on the satellite images acquired in 1997 and 2017 indicated that the farmland, shrub land and bare land in the study area have been changed to settlement areas in different parts of the administrative zone. The expansion of settlement area at the expense of the other LU/LC classes is shown in Figure 4.5.

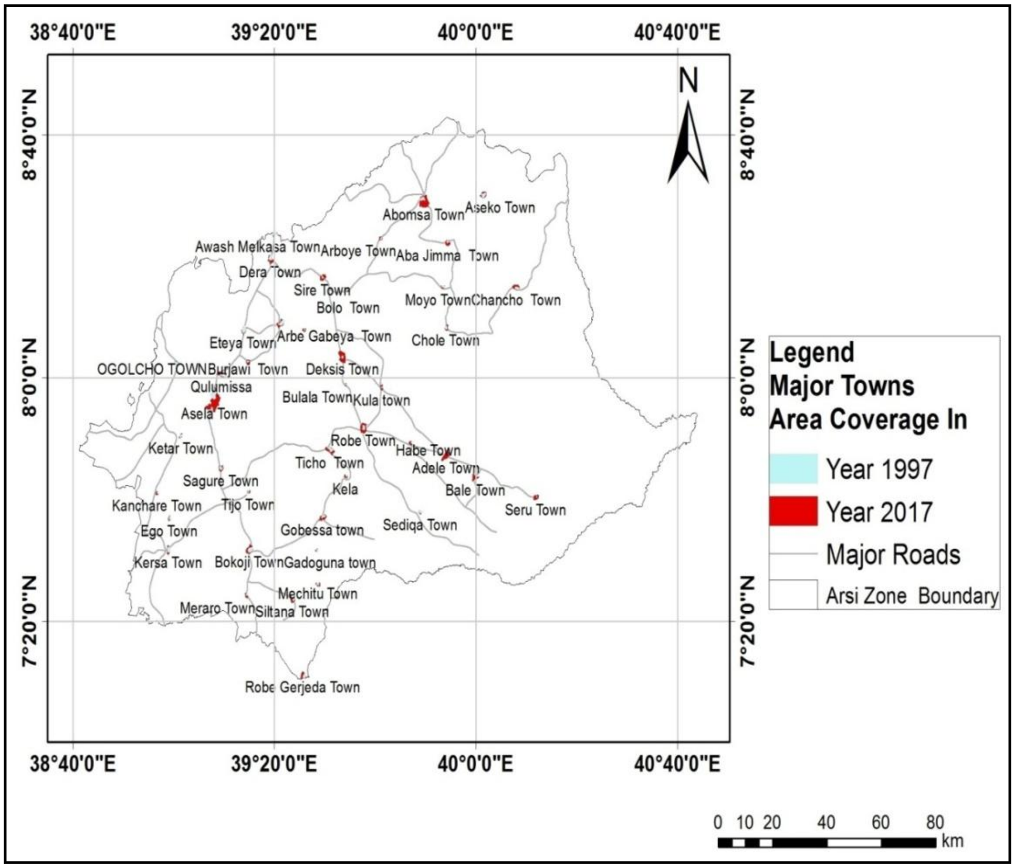



**Figure 4.5:**The trend of expansion of settlement area from the year 1997 to 2017 in Arsi zone

## 4.4 Accuracy assessment

The accuracy assessment of LU/LC for the years 1997 and 2017 recorded the overall classification accuracy of 86.03%, and 85.15%, respectively. The classification Kappa statistics for the year 1997 and 2017 values are 0.8374 and 0.8256 respectively. The detailed information of producers and users accuracy is indicated in table 4.3.

**Table 4.3**: Statistical information of accuracy assessment for the year 1997 and 2017

| Class Name | 1997 | | 2017 | |
|---|---|---|---|---|
| | **Producers accuracy** | **Users accuracy** | **Producers accuracy** | **Users accuracy** |
| Farm land | 85.12% | 84% | 85.12% | 84% |
| Shrub land | 85% | 86.12% | 85% | 85.12% |
| Forest | 90% | 90% | 85% | 85% |
| Grass land | 90% | 9.20% | 80% | 80.20% |
| Bare land | 85.10% | 85.10% | 85.10% | 85.10% |
| Settlement | 87.50% | 87.50% | 90.50% | 90.50% |
| Wet land | 85.52% | 85.32% | 90.52% | 90.32% |
| Water body | 80% | 80% | 80% | 80% |
| Overall classification accuracy | | 86.03% | | 85.15% |
| Overall Kappa statistics | | 0.8374 | | 0.8256 |

## 4.5 Normalized difference vegetation index

In this study, it has been observed that the vegetation cover was more in 1997 than in 2017 with maximum NDVI values of 0.65 and 0.60 respectively. The highest value shows healthy vegetation. Vegetation cover has decreased for the year 2017 with the NDVI value of 0.05.NDVI result for the years 1997 and 2017 are presented in figure 4.6 and figure 4.7 bellows. The NDVI result of 1997 and 2017 showed that the central part of the study area has a higher NDVI value and these are Chilalo,Kaka and Gugu mountains areas. However, settlement and bare land area along eastern, northern and north western parts have relatively low NDVI values. As indicated in figure 4.6 and figure 4.7 vegetation cover has decreased and non-vegetated area has been increasing gradually over the study period. However, in 2017 plantation (eucalyptus trees and some perennial crops area has slightly increased due to the expansion of cash crop plantation.

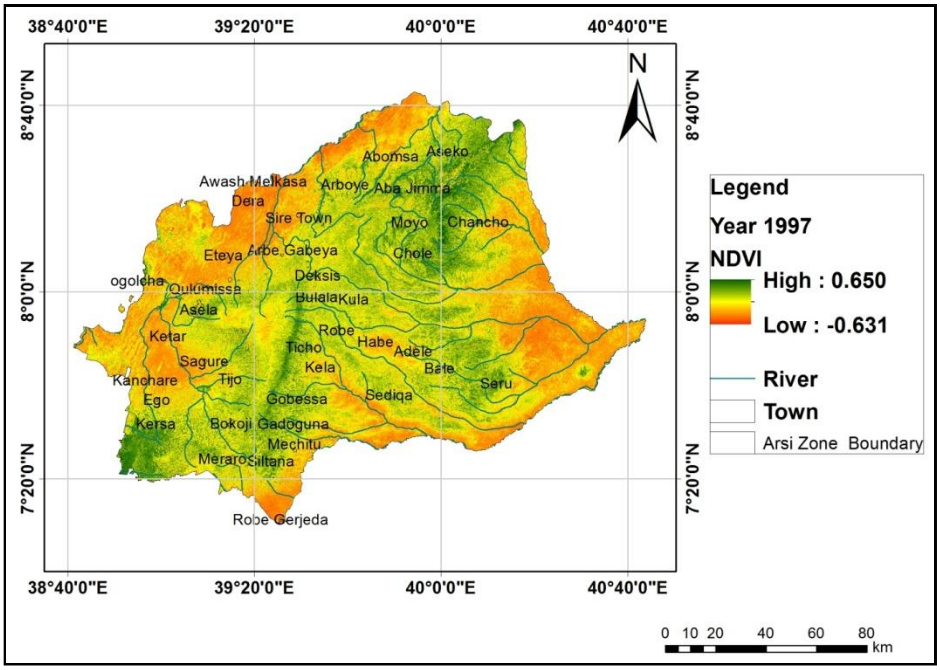



**Figure 4.6:** Normalized difference vegetation index maps of the study area of the year 1997

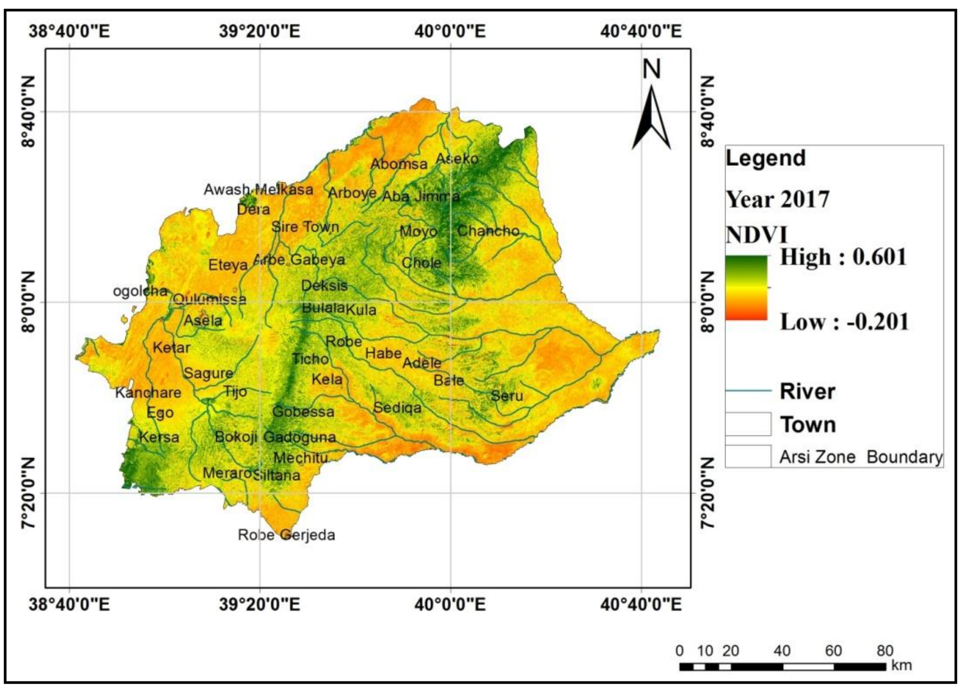



**Figure 4.7**:Normalized difference vegetation index maps of the study area of the year 2017.

### 4.6 Zonal Statistics and the relationship between land-use/land-cover types and NDVI

Normalized difference vegetation index maps extracted from near infrared and red-bands of the study periods indicated that different LU/LC has different NDVI values. As NDVI value is related to the vegetation condition, the value varies from area to area based on vegetation vigor intensity. Forest and shrub land have the highest NDVI value than other classes. The graph shows that the red line shows the NDVI of 1997 and the blue line shows the NDVI of 2017 respectively. This means the NDVI of 1997 is higher than the NDVI of 2017.

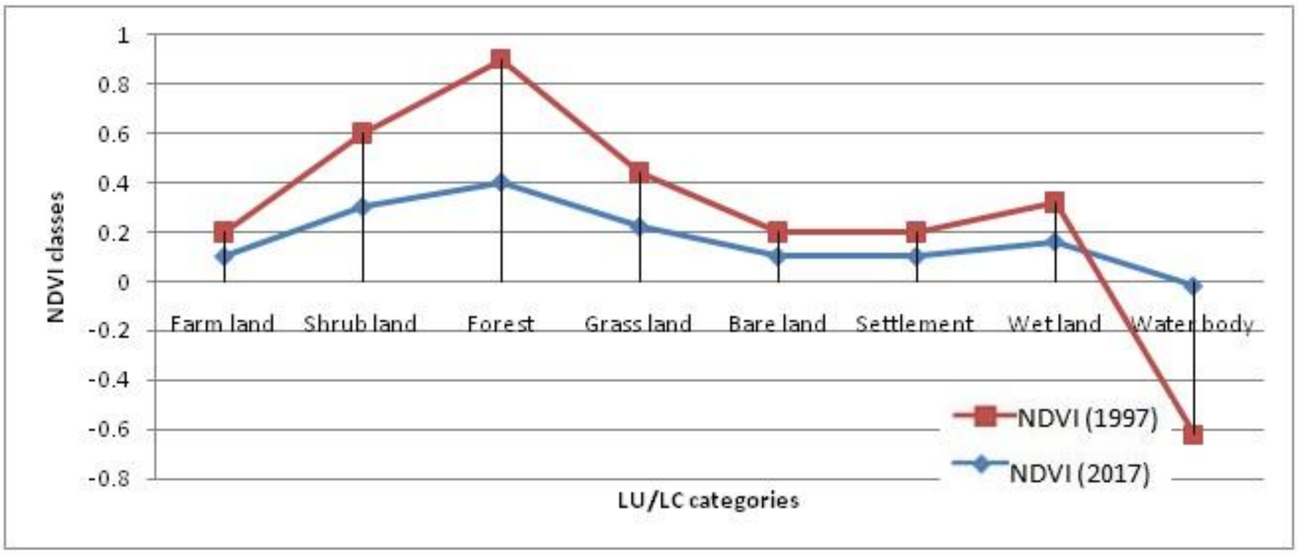



**Figure 4.8:**Zonal statistical description of NDVI in 1997 and 2017 over different LU/LC classes in the study area.

### 4.7 Spatial pattern of Land Surface Temperature (LST) in Arsi zone

The spatial distribution of LST of the study area was extracted and quantified using Landsat5 TM of 1997 and Landsat 8 of 2017 OLI/TIRS thermal bands. The analysis from such images indicated that the LST value of the study period ranged from 5.11°C to 44.90°C. As it was observed from the processed thermal images, the east, north, some north western parts of the study area exhibited relatively high temperature. This is mainly due to altitude, slope and LU/LC types. On the other hand, the central parts and around mountains Chilalo,Kaka and Gugu area exhibited relatively low LST values.

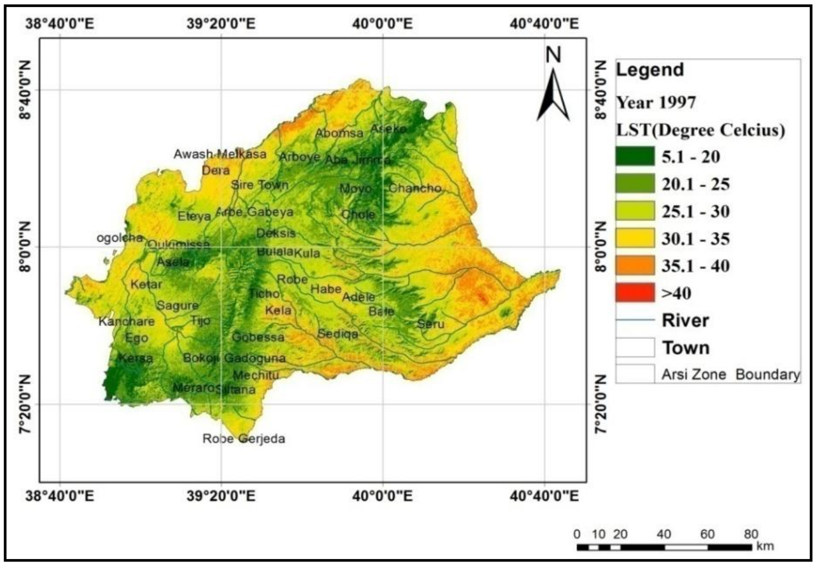



**Figure 4.9**:Land surface temperature maps of the study area of the year 1997

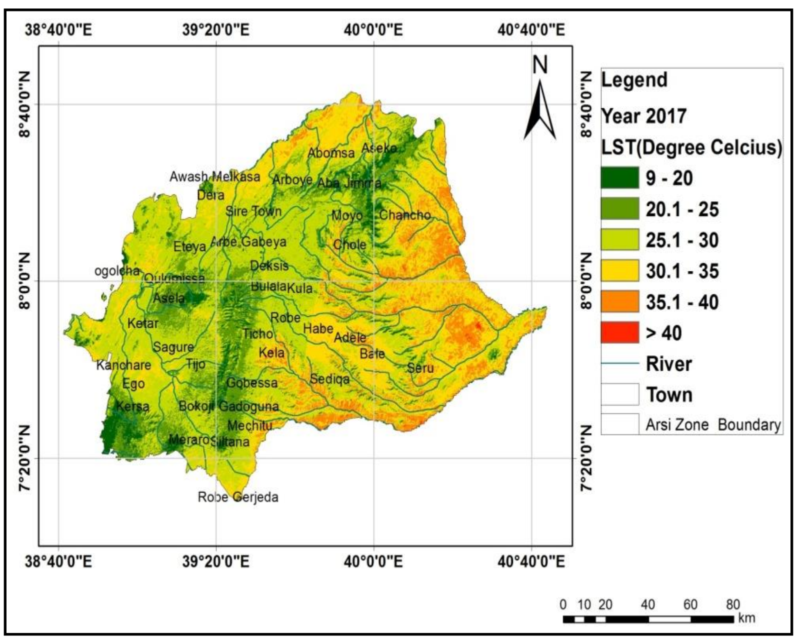



**Figure 4.10:**Land surface temperature maps of the study area of the year 2017

## 4.8 Impact of land-use/land-cover change on land surface temperature

Land-use/land-cover dynamics has an impact on land surface temperature. The changes in LU/LC resulted in variation in land surface temperature, particularly in the settlement, farmland (after harvest) and bare land. The reason behind farmland LU/LC classes of high LST was that the image used for the analysis was taken after harvesting period and dry weather condition. For each of LU/LC classes LST value varies from place to place because of vegetation and climate condition. The conversions of farmland, bare land and other types of LU into settlement area also contributed to the increase of LST. As observed in Figure 4.5 (Expansion of settlement area from the year 1997 to 2017), the settlement area has highly increased specially in the northern and southern parts of the zone. In addition to that, settlement area has increased in smaller towns located in the zone.

## 4.9 Relationship between land-use/land-cover types and land surface temperature

Land-use/land-cover types and LST map of the study area revealed how the categories and corresponding land surface temperature have changed during the study period. Land-use/land-cover categories that recorded minimum temperature were Water body, Wet land, Forest, Shrub land and grassland respectively. Water body and Vegetated area played crucial role in minimizing the LST. Vegetated area and eucalyptus trees in different part of the area provide shade, which help lower land surface temperatures and reduce air temperature through evapotranspiration, in which plant release water to the surrounding air. Relatively, the highest LST value was recorded on bare land, farmland and settlement. The LST value was high in farmland during the acquisition time of the image.

From 1997 to 2017, the mean LST of Arsi zone has increased by 4 °C. Table 4.4 indicates that all major LU/LC categories have recorded increase in the LST over the study period. The highest mean LST was recorded in bare land, farmland and settlement area. Whereas, the lowest mean LST was recorded in water body, wetland, forest, Shrub land and grassland area. Comparisons of mean LST with LU/LC classes for the study period are indicated in figure 4.11. The land surface temperature in the study area has increased considerably from1997 to 2017(Table 4.4).

**Table 4.4:**Mean temperature of 1997, 2017 and changes in temperature during 1997−2017 in the study area.

| | LU/LC classes | Mean of 1997 | Mean of 2017 | 1997-2017Mean Change in (ºC) |
|---|---|---|---|---|
| 1 | Farm land | 20.02 | 21.86 | 1.84 |
| 2 | Shrub land | 12.12 | 13.74 | 1.62 |
| 3 | Forest | 10.10 | 11.96 | 1.86 |
| 4 | Grass land | 14.25 | 16.00 | 1.75 |
| 5 | Bare land | 35.14 | 40.44 | 5.30 |
| 6 | Settlement | 18.04 | 19.54 | 1.50 |
| 7 | Wet land | 7.05 | 8.99 | 1.94 |
| 8 | Water body | 5.02 | 6.95 | 1.93 |

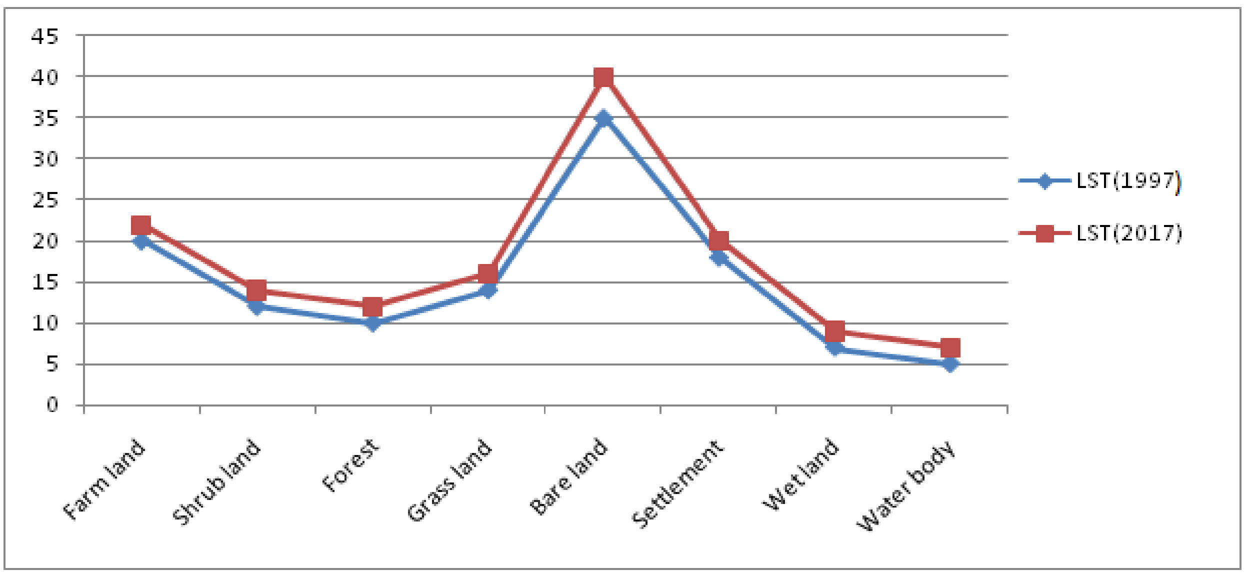



**Figure 4.11:** Comparisons of mean land surface temperature in different land-use/land-cover classes during the study period in Arsi zone.

## 4.10 Relationship between normalized difference vegetation index and land surface temperature

The analyzed Landsat images of 1997 and 2017 indicated that NDVI and LST have indirect (inverse) relationships. A Low NDVI value has high LST and high NDVI values have low LST. However, the relationship between NDVI and LST were direct/positive relationship for the case of water body, because both NDVI and LST value was less for water body. The $R^2$ values of the study period between NDVI and LST correlations indicated 95.50%, and 95.59%, respectively.

These results show that, in (1997) 95.50% value of LST variability was due to the difference in NDVI value, the coefficient variation values are also the same for 2017. Generally, negative correlation was found between NDVI values with LST. Land surface temperature and NDVI correlation for the years 1997 and 2017 are shown in figure 4.12 bellows

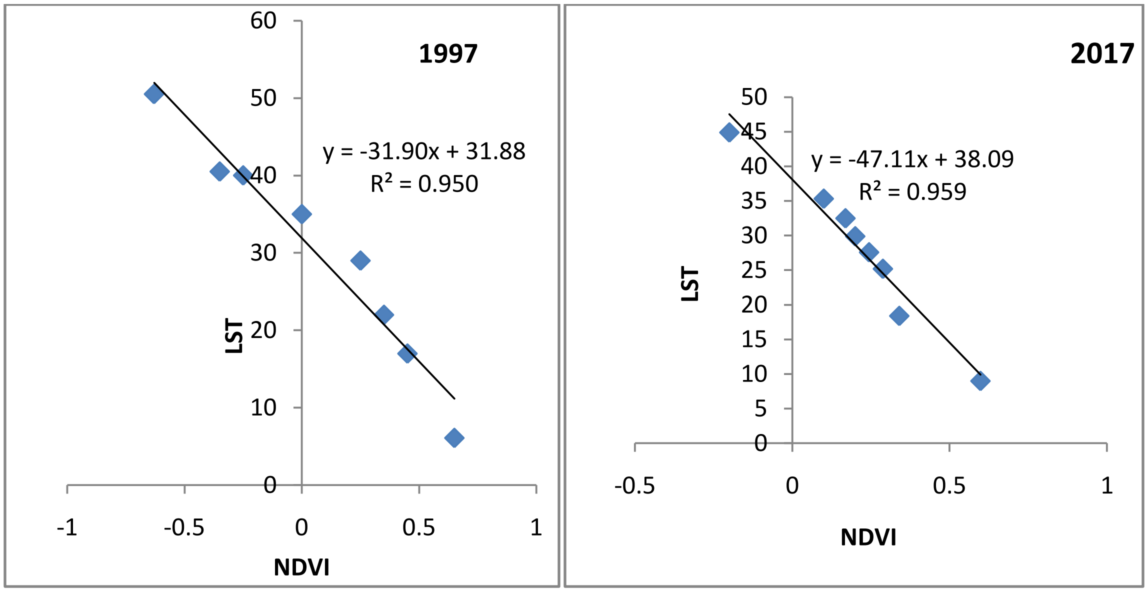



**Figure 4.12:** Land surface temperature and normalized difference vegetation index correlation for the years 1997 and 2017 for the study area.

### 4.11 Verification of the result for land surface temperature

The land surface temperature extracted from Landsat thermal band of the study area and the interpolated atmospheric temperature have shown the direct relationships. However, LST trend attained in this study was from Landsat imagery acquired during dry weather condition and harvesting time. Considering the existing metrological and acquired time of Landsat, the spatial distribution of the LST was validated. Land surface temperature was verified using meteorological data and LU/LC classes of the study area, which was validated with GPS point collected from field and Google Earth. Interpolation of rainfall and temperature were done based on the meteorological data collected from fifteen stations within and inside the study area. Abomsa,Arbgebeya,Arsirobe,Assela,Bekoji,Chole,Sude,Etheya,Golelcha,Jeju,Sagure,Seru,Sire,Sodare and Ticho are the towns which were the Meteorological data were collected. There is a strong relationship between LST and atmospheric temperature, which was interpolated from fifteen stations. Remotely sensed LST is most valuable in characterization and prediction of spatial temporal patterns of atmospheric temperature. Therefore, LST can be used as indicator of atmospheric temperature. Interpolated map of rainfall and atmospheric temperature are given in Figure 4.13 and 4.14 bellows

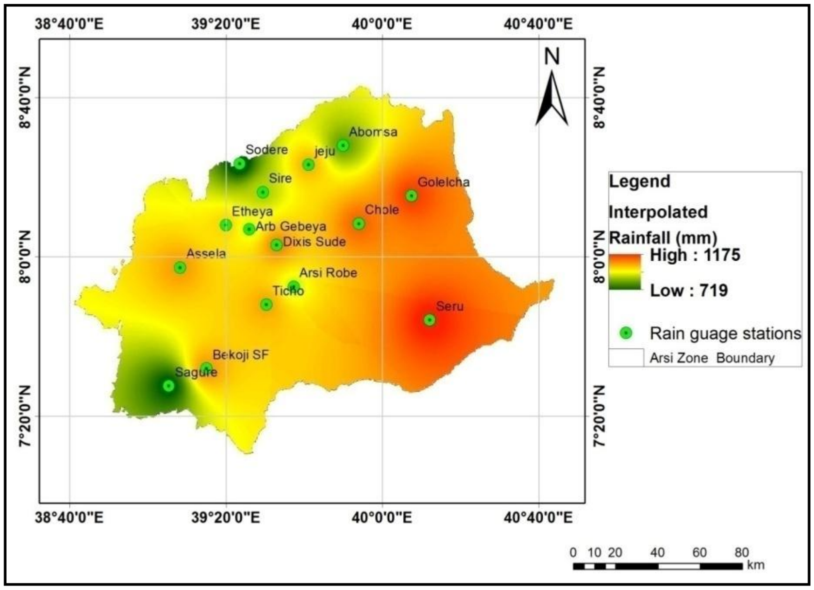



**Figure 4.13:** Interpolated map of rainfall of Arsi zone

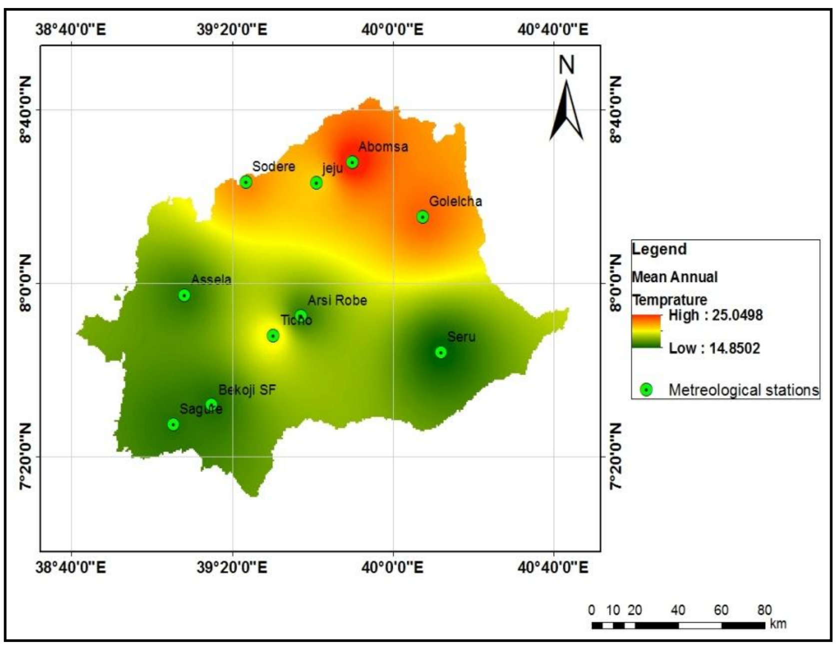



**Figure 4.14:**Interpolated map of temperature of Arsi zone.

As observed from the interpolated map of the study area, both rainfall and temperature results were low at the eastern, some north and western parts of the study area. However, rainfall map of the central parts have high values than eastern, northern and north western parts. Interpolated map of temperature result showed that the most northern part have higher LST value in ºC than east, southern and western relatively.

The result of LST extracted from Landsat thermal bands, also revealed that the eastern, some northern and north western part had the highest value in each of the study periods, where as the eastern and some central parts had low value. However, in the area of plantation of eucalyptus trees and perennial crops had low LST values. For instance, around mountain Chilalo,Kaka and Gugu area; the LST was very low but in the interpolated temperature map shows relatively medium temperature. The mean LST, which was extracted from thermal bands of the study period, was ranged from 5.02 ºC to 40.44 ºC. Whereas, the interpolated atmospheric temperature result ranged from 14.85 ºC – 25.04 ºC

# CHAPTR FIVE

# 5 DISCUSSION

## 5.1 Land-use/land-cover status of East Arsi zone

The LU/LC changes observed across the East Arsi zone shows that there is an indication of relatively higher population growth and the increase of needs for land for settlement and agriculture. These changes have brought about a series of adverse impacts on the environment. The study conducted as Houghton (1994), indicated that human population growth, economic development, technology and environmental changes are major factor responsible for LU/LC variability. According to FAO (1999), LU/LC changes have become major problems and it is a significant driving agent of environmental changes. Alemayehu (2008) also showed some of the evidence for climate change including occurrence of drought, rising temperature, flood, reduced annual rainfall and rising sea levels. The present study revealed that during the study period of 20 years there were drastic changes in LU/LC. In 1997, the bare land and settlement area was 193.04 $km^2$ and 67.07 $km^2$ and then it reached 293.90 and 117 $km^2$ in 2017 respectively. It is one of the evidences for the increasing needs of land for settlement and the removal vegetation for agriculture. In general, the classified satellite image indicates that there is a significant change in LU/LC.

## 5.2 Normalized difference vegetation index

Normalized difference vegetation index is a measure of vegetation condition and it is used to determine LST. According to Mihai (2012) and Weng (2004), NDVI is found as an acceptable indicator of LST and dryness. The findings of the present study also revealed that NDVI varied from the central parts of the study area towards to the east, north and some North West parts of the zone. As farmland and shrub land classes dominate the present study area, the vegetation cover also varies. The NDVI and LST correlation coefficient was evaluated in this study and it was $R^2$=0.95 for the year 1997, which indicate how the vegetation condition determine the LST of the area and NDVI values accounts 98 % in distribution of LST. In line with this, the present study revealed that NDVI have strong inverse relation with LST (with the exception of water body class).

## 5.3 Land surface temperature

A thermal band of Landsat image was required/used in quantifying the LST of the area. In the present study farmland, settlement and bare land have the highest LST. The main reason behind less NDVI and high LST values in the area of farmland LU/LC class is that the image was acquired during the dry season and during harvesting time November and December. In Ethiopia, the main harvesting season is November, December and January. Due to this, farmland, bare land and settlement classes show high surface reflectance. After harvest of crops, the land was very dry and at the same time, land reflectance was also high. Normalized Difference Vegetation Index value is less for water body (zero) bare land, and settlement and farmland classes. However, in the case of forest and shrub land, the values were relatively high. To evaluate the thermal status of land surface by satellite, it is important to find the relation between LU/LC type and LST. Normalized difference vegetation index play an important role in assessing and investigating of LST. Land surface temperature and NDVI have indirect relationships in different LU/LC categories except in the case of water body. Water body LU/LC class has low NDVI and LST value. Vegetation condition (NDVI value) and types of LU/LC have impacts on LST value. However, it does not mean that the type of LU/LC is the only factor for the increase of LST. There are a number of other contributing factors for increasing or decreasing the LST value. For instance, types of soil, geothermal energy, geological setting, altitude and climate condition in the area are some to mention.

Different researchers used thermal bands to study LST. Gebrekidan Worku (2016) used Landsat satellite imagery to study LST situation of Addis Ababa city. The study investigated the relationship between LU/LC, LST and NDVI. Gebrekidan Worku (2016) found negative linkage in NDVI and LST values. However, in this case, water body should be considered as exception, as water body has low NDVI and LST value. The result of present study shows that different LU/LC has different NDVI and LST values during the study period.

Maitima *et al*. (2009), Khin *et al.* (2012) and Kerr *et al.* (2004) agree with that the main factor for increase of LST in rural as well as urban areas land-cover changes and unplanned use of land resources. In less developed areas the relation between Land-cover change, biodiversity and land deterioration is very high, because of that land-cover are transformed to human settlements, farmlands and grazing lands at the expense of forest and vegetation (Maitima *et al*. 2009). With regard to LU/LC changes in the study area, with the expansion of settlements, water body and vegetation (forest, shrub land, grass land, wet land and open space) and farmland have highly declined. This is clearly observed, especially in Arsi zone. In this area, due to the expansion of settlement area, small-scale farmers moved and start to settle in open space and shrub land, grass land and forest. In addition to this, eucalyptus trees and some perennial plantation also extended its area towards the previously open space, grass land, forest, shrub land and farmland. In 997, at around Chilalo, Kaka and Gugu mountains area, there were some sparsely vegetated land. But, through time, this area was totally changed into farmland and settlement. Thus, the study area is highly degraded and exposed to natural disasters such as soil erosion. As evident from the classified satellite images. However, sometimes LU/LC has a positive impact on environment. For instance, the conversion of open space/bare land/ to plantation LU/LC type. This might help to control the increment of LST.

Normalized difference vegetation index and LST have indirect/negative/ relationship. However, that could be a positive/direct/ relationship, especially in water body and high potential geothermal areas. According to Burgan and Hartford (1993), the negative values are indicative of water, snow, clouds, non-reflective surface and other non-vegetated areas while positive values expresses reflective surfaces such as vegetated area. However, it does not mean that all negative values of NDVI have high LST value. Land surface temperature depends up on the reflective conditions of the surface of the earth. In general, area of non-vegetated and non-reflective surface, have high LST than those of vegetated and water body.

According to the result of this study, there are eight major LU/LC classes and for each class LST value varies. Water body and vegetation classes (forest, shrub land, grassland and wet land) have lowest LST value where as settlement; bare land and farmland class have highest LST. Spatial and temporal distribution of LST during 1997 and 2017 revealed that during the study period drastic changes had taken place in the area. In 1997, the distribution of LST was 5.11ºC and 40.93ºC, minimum and maximum, respectively, where as in 2017 the minimum and maximum Values of LST ranges from 9.02ºC–44.90ºC, respectively.

# CHAPTR SIX

# 6 CONCLUSION AND RECOMMENDATIONS

## 6.1 Conclusion

Satellite data are useful for different applications such as LU/LC change detection and environmental management programs. Landsat imageries have the potential to examine the LU/LC dynamics and to analyze the spatio-temporal distribution of LST. The present study has used Landsat TM 5, and Landsat 8 OLI/TIRS images to evaluate and analyze the impact of LU/LC changes on LST. Land surface temperature and LU/LC derived from such data provides important information to monitor human activities and environmental changes. It was reveals that Landsat images are very useful in quantifying and mapping LU/LC change, NDVI and LST in Arsi zone. The LU/LC pattern of the study area has attributed to socio-economic and natural factors and their exploitation in time and space. Water body and vegetation classes (forest, shrub land, grassland and wet land) have lowest LST value where as settlement; bare land and farmland class have highest LST. Land-use/land-cover has been changing from time to time in the present study area. Land-use/land-cover change has an impact on LST. For each year, the minimum and maximum LST has increased. Hence, calculated LST plays an important role or functions in monitoring LU/LC changes and tracking temperature variations and condition in the area. The findings of this study showed that LSTs of Arsi zone has increased during period of 1997and 2017. This was because of LU/LC changes, human activities and climate variability of the area. The land surface temperature of the zone indicated a high variation in LST between different LU/LC types. The derived LST values from satellite data were found to be in fine harmony with interpolated temperature values from the weather stations used. The derived NDVI values from satellite data also some how a good indicator of LST status of the study area. Therefore, the use of GIS and remote sensing data to investigate the differences in LST and different LU/LC class pattern in the study area illustrates that it suggest a quicker and cost effective technique with the advantage of covering large area.

### 6.2 Recommendations

The focus of this study was to assess and investigate the impact of LU/LC changes on LST in Arsi zone based on Landsat imagery of 1997 and 2017. The study showed that the conversion of

LU/LC types to another type of LU/LC types such as from vegetation area to farmland, farmland to settlement and the value of LST was different for each LU/LC class. However, there is case in which the change could make a positive impact on LST. For instance, the plantation of eucalyptus trees and some perennial crops had a positive contribution for the low LST value. Therefore, based on the result of this study, the following recommendations have been drawn.

- ❖ Land-use/land-cover change becomes a central component in current strategies for managing resources and monitoring environmental changes. Therefore, the governmental and non-governmental bodies should give high attention to the proper land-use management and ecological effect of each LU/LC.
- ❖ Conservation activities have to be taken on both rural and urban green areas of the study area and recommended to plant trees and delineate green areas, especially at high density settlement and bare land areas.
- ❖ Land managers and environmental experts should control LU/LC changes through different measures to minimize the influence on the environments.
- ❖ The output of this research can serve as an input for future researchers who want to study the impact of LU/LC changes and increase in LST on environmental issues and livelihood of the communities in the zone.

## References

Agarwal, C., Green, G. M., Grove, J. M., Evans, T. P., and Schweik, C. M. (2002). A review and assessment of land-use change models: dynamics of space, time, and human choice.

Aires, F., Prigent, C., Rossow, W. B., and Rothstein, M. (2001**.** A new neural network approach including first guess for retrieval of atmospheric water vapor, cloud liquid water path, surface temperature, and emissivities over land from satellite microwave observations. *Journal of Geophysical Research*: Atmospheres, 106(D14), 14887–14907.

Alemayehu Mengistu (2008). Climate Variability and change. *Ethiopian journal of Animal production*.8 (1), 94–98.

Ali, H. (2009). Land use and land cover change, drivers and its impact: A comparative study from Kuhar Michael and Lenche Dima of Blue Nile and A wash Basins of Ethiopia (Doctoral dissertation, Cornell University).

Becker, F.,and Li, Z. L. (1990**)**. Towards a local split window method over land surfaces. Remote Sensing, 11(3), 369–393.

Billah, M., and Rahman, G. A. (2004**)**. Land-cover mapping of Khulna city applying remote sensing technique. In Proceedings of the 12th International Conference on Geoinformatics (Sweden: Geospatial Information Research: Bridging the Pacific and Atlantic, University of Gävle) pp. 707–714.

Burgan, R. E., and Hartford, R. A. (1993). Monitoring vegetation greenness with satellite data.

Burrough, P.A., (1990). Principles of Geographic information systems.Pp.333.Oxford University press, UK.

Buyadi, S. N. A., Mohd, W. M. N. W., and Misni, A. (2013). Impact of land use changes on the surface temperature distribution of area surrounding the National Botanic Garden, Shah Alam. Procedia-Social and Behavioral Sciences, 101, 516–525.

CSA. (2007) Central Statistical Agency. Summary and statistical report of the population and housing census. Addis Ababa, Ethiopia.

Chen, X., (2000). Using RS and GIS to analyze land-cover change and its impacts on the Regional Sustainable Development. *International Journal Remote Sensing*. (23), 107–113.

Coppin, P. R., and Bauer, M. E. (1996). Digital change detection in forest ecosystems with remote sensing imagery. Remote sensing reviews, 13(3-4), 207–234.

C. Wloczyk, R. Richter, E. Borg, W. Neubert, "Sea and lake surface temperature retrieval from Landsat thermal data in Northern Germany," International Journal of Remote Sensing, vol. 27, no. 12, pp. 2489-2502, 2006.

Di Gregorio, A., and Jansen L.J., (2000). Land-cover classification: classification concepts and user manual, Food and Agriculture Organization (FAO) of the United Nations Rome.

Emilio, C. (2008). The role of satellite RS in monitoring global environment "department of Geography University of Alkala Spain, PP. 1–2.

FAO/UNEP., (1999).Terminology for integrated resources planning and management. Food and agriculture organization/United Nations Environmental program, Rome, Italy and Nairobi, Kenya.

Farooq, A. (2012). Landsat ETM+ and MODIS EVI/NDVI data products for climate variation and Agricultural Measurements in Holliston Desert. *Global Journal of Humanities, social science*: Geography and Environmental Geosciences, 12 :( 13).111.

Foresman, T. W. (Ed.). (1998). The history of geographic information systems: perspectives from the pioneers. Prentice Hall.

Gebrekidan, Werku (2016). Modeling land surface temperature from satellite data, the case of Addis Ababa. ES RI, Eastern Africa Education GIS conference. Held at Africa hall, United Nations conference center from23-24 sept. 2016, Addis Ababa.

Gumindoga, W. (2010). Hydrologic Impact of Land-Use Change in The Upper Gilgel Abay River Basin, Ethiopia; TOPMODEL Application (Doctoral dissertation, M. Sc. Thesis, ITC Netherlands).

Guo, Z., Wang, S. D., Cheng, M. M., and Shu, Y. (2012). Assess the effect of different degrees of urbanization on land surface temperature using remote sensing images. Procedia Environmental Sciences, 13, 935–942.

Hardegree, L. C. (2006). Spatial Characteristics Of The Remotely-sensed Surface Urban Heat Island in Baton Rouge, LA: 1988-2003 (Doctoral dissertation).

Houghton, R. A. (1994). The worldwide extent of land-use change. BioScience, 44(5), 305-313.

Kayet, N., Pathak, K., Chakrabarty, A., and Sahoo, S. (2016). Spatial impact of land use/land cover change on surface temperature distribution in Saranda Forest, Jharkhand. Modeling Earth Systems and Environment, 2(3), 1–10.

Kern, A. (2011). Deriving Normalized Difference Vegetation Index based on remotely sensed AVHRR and MODIS data (Doctoral dissertation, Eötvös Loránd University).

Kerr, Y.H., Lagouarde, J.P., Nerry, F., Ottle, C. (2004). Land surface retrieval techniques and applications: case of AVHRR, in: Quatrocci, D.A., Luvall, J. C. Thermal remote sensing in land surface processes. CRC press, Florida, USA, 33–109.

Khin, M.Y., Shin D.Y., Park, J.J., Choi C.C., (2012). Land surface temperature changes by LU changes of Inlay Lake area, Myanmar. Department of Spatial Information Engineering, Pukyong National University, South Korea.

Kumar, R., and Singh, S. (2016). Case Study for Change Detection Analysis and Land Surface Temperature Retrieval in Uttrakhand Region and their correlation. Imperial Journal of Interdisciplinary Research, 2(9).

Lambin, E. F., Turner, B. L., Geist, H. J., Agbola, S. B., Angelsen, A., Bruce, J. W., ... and George, P. (2001). The causes of land-use and land-cover change: moving beyond the myths. Global environmental change, 11(4), 261–269.

Lambin, E.F., and Meyfroidt, P. (2010). Land-use transitions: socio-ecological feedback versus socioeconomic change, land-use policy, 27,108–118.

Lemlem Abraha (2007). Assessing the Impact of Land Use and Land Cover Change on Groundwater Recharge using Rs and GIS; a Case of Awassa Catchement, Southern Ethiopia (Doctoral dissertation, AAU), Addis Ababa.

Lillesand, T., Kiefer, R. W., and Chipman, J. (2014**)**. Remote sensing and image interpretation. John Wiley and Sons, New Delhi.

Macleod, R. D., and Congalton, R. G. (1998**).** A quantitative comparison of change-detection algorithms for monitoring eelgrass from remotely sensed data. Photogrammetric engineering and remote sensing, 64(3), 207–216.

Maguire, D.J., (1991). An overview and definition of Geographic information system. In geography information systems: principles and applications. London Longman, Vol.1,9–20.

Maitima,J.M.,Mgatha,S.M.,Reid,R.S.,Gachimbi,L.N.,Majule,A.,Lyaru,H.,Pomery,D.,Mathai,S.,andMugisha,S.,(2009). The linkage between land-use change, land degradation and biodiversity across East Africa. *Africa Journal of environmental science and technology*, 3 (10), 310–326.

Mather, A. S., and Needle, C. L. (2000). The relationships of population and forest trends. TheGeographical Journal, 166(1), 2–13.

Meyer, W. B., and Turner, B. L. (1992). Human population growth and global land-use/cover change. Annual review of ecology and systematics, 23(1), 39-61.

Mihai,V.H.(2012).Using Satellite Images Landsat TM For calculating Normalized Difference Indexes for the landscape of Parang mountains.Lect.Ph.D.Eng.Banat University of Agricultural sciences and Veterinary medicine, Romania.

Miheretu Birhan and Assefa Abegaz (2017). Land use/land cover changes and their environmental implications in the Gelana sub-watershed of Northern highlands of Ethiopia. Environmental Systems Research, 6(1), 7.

Naissan, O.W., and Lily,T.(2016). Aesthetc Dermatology,effects of climate change on skin,Dermatology news USA,May 16, 2016.

Nuruzzaman, M. (2015). Urban Heat Island: Causes, Effects and Mitigation Measures-A Review. *International Journal of Environmental Monitoring and Analysis*, 3(2), 67.

Oluseyi, I. O., Danlami, M. S., and Olusegun, A. J. (2011**)**. Managing Land Use Transformation and Land Surface Temperature Change in Anyigba Town, Kogi State, Nigeria. *Journal of Geography and Geology*, 3(1), 77.

Paramasivam, C.R. (2016**)**. Remote Sensing and spectral studies of magnesite mining area, Salem, India. For the award of the Degree of Doctor of Philosophy in Geology thesis submitted to Periyar University, Salem, India

Prata, A.J., and Caselles, C., (1995). Thermal remote sensing of land surface temperature from satellites: status and future prospects. Remote sensing rev.12, 175–223

.

Rajeshwari, A., and Mani, N. D. (2014). Estimation of land surface temperature of Dindigul Woreda using Landsat 8 data. *International Journal of Research in Engineering and Technology*, 3(5), 122–126.

Santa, P. (2011). Forest cover and land-use changes: a study of Laljihadi forest (corridor), far western development region, Nepal.MSc Thesis Tribhuvan University.

Sheng, T. C. (1993). Watershed management field manual: watershed survey and planning. French. Cahier FAO: Conservation (FAO). no. 13/6. http://www.fao.org/docrep/006/T0165E/t0165e10.htm accessed on January 10, 2017.

Shukla, J., Nobre, C., and Sellers, P. (1990). Amazon deforestation and climate change. Science (Washington), 247(4948), 1322–1325.

Sobrino, J.A., Rosa, O., Guillen, S., Juan, C.J., Belen.F. Victoria.H., Cristian, M., Yves,J.,Juan,C.,Mireia,R.,Antonio,G.J.,Eduardo,D.M.,Remo,B.,andMarc,p.(2012).Evaluation of the surface UHI effect in the city of Madrid by thermal RS. *International journal of remote sensing*, 34, 910.

Streutker, D. R. (2003). Satellite-measured growth of the urban heat island of Houston, Texas. Remote Sensing of Environment, 85(3), 282–289.

Turner, W., Spector, S., Gardiner, N., Fladeland, M., Sterling, E., and Steininger, M. (2003). Remote sensing for biodiversity science and conservation. Trends in ecology and evolution, 18(6), 306–314.

USAPA, (2004). A Summary of Models for assessing the effects of Community Growth and change on land-use patterns.EPA.600.R-00.098.U.S.Environmental protection Agency office of research and development , pp. 260.

Voogt, J., (2000). How researchers measure UHI. Glossary of Meteorology, 2nd edition, Canada.

Walsh, C. L., Dawson, R. J., Hall, J. W., Barr, S. L., Batty, M., Bristow, A. L., and Tight, M. R. (2011). Assessment of climate change mitigation and adaptation in cities. Proceedings of the Institution of Civil Engineers-Urban Design and Planning, 164(2), 75–84.

Weng, Q.H. (2004). A remote sensing and GIS evaluation of urban expansion and its impact on surface temperature in the Zhujiang Delta, China. *International journal of remote sensing*22(10), 1999-2014.

Weng, Q., Lu, D., and Schubring, J. (2004). Estimation of land surface temperature–vegetation abundance relationship for urban heat island studies. Remote sensing of Environment, 89(4), 467–483.

Yue, W., Xu, J., Tan, W., and Xu, L. (2007**)**. The relationship between land surface temperature and NDVI with remote sensing: application to Shanghai Landsat 7 ETM+ data. *International Journal of Remote Sensing*, 28(15), 3205–3226.

Zha, Y., Gao, J., Jiang, J., Lu, H., and Huang, J. (2012). Normalized difference haze index: a new spectral index for monitoring urban air pollution. *International journal of remote sensing*, 33(1), 309–321.

Zubair, A.O. (2006). Change detection in LU/LC using RS data and GIS a case study of Ilorin and its environments in Kwara State. Department of geography, University of Ibadan.

# Appendices

**Appendix 1:** Classification accuracy assessment report for the year 1997.

ACCURACY TOTALS

| Class Name | Reference Totals | Classified Totals | Number Correct | Producers Accuracy | Users Accuracy |
|---|---|---|---|---|---|
| Settlement | 9 | 8 | 6 | 87.50% | 87.50% |
| Wet land | 7 | 8 | 8 | 85.52% | 85.32% |
| Grassland | 5 | 6 | 4 | 90.00% | 90.20% |
| Bare land | 10 | 10 | 9 | 85.10% | 85.10% |
| Water body | 7 | 7 | 3 | 80.00% | 80.00% |
| Forest | 9 | 9 | 9 | 90.00% | 90.00% |
| Farm land | 8 | 7 | 8 | 85.12% | 84.00% |
| Shrubs | 5 | 5 | 5 | 85.00% | 86.12% |
| Totals | 60 | 60 | 52 | | |

Overall Classification Accuracy = 86.03%

----- End of Accuracy Totals -----

KAPPA (K^) STATISTICS

Overall Kappa Statistics = 0.8374

Conditional Kappa for each Category.

| Class Name | Kappa |
|---|---|
| Unclassified | 0.0000 |
| Settlement | 0.8874 |
| Wet land | 0.8567 |
| Grassland | 0.8177 |
| Bare land | 0.8319 |
| Water body | 0.8616 |
| Forest | 0.8810 |
| Farm land | 0.8915 |
| Shrubs | 0.8704 |

----- End of Kappa Statistics -----

**Appendix 2:**Classification accuracy assessment report for the year 2017.

ACCURACY TOTALS

| Class Name | Reference Totals | Classified Totals | Number Correct | Producers Accuracy | Users Accuracy |
|---|---|---|---|---|---|
| Settlement | 9 | 8 | 6 | 90.50% | 90.50% |
| Wet land | 7 | 8 | 8 | 90.52% | 90.32% |
| Grassland | 5 | 6 | 4 | 80.00% | 80.20% |
| Bare land | 10 | 10 | 9 | 85.10% | 85.10% |
| Water body | 7 | 7 | 3 | 80.00% | 80.00% |
| Forest | 9 | 9 | 9 | 85.00% | 85.00% |
| Farm land | 8 | 7 | 8 | 85.12% | 84.00% |
| Shrubs | 5 | 5 | 5 | 85.00% | 86.12% |
| Totals | 60 | 60 | 52 | | |

Overall Classification Accuracy = 85.15%

----- End of Accuracy Totals -----

KAPPA (K^) STATISTICS

Overall Kappa Statistics = 0.8256

Conditional Kappa for each Category.

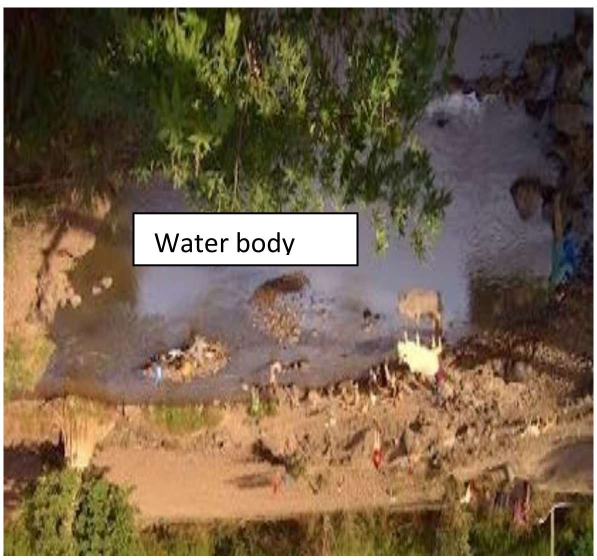
| Class Name | Kappa |
|---|---|
| Unclassified | 0.0000 |
| Settlement | 0.8674 |
| Wet land | 0.8564 |
| Grassland | 0.8174 |
| Bare land | 0.8312 |
| Water body | 0.8419 |
| Forest | 0.8312 |
| Farm land | 0.8512 |
| Shrubs | 0.8786 |

----- End of Kappa Statistics -----

**Appendix 3**: Sample of different LU/LC photographs.

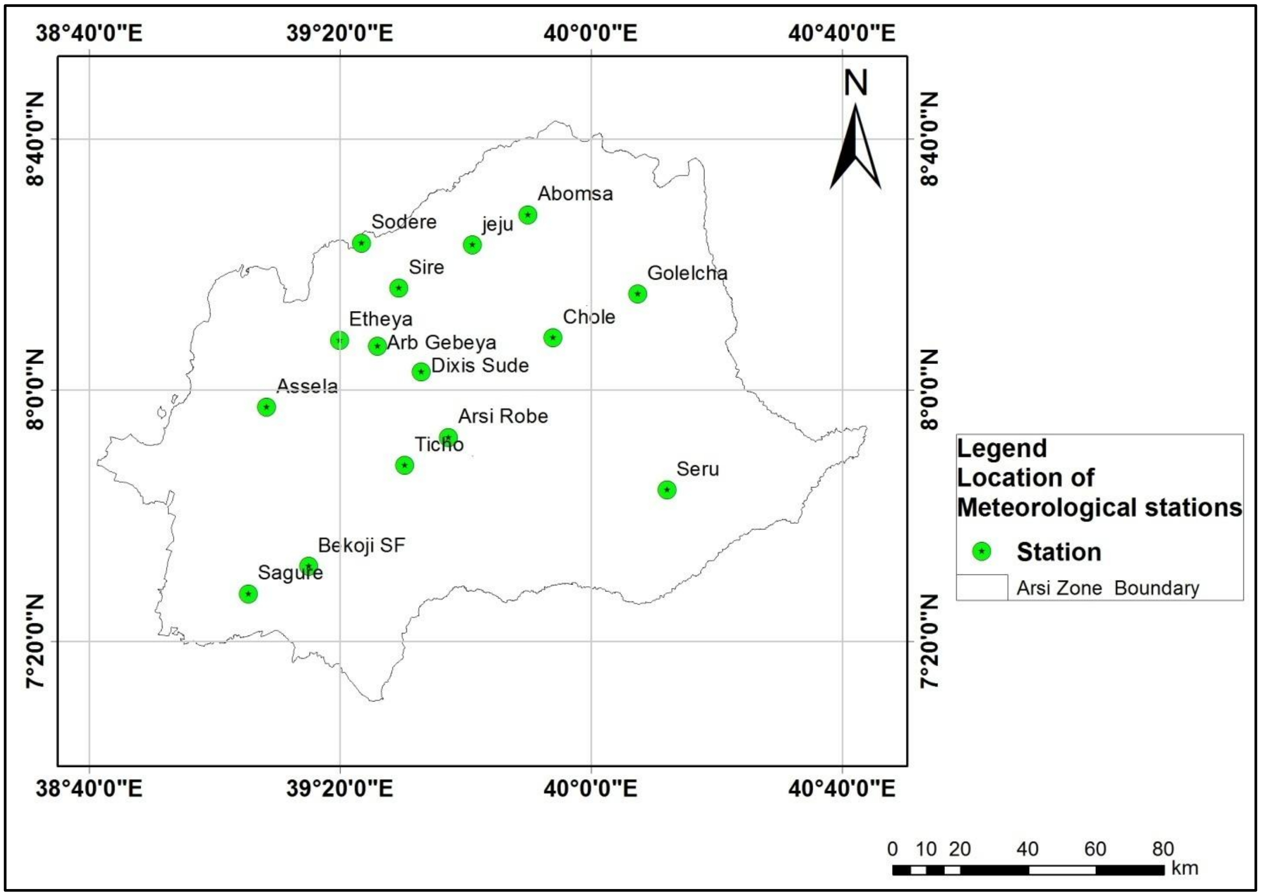

Bare land


Wet land

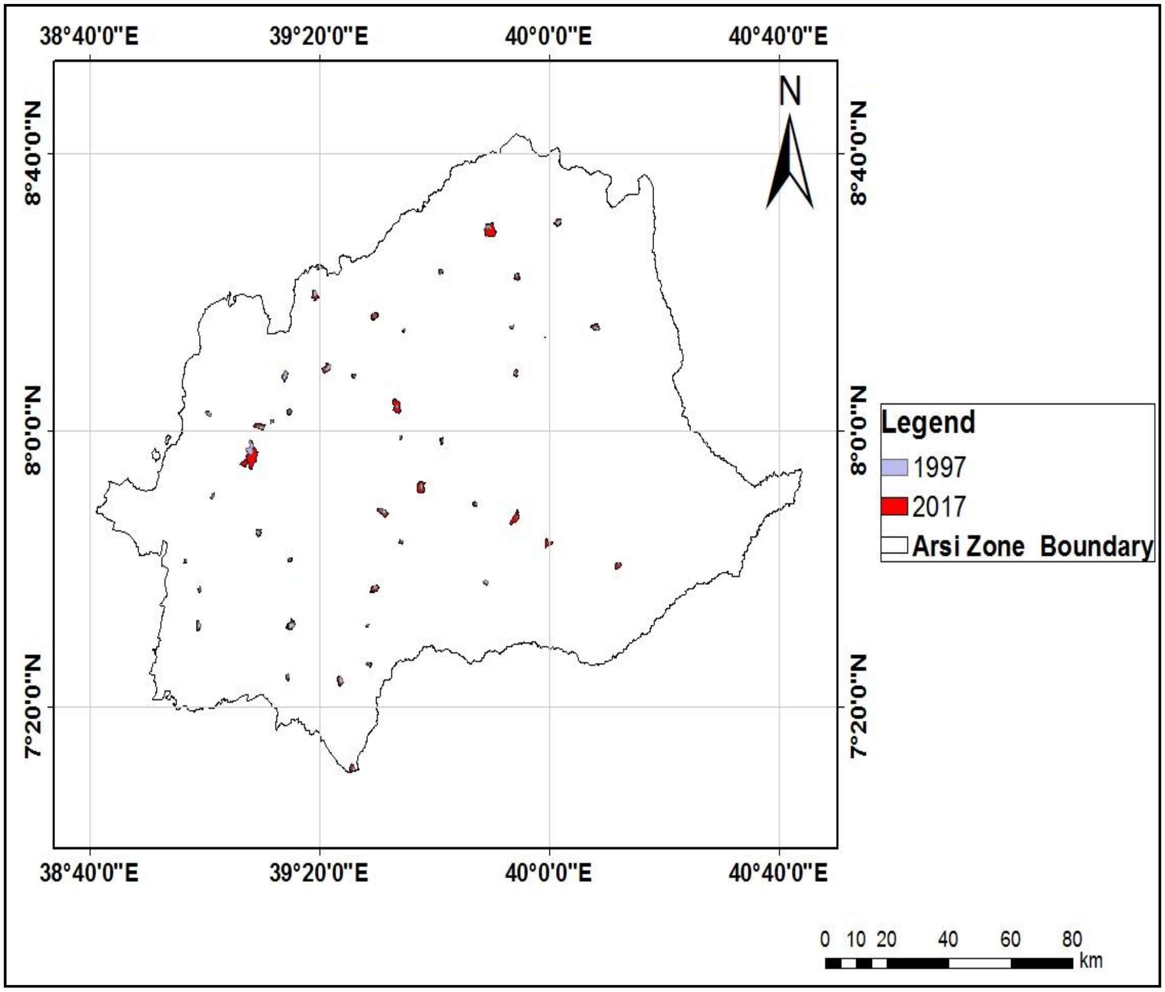

Water body


Grass land

**Appendix 4:** Location of meteorological stations map.



**Appendix 5:** Points Settlement expansion during 1997-2017



**Addis Ababa University**
**School of Earth Sciences**
**ANNEX 1: FORMAT FOR THESIS ORIGINALITY TEST REPORT**

| | |
|---|---|
| Name of student | Morka Abebe Feyisa |
| ID No | GSR/047/08 |
| Stream | Remote sensing and Geo-informatics |
| Thesis title | *Impact of Land-Use/Land-Cover Changes on Land Surface Temperature in Arsi zone, Eastern Ethiopia* |
| Online site used for originally test | http://www.paperrater.com/plagiarisim_checker |

| No | particulars | Test I | | Test II | | Test II | | Test IV | | Test V | | Average | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Originality (%) | Plagiarism (%) | Originality (%) | Plagiarism (%) | Originality (%) | Plagiarism (%) | Originality (%) | Plagiarism (%) | Originality (%) | Plagiarism (%) | | |
| 1 | Abstract | 100 | - | - | - | - | - | - | - | - | - | 100 | |
| 2 | Introduction | 100 | - | 100 | - | 100 | - | - | - | - | - | 100 | |
| 3 | Literature review | 91 | 9 | 99 | 1 | 100 | - | 100 | - | 100 | - | 98 | |
| 4 | Methodology | 100 | - | 100 | - | 100 | - | 100 | - | 100 | - | 100 | |
| 5 | Results | 100 | - | 100 | - | - | - | - | - | - | - | 100 | |
| 6 | Discussion | 100 | - | - | - | - | - | - | - | - | - | 100 | |
| 7 | Conclusion | 100 | - | - | - | - | - | - | - | - | - | 100 | |
| | Overall Thesis | | | | | | | | | | | 99.7 | |

| | Name | Signature |
|---|---|---|
| Student | Morka Abebe Feyisa | |
| Advisor (1) | Dr. Tesfaye Korme | |
| Advisor (2) | Getachew Haie | |

## DECLARATION

I the undersigned declare that this thesis is my original work and has not been presented for a Degree in any other university and that all sources of materials used for the thesis have been duly acknowledged.

Morka Abebe Feyisa

Signature _________________________ Date________________________

School of Earth Science

June, 2018

This thesis has been submitted for examination with my approval as university advisor.

Dr. Tesfaye Korme

Signature ___________________Date____________________

Getachew Haile

Signature ___________________Date____________________